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ABSTRACT

These proceedings of the 1994 convention of the Association for Educational Communications and Technology (AECT) contains 75 papers and 1 symposium. Topics addressed by the papers include teacher competency regarding instructional technology; electronic journals; constructivist design; adult education; instructional design; integration of technology in schools; school restructuring; knowledge representation; computer based instruction; educational technology; cooperative learning; metacognition; cooperative instruction; learning strategies; distance education; instructional multimedia; interactive software; educational motivation; and problem solving. The symposium topic was a dialogue on applying critical approaches to educational technology. This volume also includes a list of reviewers for the research papers in the proceedings; a list of Research and Theory Division officers; a list of ERIC document numbers for previous proceedings; a description of AECT and membership enrollment form; and author and descriptor indexes. (JLB)

16th ANNUAL

PROCEEDINGS

of SELECTED RESEARCH AND DEVELOPMENT PRESENTATIONS

at the 1994 National Convention of the Association for Educational Communications and Technology

Sponsored by the
Research and Theory Division
Nashville, TN

aect

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at the 1994 Convention of the
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PREFACE

For the sixteenth year, the Research and Theory Division of the Association for Educational Communications and Technology (AECT) is sponsoring the publications of these Proceedings. Papers published in this volume were presented at the national AECT Convention in Nashville, TN. A limited quantity of this volume were printed and sold. It is also available on microfiche through the Educational Resources Information Clearinghouse (ERIC) system.

REFEREEING PROCESS: All research papers selected for presentation at the AECT convention and included in this Proceedings were subjected to a rigorous blind reviewing process. All references to author were removed from proposals before they were submitted to referees for review. Approximately fifty percent of the manuscripts submitted for consideration were selected for presentation at the Convention and for Publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

This volume contains two indexes. The first is an author index; the second is a descriptor index. The index for volumes 1-6 (1979-84) is included in the 1986 Proceedings, and the index for volumes 7-10 is in the 1988 Proceedings.

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YEAR	LOCATION	ED NUMBER
1979	New Orleans	171329
1980	Denver	194061
1981	Philadephia	207487
1982	Dallas	223191 to 223236
1983	New Orleans	231337
1984	Dallas	243411
1985	Anaheim	256301
1986	Las Vegas	267753
1987	Atlanta	285518
1988	New Orleans	295621
1989	Dallas	308805
1990	Anaheim	323912
1991	Orlando	334969
1992	Washington, DC	347970 to 348041

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AECT is the only national, professional association dedicated to the improvement of instruction through the effective use of media and technology. AECT assists its members in using technology in their jobs and to enhance the learning process.

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- Learning resource specialists
- Curriculum developers
- Television producers and directors
- Communications specialists
- Education administrators
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AECT began as the Department of Visual Instruction at the National Education Association in 1923, in the days when visual aids consisted of films and slides. In 1947, as educators were adapting technology used to train World War II service personnel for the classroom, the name of the organization became the Department of Visual Instruction (DAVI). Twelve years later, DAVI became an affiliate of the NEA and finally the autonomous association, AECT, in 1974.

Today, AECT keeps an eye on the future of instructional technology while assisting educators with the changes and challenges that face them now. AECT members, now numbering 4,500 are professionals devoted to quality education.
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Research and Theory Division (RTD) improves the design, execution, utilization, evaluation, and dissemination of educational technology research and theory; advises educators on using research results.

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Table of Contents

Title:

Teachers' Competence, Affect, Familiarity, and Perceived Skill Regarding Instructional Technology

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ABSTRACT

While innovation advocates have focused on the need to reform Philippine schools to meet the needs and demands of society, little has been done to change the teachers' practices. Recent studies have pointed to inadequate teacher training as one of the reasons for Filipino students' low achievement. This study was conducted to identify specific variables which contributed significantly to teacher competence, affect, familiarity and perceived skill. Four independent variables were analyzed: place of work, academic subject, years of teaching experience and training in instructional technology. Findings suggest specific variables significant in designing a curriculum for preparing teachers in implementing educational programs.

Purpose of the Study

This study was undertaken in response to recent, widespread calls for reforms and improvements in Philippine schools, secondary schools in particular (Congressional Commission on Education, 1991; Cortes, 1990; Quisumbing, 1987; Sutaria, 1989). It has been acknowledged that changing these schools will require changing teachers' practices, since teachers have the major responsibility for implementing educational programs (Gonzales, 1986). Innovation advocates recognize the contribution of technology in reforming the school system. The technology brought earlier to the military (Bush, 1990) and industry (Geber, 1990) has set the pace and opened great promises of what technology can bring to education. Instructional technology (IT) with its system of designing, implementing and evaluating instruction, seems to offer a body of principles and techniques that can improve instructional practice and curriculum development. This study was undertaken to determine:

1. How competent are Philippine teachers in the use of instructional design and technology?

2. To what extent do Philippine teachers value instructional design and technology?

3. How familiar are Philippine teachers with instructional design and technology?

4. To what extent do Philippine teachers believe that they are skilled in the use of instructional design and technology?

Literature Review

Studies of Philippine education from the Monroe Survey in 1925 (Cortes, 1993) to the Congressional Commission on Education Report in 1991 have consistently reported the low levels of achievement among students. The findings showed that, "Pupils on the average learn only 55 percent or even less of what must be learned at every grade level" (Congressional Commission on Education Report, 1991, p. 10). The Congressional Commission on Education Report has generated a lot of concern from both the government and non-government sectors. Rama (1993) expounds the theory of economic development being dependent on the literacy level of the people, noting that "The better educated the people, the more prosperous a country. By the same token, the poorer the standard of education, the poorer the country" (p. 4). Unfortunately while the 1990 Philippine Census of Population and Housing claims 93.5 percent literacy (cited in Braid, 1993), the Functional Literacy Education and Mass Media Survey establishes only 73.2 percent of those ten years old and above as functionally literate (cited in Santos, 1993). Braid (1993) defines functional literacy as enabling "the individual to survive and function within his society" (p. 16).

Education which can help propel the Philippines to its dream of economic prosperity in the year 2000 (Braid, 1993) requires quality teachers. "Time and again the success of educational reforms has been found to be decisively dependent on ... the quality of teachers. No education system can rise too far beyond the level of the teachers" (Roy Singh, 1991, p. 75). If teachers are not proficient to teach, the quality of education equally suffers. Cortes (1993) attributes the problem of quality education to varied factors, but stresses that the key to quality education are the teachers. An earlier study (Cortes, 1987) has confirmed that the teacher factor contributes to the low level achievement of Filipino students. Equally the Congressional Commission on Education Report (1991) singled out the teacher as the most important factor in education whose influence as a change agent in society is beyond question.

Earlier reports on teacher competence have shown the low qualifications of many teachers to teach subjects they have been assigned to teach (Gonzales, 1989; Sutaria, 1989; Tarvin & Faraj, 1990). This condition could be traced to poor teacher training (Congressional Commission on Education Report, 1991). To correct the flaws, the Congressional Commission on Education Report (1991) has recommended two important points among others: 1) strengthening pre-service teacher education, and 2) improving and expanding the in-service training programs for teachers.

Quality teaching is defined operationally as skills in teaching, production of instructional media and test and measurement (Salinas, 1989). Teachers are expected to have solid background in the psychology of teaching and learning, a variety of teaching strategies and an adequate knowledge of what to teach (Cortes, 1993). Philippine education calls for reforms which include a system to improve instructional practices. The field of instructional technology, with a system in designing, implementing and evaluating the total process of instruction (Reiser, 1987) offers the mode of reform for Philippine education.

Although before this study reported herein there had been no studies involving Philippine secondary school teachers' competence, affect, familiarity and perceived skills regarding instructional design and technology, generalizations regarding specific variables treated in this study have appeared in some literature.

Knupfer's study (1988) showed that teachers in urban areas had more in-service training than teachers in rural areas. Training was observed to have a significant correlation to positive attitude towards innovations (Burke, 1986; Knupfer, 1988; Mims, 1975; Salinas, 1989; Streeter, 1967; Woolsey, 1986). In-service training consistently improved teachers' performance (Cortes, 1993).

Dawson (1977) found physical science majors to have significantly higher scores on the IT Attitude Scale than social sciences majors. Likewise physical science teachers were noted to have more positive attitude towards microcomputers than the social sciences teachers (Fary, 1989).

Ewing's study (1986) revealed that the use of IT was a function of users' experience and familiarity with technology. Computer anxiety was affected by lack of skills and resistance declined with familiarity and experience with automated technology (Albritton & Sievert, 1984). Van Duinen (1975) noted in his study that sex, educational attainment, and number of years in the teaching service significantly influence the expressed knowledge of, attitude towards and experiences of teachers in instructional development.

It may be concluded from this summary of literature review that to introduce change in schools a concerted effort should be focused on the teacher, the key implementor of change. Probably among the important variables to influence teachers' competence, affect, familiarity and perceived skills regarding instructional design and technology are teachers' place of work, field of specialization, training, and years of teaching experience. All these criteria were included in this study in identifying training needs of Philippine secondary school teachers.

Method

The survey research method employing face-to-face data collection was used in this study.

Subjects

Subjects were 389 Philippine secondary school teachers drawn via stratified, multi-stage, random sample to represent rural (Albay), urban (Iloilo), and metropolitan (Manila) areas. These teachers represented both physical science and social science instructors (academic subject), with teaching experience of from 1 to 20+ years, and with different levels of training (College plus Inservice, College, Inservice and No Training) in instructional technology. These four factors were the independent variables in the study. Complete data were obtained on 370 (95%) of the sample.

Instruments

A three-part instrument was developed for the study. Part I - Competence Test - was a test of instructional design skills. This portion of the instrument (21 items) focused on the seven instructional design components described in Dick and Reiser's (1989) book, *Planning Effective Instruction.* Part II - Instructional Technology Scale (IT Scale) - of the instrument consisted of 38 phrases with an accompanying Likert scale to assess the respondents' perceived skill, familiarity, and values regarding instructional media and instructional design. Part III of the instrument dwelt on demographic information such as place of work, field of specialization, years of teaching experience and training in instructional technology. The instrument was pilot tested before it was used in the study.

Procedures

In most schools the primary investigator was able to gather the teachers in a single location to administer the research instrument. The exception was in Manila where overcrowding in classrooms and the consequences of recent natural disasters in the Philippines required that school principals supervise the distribution and collection of the completed instrument. Completed questionnaires were picked up by the primary investigator on the average of one week from the date of delivery. The data collection took about two months as it required travel both by land and air to gather the materials from the different islands in the country.

Data Analysis

Data gathered from Part I of the questionnaire were coded according to correct answers, while demographic data (Part III) were coded according to each respondent's region, province/city, years of teaching experience, educational level completed, age, academic subject, and IT training. Part II of the questionnaire was coded in the same way as the five-point scale used: 5 - A complete extent; 4 - A considerable extent;
3 - A moderate extent; 2 - A very little extent; and 1 - No extent. The completed answer sheets were optically scanned. Besides descriptive statistics, ANOVA was used to test for

significant differences in competence, perceived skill, familiarity, and values based upon the four independent research variables -- region, academic subject, training in instructional technology and years of teaching experience. Where variables yielded a significant F value, a Scheffe Post Hoc Test was used to detect which mean differences contributed to the significance. Correlational and partial correlational analyses were used to determine he relationships among the study's dependent variables -- competence, perceived skill, familiarity, and values regarding instructional design and technology. All data were analyzed using the Statistical Analysis System.

The questionnaire was tested for internal consistency reliability. The resulting Cronbach alpha for each scale of the questionnaire was determined. The reliability calculations were processed using the ANLITH system.

For the purpose of reporting the data, the average Likert scale ratings were divided by 5 and results reported as percentage. Mean raw scores on the competence test were divided by 45 and reported as percentage.

Results and Analysis

Competence of Philippine teachers in the use of instructional design and technology

The data pertinent to research question 1 show that the mean proficiency score was 60%. The Cronback's alpha for the proficiency test was .56.

Significant differences were observed among the means of the teachers grouped by levels of training in instructional design and technology. The groups which contributed to the significant F value were the College plus Inservice (teachers who have College and Inservice training in instructional technology) and the Inservice training groups. No significant differences were observed among the mean responses of teachers grouped by region, academic subject, and years of teaching experience.

Two notable findings were observed when means of perceived skill, familiarity, and value were compared with the proficiency means (see Table 1). Albay consistently ranked lowest in self-rated perceived skill, familiarity, and value regarding instructional design and technology, but ranked highest on the competence test.

Table 1
Means of Respondents Grouped by the Four Independent Research Variables on the Four Research Scales Converted to Percentage

Group	Familiarity	Skill	Value	Competence
Albay	74.6	68.6	74.6	60.6
Iloilo	76.8	69.6	75.6	59.6
Manila	76.0	71.0	75.8	59.0
Physical Sc.	76.4	69.8	76.0	60.7
Social Sc.	76.0	70.4	75.4	58.9
College+Inservice	79.6	74.4	80.6	64.8
College	80.6	73.0	79.0	60.4
Inservice	76.4	70.4	75.6	58.4
No-Training	72.4	66.4	72.6	60.8
0-1 year	78.8	66.2	80.8	60.6
2-3 years	72.4	64.8	73.2	62.0
4-5 years	68.4	61.2	65.8	58.8
6-7 years	70.6	63.2	70.0	60.3
8-9 years	71.0	66.2	71.8	61.2
10-11 years	71.0	62.0	69.4	58.7
12-13 years	73.2	64.8	71.8	59.2
14-15 years	69.6	65.0	70.8	57.0
16-17 years	68.8	61.4	69.2	59.4
18-19 years	74.2	66.4	74.4	62.4
20 & above years	69.6	64.2	69.2	57.9

Similarly, an unusual finding was observed among the No-Training group which perceived themselves to be less familiar with, and less skilled in the use of instructional design and technology. They also ranked lowest in value toward instructional design and technology. The mean score of the No-Training group on the competence test, although not statistically different from the other training groups, ranked second highest.

Competence and perceived skill, familiarity, and value showed little correlation, which means that knowledge of the perceived skill, familiarity, and value were not reliable indicators of teachers' actual competence in the use of instructional design and technology.

As a predictor of competence, perceived skill and value were found to be significant; however, the most important predictor of the competence score was training. Training accounted for 2.9% (see Table 2) of the competence score.

Table 2

Summary Table Comparing Familiarity, Perceived Skill, Value, and Training with Competence Scores (Partial Correlation)

Source	df	SS	MS	F	p	r^2	r
Familiarity	1	48.02	48.02	2.29	0.132	.0058	.076
Skill	1	170.17	170.17	8.11	0.004	.0207	.144
Value	1	149.21	149.21	7.07	0.008	.0180	.134
Training	3	237.65	79.21	3.77	0.011	.0289	.170
Error	363	7610.02	20.96				
Total	369	8215.07					

Values of Philippine teachers regarding instructional design and technology

The findings pertinent to research question 2 indicated a moderate extent of value toward selected components of instructional design and technology. All four comparison groups reported a mean value which fell within the range of moderate extent of value.

Significant differences in the mean value of instructional design and technology were observed among teachers grouped according to level of instructional design and technology training. The main contributor to the significant F value was the mean difference between the College plus Inservice and the No-Training groups.

There were no significant differences in the mean value regarding instructional design and technology among the three regions, the two academic subjects and the 11 groups of teachers grouped according to years of teaching experience selected for the study.

An examination of the mean responses by the four independent research variables (see Table 1) showed that value was highest among beginning teachers (0-1 year) and lowest among those with 4-5 years of teaching experience. Overall, means of value ranked second to those on familiarity, while perceived skill ranked lowest among the self-reported variables.

High positive correlations were observed between expressed value and familiarity and between value and perceived skill. The correlation between value and competence was statistically significant, but the correlation coefficient of $r=.123$ was not particularly important. As a predictor, value accounted for 1.8% (see Table 2) of the competence score.

The Cronback's alpha for the Instructional Technology Scale on the value variable was .94.

Familiarity of Philippine teachers with instructional design and technology

The findings pertinent to research question 3 indicated a moderate extent of familiarity with selected components of instructional design and technology. All four comparisons reported a mean value which fell within the range of moderate extent of familiarity. The medians were generally higher than the means, which indicated that there were more teachers who perceived themselves familiar with selected components of instructional design and technology than those who perceived themselves as less familiar.

Significant differences were observed among teachers grouped by level of training in instructional design and technology. The main contributors to the significant F value were the mean differences between the College and the No-Training groups and between the College plus Inservice and the No Training group.

No significant differences were noted on the mean responses of teachers from the three regions studied, teachers from the Physical Sciences and the Social Sciences, or the mean responses of teachers grouped by years of teaching experience.

An examination of the mean responses by the four independent research variables (see Table 1) showed that familiarity was highest among beginning teachers and lowest among those with 4-5 years of teaching experience. Overall, mean responses of familiarity ranked highest followed by the mean responses in value and perceived skill.

High positive correlations between familiarity and perceived skill and between familiarity and value were observed. The correlation between familiarity and competence was low (r=.064). Familiarity accounted for 0.58% (see Table 2) of the competence score.

The Cronback's alpha for the Instructional Technology Scale on the familiarity variable was .94.

Perceived skills in the use of instructional design and technology

The findings pertinent to research question 4 indicate a moderate extent of perceived skill regarding the use of instructional design and technology. All four comparisons reported a mean value which fell within the range of moderate extent of perceived skill. Comparisons of means and medians revealed very little difference between these measures of central tendency.

A significant difference was observed on the scale assessing perceived skill among the teachers grouped by levels of training in instructional design and technology. Contributors to the significant difference were observed between the Inservice and No-Training groups and between the College plus Inservice and the No-Training groups. No significant differences were observed on the mean responses of teachers grouped by region, academic subject, and years of teaching experience.

An examination of the mean responses by the four independent research variables (see Table 1) showed that perceived skill regarding the use of instructional design and technology was highest among teachers with College plus Inservice training. The lowest mean was among teachers with 4 - 5 years of teaching experience.

Perceived skill, although not correlated with competence, was highly correlated with familiarity and value. Perceived skill was observed to account for 2% of the competence score (see Table 2).

The Cronback's alpha for the Instructional Technology Scale on the perceived skill variable was .93.

Summary

Data analysis revealed the following major findings:

Among the four independent variables (place of work, academic subject, training and years of teaching experience), only training in instructional technology was significantly related to differences in competence, perceived skill, familiarity, and values regarding instructional design and technology.

A significant difference was consistently observed for respondents with College plus Inservice training both on the IT Scale and the Competence Test. The No Training group consistently ranked lowest among the training groups on the IT Scale. Although the Competence Test score of the No Training group was not statistically different, it ranked second highest topping those with either only College or only Inservice training.

There were very high correlations among the variables of perceived skill, familiarity, and values. On the other hand, correlations between these "self-reported" variables and assessed competence in instructional design were very low.

Training in instructional technology was the single most important predictor of scores on the competence test, yet it accounted for a relatively small amount of the variance (2.9%).

Respondents reported moderate degrees of perceived skill, familiarity, and positive value toward instructional design and technology; their average score on the competence test was 60%.

Conclusions and Recommendations

The results of the study suggest the need to interpret any "self-reported" data regarding familiarity with or competence in instructional design with extreme caution. Needs assessment that rely on self-assessments may be very inaccurate. The results suggest that the constructs of perceived skill, familiarity, and valuing may be nearly identical -- indistinguishable psychometrically. Urban/rural differences, academic subject specialty, and years of teaching experience are not significantly related to teachers attitudes or skills in instructional design and technology.

Only training in instructional technology was significantly related to greater perceived skill in, familiarity with, and greater valuing of instructional design and technology and increased competence in instructional design. Teachers with College plus Inservice training were the only group which had consistently high mean responses in their competence, perceived skill, affect, and familiarity. This suggests that both College and Inservice training are required to increase the actual level of competence of Philippine secondary school teachers regarding instructional design and technology. The finding which indicates that the College training and Inservice training groups performed no better than those with No Training raises the issue of training quality provided to both groups at the preservice and inservice levels. As a result, a review of the preservice curriculum relative to the selected components of IT is in order. Likewise, the inservice training programs need to be carefully examined.

The Competence Test of this study emphasized basic teaching competencies, such as writing objectives, developing test items, choosing teaching strategies, etc.. A mean performance of 60% seemed to suggest that whatever upgrading of teaching competencies was conducted, the training did not adequately provide the needed skills to improve the teaching competencies of teachers. Sixty percent performance on planning, implementing, and evaluating instruction strongly implies a need for training on the use of instructional design.

Since the data is correlational, causation cannot be confirmed. However, this finding is supportive of the importance of training especially in the instructional technology field.

Educational implications include the need to review or perhaps refocus the present preservice curriculum and inservice training programs for secondary school teachers. Training programs should be designed based on actual needs, not on the perceived needs of teachers. Training should focus on skills essential for effective instruction. The preservice curriculum should be reviewed in the light of the findings in this study.

Research implications include the investigation of other variables which could contribute to teachers' performance. Other research concerns are the determination of the extent to which school administ. tors, teaching schedule, or loading can contribute to teachers' high performance. There is also a need to replicate the study with other populations. It is apparent that there is a lack of well developed, validated instruments to measure competence in instructional design. The instrument used in this study could serve as a beginning point to develop such a tool.

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Title:

Empowering Teachers with Technology: An Agenda for Research and Development

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Abstract

Anthropologist and sociologist have found that technological innovators are more likely to find success when they: 1) recognize the group's unique identity; 2) assist the group in under-standing and using the technology; 3) empathize with the group environmental and cultural needs, and 4) empower the group to meet those needs. After reviewing related education literature, 12 questions (3 each for 4 factors) were established for considering how articles in the major research journals of AECT (1953-1993) addressed issues that demonstrated an awareness of the teachers' culture in school. Of the 847 articles reviewed, 24% recognizes the teachers' roles, 13% demonstrated an understanding of the teachers' working conditions, 15% provide specific explanations of how educational technology can be integrated into school structures and 10% identified specific needs and corresponding educational technology solutions for empowering teachers. Recommendations include greater emphasis on teacher conditions and relevance in the research literature, articulation of how educational technology can be made effective within the schools' culture, and strategies for empowering teachers through educational technology resources.

Humans are social. Much of our incentive for learning comes from interacting with and being recognized by others. Once the responsibility of parents, changes in the American family and society are shifting expectations for social development toward teachers. Teachers shape the instruction and activities in the classroom and they serve as role models for students. Many of the crucial contributions to social development, including those requiring mentoring and peer interaction, are too complex and situational to be fully integrated within machine-mediated instructional systems (Clark, 1984; Kerr, 1989; Martin & Clemente 1990). Even so, the systems employed by educational technologists (e.g., computers and multimedia) are playing increasingly significant roles in many aspects of American life from entertainment to business and education. These conditions call for strategies that capitalize on the potential of educational technology systems while at the same time recognizing the unique contributions that teachers make in meeting the social needs of learners.

Educational technologists differ in their opinions regarding the teacher's role in directing educational technology. Some educators (Aust, Allen & Bichelmeyer, 1989; Clark, 1984; Clemente & Martin 1990; Kerr, 1985) believe that teachers are capable and willing to contribute to the advancement of educational technology. While others (Heinich, 1984, 1985) believe that the use of educational technology should be directed by instructional systems managers with teachers serving as components in instructional systems. Issues concerning who should direct instructional systems development aside, research on change agents and school reform (Finn, 1990; Frymier, 1987; Goodlad, 1990; Grady, 1988; McDonald, 1989; Pearlman, 1988; Timar & Kirp, 1989) provides compelling evidence that innovations have a high degree of failure when teachers do no believe they are significantly involved in and empowered by the innovation (Maeroff, 1988).

To consider the evolution of these and other perspectives regarding teachers and educational technology, we conducted an initial review of literature in anthropology, sociology and education. This review was used to derive a series of questions for reviewing 847 articles that appeared in the major research journals of the Association of Educational Communication and Technology (AECT) from 1953 to 1993. Our intent is to uncover trends and insights for directing research and development agendas that engage teachers in the use and design of educational technology.

Cultural Awareness

In 1952 Edward Spicer explained "It has become something of a commonplace to say 'People resist change' but a generalization that has more facts to support it is the opposite 'People accept change'...." However, sociologists also note that once a group rejects innovation the chance that the group will reject further innovation increases markedly (Rogers, 1983). What can be done to limit the risks of introducing technological innovation to teachers? Many anthropologists (Spicer, 1952; Wolcott, 1981) believe that the answers can be found by carefully considering the culture of the receiving group before introducing technological innovation. Wolcott (1981) identified four reasons groups reject technological change:

1. Change appears to threaten basic securities.
2. The group does not understand the proposed technology.
3. The group perceive the innovators as outsiders and therefore resist the technology.
4. People do not vary customary behavior or tools unless they have a need for change.

Innovation rejection is not the only risk in introducing technological innovation to a group. An anthropological study of Yir Yoront, a tribe of Australian aborigines, exemplifies the negative impact that introducing technology can have on the receiving group's culture

(Blumenfeld, Hirschbuhl & Al-Rubaiy, 1979). In the Yir Yoront's isolated stone-age culture, the stone ax was a "privileged" symbol of authority used in elaborated trading practices (Sharp, 1952). When missionaries decided to widely distribute more effective steel axes, they seriously disrupted the social structure and traditions of the tribe. Attendance at traditional meetings and social functions decreased. Trade practices and rituals became chaotic and The Yir Yoront myths and beliefs were compromised. Because of the missionaries' haphazard innovation introduction, the Yir Yoront loss a significant part of their cultural identity and received no long-term benefits.

As defined in this article, "empowerment through technological innovation" is when a group of people addresses needs or receives benefits that cannot be met by current strategies or technology. Furthermore, a technology is "empowering" only when it satisfies this criteria without imposing significant negative effects on the group's culture. The above literature was used in deriving four categories to consider when introducing technological change into a culture. Innovators are more likely to be successful (or empowering) when they: 1) recognize the group's unique identity; 2) assist the group in understanding and using the technology; 3) empathize with the group environmental and cultural needs, and 4) empower the group to meet those needs.

Article Review Method

A total of 847 articles appearing in the professional journals of the AECT were reviewed, including: Audio Visual Communications Review (1953 - 1963), AV Communications Review (1964 - 1977), Educational Communications and Technology Journal (1978 - 1988) and Educational Technology Research and Development (1989-1993). After identifying the four basic factors for introducing change into a culture, we conducted a further review of education literature to derive the criteria for evaluating the AECT articles. This review included educational technology studies that were used to construct 13 items for applying the basic anthropological concepts specifically to the empowerment of teachers through educational technology. Three items were developed as indicators for each of the four factors. A question, concerning teachers being directed by instructional system design professionals, was also added in response to and extended dialog in AECT literature (Clemente & Martin, 1990; Heinich, 1984, 1985; Martin & Clemente, 1990; Shrock & Higgins, 1990).

A Hypercard data base was developed that included the journal name, title, volume, number, authors and year of publication. Each article appeared on a separate card. The thirteen items were listed as buttons. If an article included information that corresponded to one of the thirteen items, the appropriate button was clicked and the association between item and article was automatically recorded. Below are the thirteen items used to evaluate the articles. Each listing shows the question asked, the rationale for including the item, the criteria used, and an example for satisfying the criteria.

Recognition

The following questions concern how educational technologists can recognize teachers as primary users of educational technology and therefore cause teacher to feel more comfortable using the technological innovations.

1: Describes the teacher's role?

Rationale: Anthropologists (Wolcott 1981; Spicer, 1952) note that a receiving group rejects a technology when it threatens the group's basic securities. Similarly, Educational

Technologists (Heinich, 1984) found that some teachers will go so far as to sabotage educational resources that they find threatening. Consequently, teachers may find educational resources less threatening, if the developers recognize teachers as the receiving group of the technology.
Criteria: This item was checked if the article suggested (even briefly) teacher involvement with the technology.
Example: The article mentions teachers as users or observers of educational technology.

2: Explains to teachers how to use technology?

Rationale: Anthropologists state that a group of people feels less threatened by a technology if the use of a technology is communicated well (Blumenfeld, Hirschbuhl & Al-Rubaiy, 1979). Correspondingly, teachers may not accept technology, if they do not understand its use.
Criteria: This item was checked if teachers' use of the technology was clearly defined.
Example: The article describes how the technology is used by teachers as a record-keeping device, student evaluation, content presentation and/or lesson developing tool.

3: Explains how the technology will make the teacher more effective?

Rationale: Anthropologists found that a group feels acknowledged by a technologist, if he/she explains how the technology will make them more effective in their livelihoods (Rogers, 1983; Spicer 1952). Instructional designers also must describe how technology will make teachers more effective (Clemente & Martin, 1990).
Criteria: This item was checked if the article explained how teachers use of technology would make them better teachers.
Example: The article describes why using an instructional design could help a teacher to teach to specific curriculum objectives. The article explains several advantages of using an overhead projector in the classroom.

Empathy

As explained in both educational (Goodlad, 1990; Grady, 1988; McDonald, 1989) and anthropological (Wolcott, 1981; Blumenfeld, Hirschbuhl & Al-Rubaiy, 1979) literature, innovators are perceived as "outsiders" unless they demonstrate an understanding or "empathy for" the group's culture. As long as the group perceives the technologist as an outsider, the group will reject the technology. In like manner, teachers reject educational technology as an outsider's intervention, if the technologist does not appear to empathize with the "real-life" culture and environment of the teacher.

4: Describes how available the technology is for teachers?

Rationale: When change agents attempt to introduce a technology that is not currently available to a group, they also risk appearing as outsiders (Blumenfeld, Hirschbul, & Al-Rubaly, 1979; McDonald, 1989). This perceived lack of understanding and inconvenience can cause the receiving group to reject the technology. For example, teachers rejected early educational television programming because good programs were not available during convenient class times (Cuban, 1984).
Criteria: This item was checked if the article described clearly where and how teachers can gain access to the technology
Example: The article describes how a teacher or administrator can obtain a book on a

particular instructional design. The author explains how many overhead projectors are currently available in most school districts.

5: Considers the teacher's workload?

Rationale: Anthropologists suggest that innovators will be considered outsiders, if they do not consider the environmental and cultural demands on the group (Wolcott, 1981). Teachers similarly are often on tight schedules that limit their ability to use technology (Bichelmeyer, 1992). Educational technology strategies are likely to be more accepted if educational techn-ologists make an effort to accommodate or lessen the teacher's workload.
Criteria: This item was checked if the article mentioned the daily tasks demanded by teachers and the time frame in which they have to complete these tasks.
Example: The article describes how lesson plans are demanded by most district and an instructional design is a simple method of satisfying these districts' demands. The author mentions something about accommodating class schedule. For example, the average classroom size in 1992 was more than 26 students and an overhead projector can present information easily to a group of 30 or more.

6: Describes how educational technology improves teacher/ student interactions?

Rationale: For most groups, social interactions and interconnectedness are the customs of their culture. If the innovation is perceived as threatening to a valued custom, the innovation will not be used (Spicer 1952). Likewise, one of the teacher's most valued customs is the one-on-one interaction with students. Teachers cite the disruption to student-teacher interaction as a reason for rejecting some instructional system design implementations (Martin & Clemente, 1990).
Criteria: This item was checked if the article explained how technology may reduce, increase or change the interac-tions between teachers and students.
Example: The author describes how the instructional design elicits students to ask more questions of a teacher. The article explains how the overhead projector increases students to be more reflective of their questions to the teacher.

Assistance

Anthropologists state a group rejects a technology if it does not assist them in performing valued task in their current environment. (Blumenfeld, Hirschbul, & Al-Rubaly, 1979; Rogers 1983; Spicer 1952). This assistance comes only after the group understands the technology thoroughly; the technologist considers the strategies the technology is replacing; and explains how the technology will be managed.

7: Explains teacher or pre-teacher training procedures?

Rationale: Anthropologists find that groups ignore technology, if it is not proven to assist the group is some manner. If a group contains a thorough understanding of the technology, they are more likely to recognize its helpfulness (Blumenfeld, Hirschbul & Al-Rubaly, 1979; Rogers 1983; Spicer 1952). Training is one of most effective means of guaranteeing this understanding. Teachers are less likely to adopt innovation if they believe that the training is inadequate (McCombs, 1985).
Criteria: This item was checked if the article described the process for conducting training in the use and benefits of the technology.
Example: The author mentions instructional design courses that are now being offered

at teacher-education colleges. The article describes a successful workshops for training in the use of educational technology.

8: Describes the relationship to existing strategies and structures?

Rationale: In anthropology, a group ignores an innovation if the traditional methods of the group are not acknowledged and protected. In addition, change will not be accepted if advantages over traditional strategies are not proven and observable (Blumenfeld, Hirschbuhl & Al-Rubaiy, 1979 Rogers, 1983; Wolcott, 1981). Teachers will reject replacement technology, if it is not proven more helpful than the methods they are currently using (Martin & Clemente, 1990).
Criteria: This item was checked if the article described how the technology will augment current teaching practices, or describes how the technology will prove more effective than current teaching methods.
Examples: The author explains how the instructional design does not replace the control and flexibility of the teachers in directing instruction. The article explains how teachers can use an overhead projector more effectively and explains how teachers might replace some blackboard functions with an overhead projector.

9: Explains approaches for managing and organizing media?

Rationale: A technology may not be perceive as helpful if the effort involved in managing and organizing its use is unreasonable. Teachers do not want to become overburdened by the bureaucracy of instructional management (Kerr, 1989).
Criteria: This item was checked if the article described who is responsible for or how the technology will be stored, organized, maintained and/or evaluated.
Example: The author explains who should be responsible for the maintenance and repair of overhead projector or the evaluation of an instructional design.

Empowers

Many anthropologists feel that the purpose of any technology is to empower the group. Empowerment (as used here) means not only acceptance of the technology, but personalizing it so each individual in the group can modify the technology to varying situations.

10: Explains how the teachers can select, control or modify technology?

Rationale: Anthropologists believe that, especially during the early stages, user should be offered considerable control and practice in implementing technology (Rogers 1983). Teachers express that they are willing to become involved in the implementation of innovations (Aust, Allen & Bichelmeyer, 1989).
Criteria: This item was checked if the article described the procedures for a teacher to use in modifying or selecting technology to fit their personal class-room environment.
Example: The author explains how a teacher can use an overhead projector in varying degrees of classroom light. The article describes how to select an instructional design that can be used for both lesson and long-range course planning.

11. Describes strategies for administrators to support teacher use of technology?

Rationale: Anthropologists have found that individuals in a group will adopt the innovation more rapidly if the adoption power is more 'equally distributed' (Freeman, Azadi,

1983). Teachers as well, may reject a techn-ology unless control of the technology is given directly to teachers not the school administration (Cuban, 1984).
Criteria: This item was checked if the article explained how administrators can be involved in distributing the control of educational resources to teachers.
Example: The author explains how the use of educational technology can be controlled by teachers. The article describes how teachers are involved in evaluating an instructional design.

12: Describes teacher's involvement in the innovation and planning?

Rationale: Studies in anthropology (Spicer 1952; Rogers, 1983) explain that the chance for empowerment through a new technology increases if the receiving groups are closely involved in the development cycle. Teachers moreover, are resistant to reforms that rely on "outside" change agents unless they have are sufficiently involved in the reform (McDonald 1989; Sirotnik & Clark, 1988; Timar & Kirp 1989).
Criteria: This item was checked if the article described how teachers are involved directly or indirectly in the development of the technology.
Example: The author explains how the complaints of blackboard dust by teachers were considered in the innovation of overhead projectors. The article describes how an instructional design was developed by a committee consisting of secondary school teachers.

Teachers in Roles Secondary to Instructional System Design (ISD) Specialists.

13. Casts teacher as inflexible or in a secondary role?

Rationale: Studies in both educational technology and anthropology have note that many technologists blame the receiving group when a technology fails (Wolcott, 1981). Such conceptions may increase chances that future technology introductions will be rejected.
Criteria: This item was checked if the article described the teachers' function in terms of an overall plan under the direction of an instructional system designer or administrator. This item was also checked if the article described teachers as unresponsive or inflexible.
Example: The article describes the teacher as a monitor in a fully-mediated classroom. The author explains that instructional planning should be performed exclusively by professional instructional designers.

Review of AECT Journals

Analysis of the data collected from the 847 articles appearing in AECT journals was intended to reveal the relative emphasis placed on factors relating to teacher's involvement in educational technology. Hypertalk routines were developed to automatically tabulate the data entered by the reviewer. Results are shown as percent of articles that met criteria for each item. Charts were constructed using Microsoft Excel.

Limitations:

This is an exploratory investigation designed to gain general insights and refine procedures. Efforts were made to maintain objectivity in reviewing all articles. However, the review of the articles was conducted by one reviewer, and inter-rater reliability has not been established. Once inter-rater reliability is established, more involved statistical procedures including correlation across factors may be warranted.

Table 1
Percent of Articles that Address Teacher Related Issues in AECT Research Journals (1953 - 1993)

Recognition 26%
- 1: Describes the teachers role? 24
- 2: Explains to teachers how to use technology? 14
- 3: Explains how the technology will make the teacher more effective? 17

Empathy 13%
- 4: Describes how available the technology is for teachers? 4
- 5: Considers the teacher's workload? 5
- 6: Describes how educational technology improves teacher/student interactions? 12

Assistance 14%
- 7: Explains teacher or pre-teacher training procedures? 5
- 8: Describes the relationship to existing strategies and structures? 12
- 9: Explains approaches for managing and organizing media? 5

Empower 10%
- 10: Explains how the teachers can select, control or modify technology? 8
- 11: Describes how administrators can support teacher use of technology? 1
- 12: Describes teacher's involvement in the innovation and planning? 5

- 13: Casts teacher as inflexible or in a secondary role? 3

Note: 874 articles were analyzed

This table shows the percent of articles that met the criteria for each item. Factor headings (e.g. Recognition) show the percent of articles that satisfied criteria for one or all of the three items associated with that factor.

Figure 1
Teachers Recognized and Teachers as Secondary to ISD

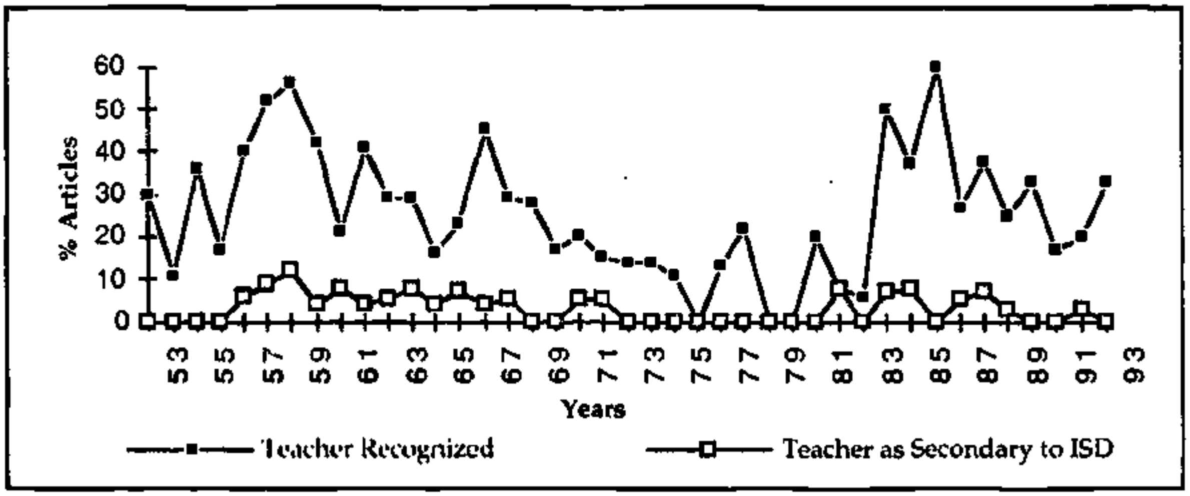

Figure 1 shows the percent of the 847 AECT articles (by year) that satisfied the criteria for the Teacher Recognition and Teacher as Secondary to ISD factors. If and article was deemed as satisfying the Teacher Recognition criteria, the reviewer must have answered yes to at least one on the following three questions: This article describes the teachers role? (and/or) This article explains to teachers how to use technology? (and/or) This article explains how the technology will make the teacher more effective? To satisfy the Teacher as Secondary to ISD criteria the reviewer must have answered yes to the question: This article casts teacher as inflexible or in a secondary role? Note that the peaks in the Teacher Recognition factor appear slightly after the peaks in the Teacher as Secondary to ISD factor.

Figure 2
Empathy for Teacher Needs

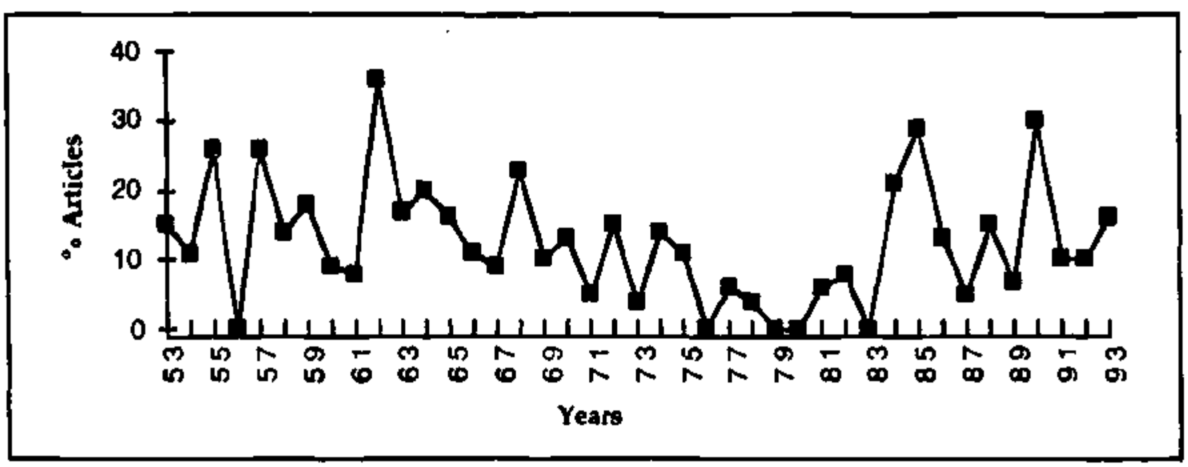

Figure 2 shows the percent of the 847 AECT articles (by year) that satisfied the criteria for the Teacher Empathy factor. If an article was deemed to meet this criteria, the reviewer had answered yes to at least one on the following three questions: This article describes how available the technology is for teachers? (and/or) This article considers the teacher's workload? (and/or) This article describes how educational technology can improve teacher/student interactions?

Figure 3
Describes Teacher Assistance

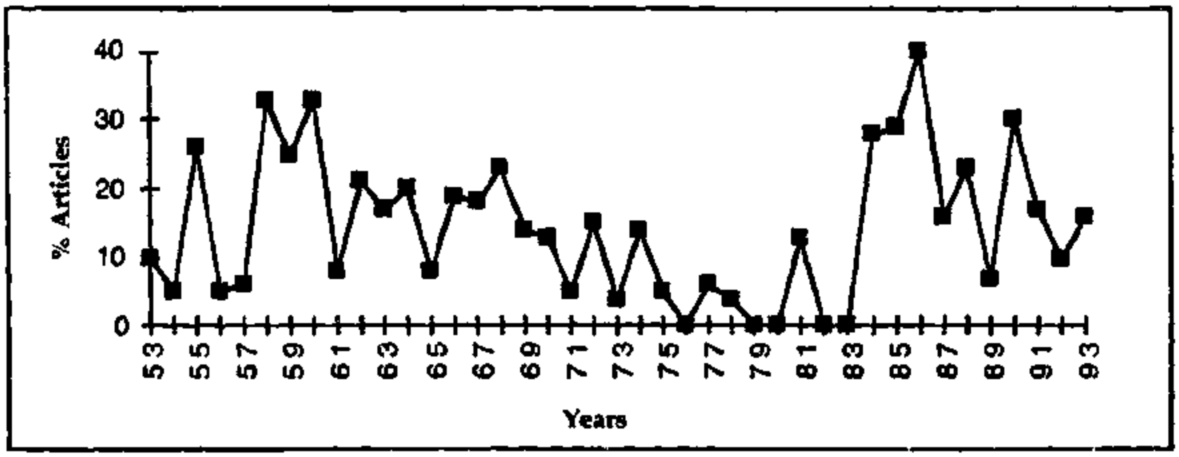

Figure 3 shows the percent of the 847 AECT articles (by year) that satisfied the criteria for the Teacher Assistance factor. If an article was deemed to meet this criteria, the reviewer had answered yes to at least one on the following three questions: This article explains teacher or pre-teacher training procedures? (and/or) This article describes the relationship to existing strategies and structures? (and/or) Explains approaches for managing and organizing media?

Figure 4
Teacher Empowerment

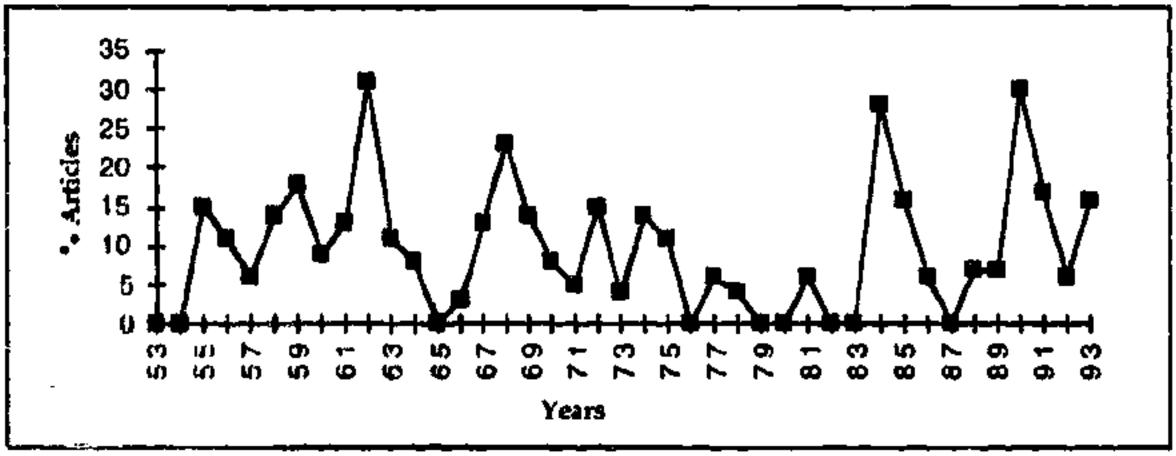

Figure 4 shows the percent of the 847 AECT articles (by year) that satisfied the criteria for the Teacher Empowerment factor. If an article was deemed to meet this criteria, the reviewer had answered yes to at least one on the following three questions: This article explains how the teachers can select, control or modify technology? (and/or) This article describes how administrators can support teacher use of technology? (and/or) This article describes teacher's involvement in the innovation and planning?

Discussion

Much of the literature in the AECT research journals focuses on the effects of mediating learning with technology. About a quarter of the articles (24%) do at least recognize the teachers' roles (see Table 1). However, the other factors concerning teachers' conditions in schools, have not received substantial attention in educational technology research and development. Only about 13% of the articles mentioned issues that demonstrate an understanding of the teachers' working conditions in schools. Fewer than 15% provide specific explanations of how educational technology can be integrated within existing curriculum or related school structures. Finally, about 10% identified specific needs and corresponding educational technology solutions for empowering teachers.

As the Yir Yoront discovered, the desirability of technology is relative to cultural values. Teachers are the first-line receivers of educational technology and this review indicates that educational technologist may not be paying enough attention to the teachers' culture. One risk is that educational technologist will appear as outsiders who, even with superior technology, will be summarily ignored by many teachers. A more consequential concern is that zealous efforts to widely demonstrate educational technologies without considering cultural implications, may be disruptive of both the culture within schools and society at large.

The review of the AECT articles also reveals patterns in the amount of attention paid to teacher issues. Figures 1- 4 show somewhat tandem cycles with the four teacher factors (recognition, empathy, assistance and empowerment) peaking in the early 1960s and mid 1980s. We do not have a single compelling explanation for these cycles. Note in Figure 1 that the peaks in the percent of articles that cast teachers as inflexible or in secondary roles appear just ahead of the peaks in teacher recognition. One explanation is that the peaks and valleys represent reaction to specific events that question sensitive issues related to either teachers or technology. For example, Robert Heinich published and article in 1984 explaining that teachers could be considered as components in ISD. Several authors (Clemente & Martin, 1990; Heinich, 1984, 1985; Martin & Clemente, 1990; Shrock & Higgins, 1990) followed with articles that cited Heinich and often presented contrary positions. Possibly, Heinich's article spawned this extended debate but there may have been any number of reasons for the rise in attention paid to teacher issues. The cycles might be a reaction to national agendas such as the reform movement, the Holmes group movement, federally funded initiatives or po· ·bly they reflect the preferences of the editorial boards. More in depth reviews of the lite· ·ure are needed to better understand and interpret these cycles.

Recommendations

The most far-reaching means for addressing teacher issues in educational technology may be a comprehensive plan for encouraging research authors to relate findings to the needs of teachers. This would not require extensive changes in the research designs or compromises in essential basic research. Instead, authors would more explicitly describe how their existing research relates either directly to the needs of teachers or how the research could lead to better understanding of teaching and learning. Of course, AECT has other literature (e.g., Tech Trends) that is intended to describe advances in and practical uses of educational technology. However, the notion that there are different "levels" of literature for different levels of audiences promote a counter productive isolationist image that deters teacher involvement. A more reasoned approach is to provide different forms of literature with different purposes that continue to maintain broad audience appeal.

Much of the current research and development concerning educational technology focuses on strategies for perfecting the interaction between learners and machines. Research addressing such issues as feedback, graphics, hypertext, integrated learning systems, cognitive styles, learner control and pacing, is needed to assist designers in refining instruction. However, such research should not overshadow questions concerning teacher empowerment with educational technology. Do teachers consider their culture as different and separate from the educational technologists -- what are the differences? How can machines improve the interaction between students and teachers? Is educational technology meeting the teachers' real-world needs for curricula and other support? Which teaching activities are best handled by technology and which are best left to teachers? How can administrators best serve to empower teacher with educational technology?

Developers of educational technology can address teacher empowerment by providing greater teacher control of the characteristics of educational resources. For example, computer instructional programs can provide overriding teacher control of feature such as: level of difficulty, amount of remediation, time, pacing, graphics and audio. Teachers (possibly in consultation with students) could then determine the most appropriate combination according to their understanding of the learner, the curriculum and current classroom conditions. In this way the resource is optimized through the teachers unique skills in mediating the complex learning situations and the mentor role of the teacher is maintained. Developers should also address teacher needs by providing guides that explain such concerns as the process skills addressed, required pre-requisites, intended grade level and consistency with curricula .

Educational technology can empower teachers by incorporating social enrichment activities within instructional systems. The · ·sper Woodbury series developed at Vanderbilt University provides an example of this form of empowerment. Several of the Jasper Woodbury segments begin by using video to establish a problem solving scenario and then encourage students to break into groups for data analysis and forming hypotheses. During these group discussions the students have an opportunity to interact with peers while the teacher's role in moderating the group and directing learning is maintained.

Advances in computer networks can also be used to address teacher empowerment through improved communications among teachers and community publishing of information services. Computer and networking technologies are advancing rapidly as government officials and private industry seek to establish a National Information Infrastructure (NII). This is a critical period for educators to become involved in demonstrating ways the NII can empower teachers and learners. One such strategy is through the development of national conferencing capabilities for a variety of teaching specialties. Using currently available technology this would involve establishing special interest bulletin boards and providing broad accessibility to schools so that teachers that share common goals but are separated by geographical and scheduling barriers can easily exchange ideas for improving teaching. As the networking and multi-media technologies advance, teachers will be able to demonstrate and monitor the on-going work of exemplary teaching.

Another example of network technology empowering teachers is the community publishing of network-based educational resources (see for example; Aust, 1993, 1992). Most teachers have a repertoire of successful teaching skills but neither the time or support for publishing extended collections. Network information services are capable of automating the processes of contributing and organizing information so a teacher can contribute a single resource (lesson plan, lab activity or field trip description) that becomes part of a large resource data base that may eventually be easily searched from any school in the nation. In this way, the teacher will contribute to libraries of educational resources while becoming vested in the goal of empowering all teachers.

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Title:

Publishing and Editing an Electronic Journal on the Internet

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Abstract

Publication is at the heart of scholarship. Traditionally, print media has been perhaps the most important vehicle for communicating research results and scholarly thought. Experimentation in publishing electronic journals (ejournals) began in the past two decades, both in North American and Europe. This paper explores, from a scholarship perspective, the rationale for publishing electronic journals. We will examine why scholars publish, the advantages and disadvantages of various media, and the issues of credibility, accessibility, and permanence within an ever-changing technical environment. *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century* (IPCT-J) will be used as an example of a scholarly, peer-reviewed, electronic journal.

Publishers of electronic journals need to be first and foremost concerned with that which every other publisher of scholarly journals is--credibility, access, and permanence--all within an every changing technical environment.

INTRODUCTION

Publication is at the heart of scholarship (Cohen, 1993): part and parcel of academic life and function. Traditionally, print media has been perhaps the most important vehicle for communicating research results and scholarly thought.

Electronic Publishing

Experimentation in publishing electronic journals (ejournals) began in the past two decades, both in North American and Europe. While there have been many models of ejournals over the years, it has only been recently that more than a handful have survived on non-commercial networks (e.g., other than networks such as DIALOG; Prodigy)[2]. In early 1993, there were probably less than three dozen such journals in the humanities that are strictly non-commercial and electronic, and perhaps double that, if the hard sciences are included. Some ejournal publishers are non-profit, university publishers. However, hardly any of the electronic journals (ejournals) are peer refereed. As the number of ejournals increases, there is a need for understanding--for development and research concerning this new vehicle for the dissemination of scholarly work.

This paper will explore, from a scholarship perspective, the rationale for publishing electronic journals. We will examine why scholars publish, the advantages and disadvantages of various media, and the issues of credibility, accessibility, and permanence. *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century* (IPCT-J) will be used as an example of a scholarly, peer-reviewed, electronic journal.

Testing the Waters

In 1992, promoting the use of technology in the classroom was one of the goals of the Center for Teaching and Technology at Georgetown University's Academic Computer Center. One avenue towards this goal was to bring scholars from around the world together to discuss ideas, to tap their expertise, and to communicate research results so that everyone can learn.

Eventually, I thought a scholarly journal might be one way to accomplish a part of this goal. Since the Center for Teaching and Technology is part of the Academic Computer Center, an journal in electronic form seemed a natural. Still, before launching a journal in any format, many decisions needed to be made. In order to gather some marketing data, I formed the *Interpersonal Computing and Technology* Discussion list (IPCT-L), hoping that the list would be valuable in determining if a market existed for a new journal, to find potential authors and subscribers, and to locate potential editors and reviewers.

I intended that IPCT-L should focus on the uses of instructional technology, but, from the first, the list attracted a number of communications scholars interested in computer-mediated communication, amongst whom was Dr. Gerry Phillips, Professor Emeritus of Speech Communication, The Pennsylvania State University.

Phillips and I entered into early discussions concerning the proposed journal. In late summer of 1992 we decided to proceed with the journal. Phillips offered his considerable experience and editorial services as Editor-in-Chief and we asked Mauri Collins, a doctoral student in Instructional Systems at Penn State, (and the other IPCT-L listowner and moderator), to assume the responsibilities of Managing Editor, and join is to form the first editorial board, with Mark Evangelista providing technical support at Georgetown, and using computer time and storage space provided by both the Academic Computer Center and Information Systems at Georgetown and the Center for Academic Computing at Penn State.

SCHOLARSHIP

Why do scholars publish?

It is important to understand something about scholarship before going too much further into the details of publishing and editing an electronic journal. Scholars basically author for two reasons, the first being, to communicate their research and ideas to others. As a by-product of the peer recognition from this, promotion, tenure and academic or professional honors are derived from their contributions to the field (Smith, 1991).

The Life-Cycle of Scholarly Thought

How does scholarship progress? Where do ideas come from? How do they move from ideas to published articles? Researchers and scholars generate ideas through such activities as observing, discussing, and reflecting. After this brainstorming or formation step, the person often drafts the idea or hypothesis and at some point decides to circulate a draft to colleagues. This can be done through conference presentations or the mail, fax or electronically in the prepublication stage. If the material is favorably received, the author may then submit the work to a journal for peer review. Passing muster here results in the article being published. Some typical postpublication steps include dissemination to individuals and libraries, indexing, and abstracting. Once other scholars react to the work with their feedback, new ideas are shaped or new research hypotheses generated and the cycle continues.

[INSERT FIGURE "SCHOLARSHIP" ABOUT HERE]
(See Appendix A for figure "Scholarship)

What is wrong with this model?

I don't think there is anything wrong with the model per se. Yet there are factors in the current implementation of the print journal model that, when not adequately addressed, result in inefficiencies and ineffectiveness, posing a threat to the scholarly process as we move toward the 21st century.

Consider, for example, library acquisitions. With books and journals going out of print quickly, and interlibrary loan often not meeting the needs of scholars, libraries are inclined to acquire as many printed materials as they can afford. In business this has been described as the "just-in-case" model of inventory. Acquisitions are made just in case someone needs them (quickly). Compare this to a just-in-time model where journal articles are available online to scholars at the library or at their own workstation only when and if they are needed.

Lack of Timely Feedback

Part of the scholarship cycle involves timely feedback to the author. If one is working on AIDS research, any delay in moving scholarly endeavors forward could mean life or death--literally. Yet delayed feedback to a historian seems much less time sensitive. As an example of the typical time lag in print journals lets look at the article I wrote in 1990, informally circulated to a few people during the beginning of 1991. I submitted it to a educational technology journal in October 1991. It was peer-reviewed and accepted for publication in October 1992. Finally it was printed and distributed late in 1993--2.5 or 3 years after I wrote it. I may now be able to remember the title, but even I can't remember the main points.

Formal publication doesn't complete the cycle. Readers need to receive a copy of the article, either through the library or individually. Then they have to respond. If the reader chooses to comment to me directly the response time may be relatively short. However, should he or she choose to send their response for peer review to the journal, or even as a a Letter to the Editor, it might take from one to three years for that feedback to reach me.

This lack of interactivity in the print process is becoming more and more a fatal flaw in the scholarship cycle. The original author's thinking has moved on from what was being articulated those many years previously. Regardless of whether the subject matter was history or biology or literature, had there been more timely feedback, new ideas that are now lost could have been generated (Harnad, 1991). This is why scholars, especially in the natural sciences, mathematics and technology, do not rely on print journals to keep current in their field.

Costs

The cost of scholarly journals is rising at a rate much greater than the rate of inflation or of libraries' budgets and funding sources. There is little by way of cost savings when moving from print to electronic form regarding editing or peer review. It should be noted that the cost of reviewing, editing, and even the production costs associated with electronic journals are often "hidden" because of the volunteer or subsidized labor of editors, reviewers and publishers. I do think there are some significant cost savings involved in ejournal production, and especially delivery (e.g., no postage costs; no paper and printing costs to the publisher). These costs savings can be passed to the subscribers.

Limits on the Size of Print Journals

There are many economic factors that put pressure on print journals to limit the number of pages published, causing editors and publishers to lower the amount of scholarly work accepted. Additionally, there are tendencies to reject such things as research showing no significant differences, and feedback from readers such as Letters to the Editor lose their places to articles reporting original research results.

ADVANTAGES OF ELECTRONIC JOURNALS

There are the obvious advantages such as the lower costs for electronic production and distribution. Secondly, the acceptance rate for articles is not limited by economic factors (this assumes there is a pool of scholarly work that was rejected for economic reasons and not because of lower quality than that accepted for the paper journal). Some other significant factors are discussed below.

Increased Speed

There is no question that the production and distribution steps during publication can be sped up by moving to epublishing. Regarding the peer review process, there can be gains in speed, but not if the reviewers let the electronic copies sit on their disk, as is often the case with papers for review sitting on their desks. But it is at the feedback link in postpublication that most benefit could be derived from epublications. Metz (1991) points out that a community of scholars can be more dynamic and interactive in their commentary to authors in a way that is currently impossible with paper journals.

Collaboration

Much of the idea above regarding speed dovetails with the notion of building knowledge collaboratively. Electronic media allows more interactivity among scholars within and between disciplines. The potential exists not only for more collaborative, international effort, but also for dissemination and scholarship among authors in different fields of study. The electronic network is able to provide, as Harnad (1992) points out, cross-disciplinary review and discussion of research.

Different Models

Morris (1989) characterizes the impact of technology in three stages: First, technology is used to automate that which has been done. Secondly, tasks change because we can do things we couldn't do before. Finally, society itself changes. Langenberg (1989) tells us that computers and telecommunications are merging to form information technology. That is, the power of computers to store and manipulate data, along with the speed and convenience afforded by telecommunications to transfer data, equals an unprecedented ability to handle information using technology.

So, what impact will this emerging information technology have upon society--in this case on scholarly society? King (1991) states:

> Just as radio offered possibilities unimagined by the newspaperman, and just as television offered possibilities unimagined by the radioman, so the electronic network medium will provide opportunities for accessing and using information which so far have not been imagined by the print mind. (p. 6)

While much of what we have been doing in epublishing mimics traditional printed journals, there are those persons who are anxious to realize new and different models in epublishing. *IPCT Journal* pretty much by design, uses the same model as print journals. However, there are those, especially in the sciences, who are working with ejournals which clearly publish new images, such as 3-dimensional models, that could not be done with print technology. As sound and animation are more commonly used, many exciting things will appear in journals that were impossible to do before epublishing. Similarly, software will allow sophisticated searching strategies and linking of current issues to back issues or to other journals--in ways impossible with print technology. Finally, there are authors such as Harnad (1990) who see "scholarly skywriting" using electronic media as significantly changing the scholarly society.

One of the keys to many of these advantages is the fact that epublishing is free from time and space limitations. Distributions and correspondence throughout the scholarship cycle are not limited by time or geography. Review, distribution, feedback and submissions can take place in an instant from around the corner or across the world.

PROBLEMS WITH EJOURNALS

While ejournals facilitate communications among scholars, they are not a panacea. However, I believe many of the problems ejournals face are overstated and overvalued. Mention is often made of the increased possibilities for plagiarism, or the question raised of the credibility of a scholarly journal that vies for space with electronic junk mail or sometimes does not even have enough structure to have an ISSN.

There are still some issues that are significant and which will not easily be overcome. Some are faced by any (new) journal regardless of the media in which it is published; other problems are unique to the electronic medium. For instance, there are other activities which fulfill scholars' need to interact (quickly) with colleagues. While it is expensive to travel, conventions, seminars, workshops, and newsletters all provide scholars with opportunities to respond to one anothers' work, and to set forth their own research and ideas.

Another example has to do with the downside to one of the advantages to electronic publishing (epublishing) mentioned above. While publishers and editors are not limited in the number of pages they can published due to cost, a higher acceptance rate often tends to give the mistaken perception of lower prestige to the ejournal.

But as many authors note (e.g., Okerson, 1991; Harnad, 1990; Amiran et al., 1991; Shamp, 1992; Bailey, 1992; Manoff, 1992), perhaps the biggest problems faced by ejournals are those faced by any (new) journal. John Franks (1993) speaks of the primary functions of publishers as credentialing, archiving and marketing. I prefer to think of my function as publisher as ensuring credibility, accessibility, and permanence (Harrison, 1991). Further, all these functions are within a constantly changing technical environment.

Credibility

Without scholars' submissions or without readers, there is no journal. The higher the credibility of the journal, the higher the quality of submissions received. There simply may not be enough peer interaction surrounding any new journal to generate the authorship and readerships necessary. Additionally, an ejournal is often not considered an official university activity. This often lessens the perception of credibility in scholars' minds. But the biggest threat to an ejournal's credibility is that most promotion and tenure committees do not count an article in ejournals equally (or at all!) compared to that same article in a print journal.

There are at least two ways to work toward overcoming problems with credibility. The quality control aspect of journals is derived from the peer-review process. An absolute must therefore, in building a journal's credibility is to have a top notch editorial board and the best referees. *IPCT Journal* has a world-class group of editors and associate editors (their main function is reviewing submissions) and submitted articles are held to the highest standards of peer review.

The problem of promotion and tenure committees not giving authors credit for work done in ejournals may have to wait until administrators and senior faculty on promotion and tenure committees retire. As the new cohort of leaders move into these positions, they may be more familiar with ejournals and their merits.

Accessibility

It doesn't matter if one has the best scholarly journal in the world if no one knows that it exits or how to access it. Again, the cost and economics of epublishing could change. The networked-based ejournals have been able to gain a foothold because networks like Bitnet and the Internet are heavily subsidized. If these networks lose their subsidies and become commercialized, the economies may change drastically and seriously affect the access by users to ejournals (Bailey, 1992).

Potential subscribers often have major technical difficulties with equipment, or getting training and other information to access the internet, let alone in finding ejournals. Secondly, users often need training on the internet resources (the electronic highway is *there*, but not everyone knows how to use it). Even if the potential subscriber has the equipment, and the knowledge to use the system, finding out about a particular journal of interest, or even if one exists, is still a daunting task.

Even the standards for citation of articles published by ejournals are in their infancy. While some authorities (Tuttle, 1991) see citing ejournals as just like any other publication, others, including *IPCT Journal's* Managing Editor, suggest that information needs to be included in the citation regarding a document's primary archive site.

Another problem ejournals have is that very few are abstracted or indexed through common services. To a large extent, scholars' awareness of a particular article germane to their own interests and work is dependent upon searching for an abstract in standard sources. Until there is a critical mass of significant ejournals (probably meaning sufficient demand from customers), indexers and abstraction services are unlikely to include ejournals.

The publisher and editorial board spend a good deal of time discussing copyright. From a scholar's perspective, communicating their ideas and research findings to the largest audience possible is one of their chief goals (as long as the proper attribution is given to their work). Yet publishers who market and distribute print journals have a more limited and limiting concept of "audience" as those who will pay for subscriptions. Since scholars almost always transfer copyright to the publisher before publication, a conflict of purposes arises between the commercial goal of the publisher and the communications purpose of the scholar.

Ejournals, for the most part, are more aligned with the scholar's point of view. To the scholar, access to ideas supersedes ownership of ideas (Metz, 1991). Most ejournals, including *IPCT Journal*, ask authors only for first publishing rights rather than exclusive rights. *IPCT Journal* allows authors to retain control over subsequent individual use of their work, as long as mention is made in reprints that the article first appeared in *IPCT Journal*. *IPCT Journal* retains copyright to the compilation, and can grant to libraries, etc. the rights to use the journal in its entirety.

Another topic that the editors and publisher discussed at length was the distribution format. There are many models that ejournals use. Some ejournals distribute each article as soon as it has been finally accepted. Some require the journal subscriber to be a member of a related discussion list. *IPCT Journal* started that way but opened a separate "journal only" list--so that subscribers such as libraries could receive the journal's table of contents without the conversation generated on the discussion list. Others send out a group of articles, including a table of contents and the full text. At *IPCT Journal*, we have chosen to send out a Table of Contents (see Appendix 1), with instructions on how to retrieve the full text for each article via Listserv, gopher or FTP. Our primary motivation for this decision was that scholars read articles, not journals. Other considerations include the size limitations on some email accounts. IPCT has over 1500 subscribers from 42 countries in February, 1994. Some subscribers, especially in countries outside North America, have severe limitations regarding input to their email account. Other subscribers are on commercial networks (e.g., Prodigy; CompuServe) and are charged for each piece of mail they receive (depending more or less also on the length of each piece of mail).

Some ejournals will also mail out paper copies of each issue or of all articles in a year, and some disseminate via CD-ROM, floppy disk and fax. Each has their unique advantages and disadvantages, and many would work for libraries and individuals not on the internet. *IPCT Journal* has been distributed only via the internet. Requests for other forms of distribution will be decided upon on a case by case basis.

While we can discuss gophers and FTP and Listserv and World Wide Web, all of which are important to access, the biggest effort to overcome the problem of accessibility is in our efforts to have ejournals abstracted through common sources. While it is important that persons in the internet have access to ejournals, it is even more important that all scholars know of the literature being built and the research being done, where it is stored and how to retrieve it (even if just from the library or other workstation).

One way to find out about ejournals is to subscribe to the related discussion lists. For instance, if you are interested or working in distance education, there are many discussion lists in that field. Subscribing to those electronic conferences is one way to find out about ejournals in that discipline (e.g., *The Online Journal of Distance Education*). In the case of *IPCT Journal*, it was conceived on the IPCT-L discussion list and is regularly mentioned there.

Finally, the acceptance and accessibility of ejournals will greatly improve when scholars are able to search for them from their workstation, in an easy and reliable way.

Permanence

Authors are extremely concerned, and rightly so, with the ephemeral and transitory perception of electronic text. No scholar wants to place his or her work in a journal that is destined to disappear or die. Ejournals are no exception--in fact, if pasthistory is any indication, ejournals do not have a good track record with regard to permanence.

Whether an ejournal ceases publication or not, their archives location is often problematic. This is one area where libraries can offer a great service by taking over the archiving of ejournals from computer centers. The mission of computer centers is clearly not to preserve and maintain scholarship, whereas a case could be made that this is a function of (some) libraries (Bailey, 1992). There may be a consortium of libraries or publishers that emerge over the next couple years to take on this role, too.

Technical Aspects

It doesn't matter if you publish the best journal in the world if readers find it too hard to read. Ease of readability in this media has a significant bearing on the format in which journals are published, (e.g., PostScript, LaTeX, SGML). *IPCT Journal* is published only in ASCII text. This limits the graphics, tables, half-tones, mathematical and scientific notations that can be used within its articles. That works fine for now for the disciplines (the humanities) which are the source of most articles that are accepted for *IPCT Journal*. But it would not work within many scientific or technical disciplines.

Additionally, there are issues such as increasing file size across the Internet and the limited email account space for some users, that cause network performance problems. In this formative period, there is a general lack of user-friendly, "reader" software and lack of sophisticated browsing capabilities.

Some scholars argue (Metz, 1991), that the fluid and changeable nature of ejournals is one of their most powerful assets. The ability to alter and modify the work based on interaction and feedback to the author is seen as a real advantage. But this advantage also creates a concern for the security of ejournal text. While we have an "official" copy of *IPCT Journal* issues on the gopher at GUVM, once distributed, there is no way to know whether versions of the journal's articles that have been unofficially modified show up elsewhere.

CONCLUSIONS

Even if ejournals are less expensive, easier to access, or save time, this is not going to allow ejournals to compete with print journals if the content of the ejournal is not perceived to be of the highest quality (Willis, 1991). Having a world-class group of editors and reviewers, along with the highest standards for peer review, are necessary ingredients for the credibility of any journal.

Scholars seek to communicate with their peers. Ejournals are especially efficient at this--provided most of those peers are fluent in using the internet. Scholars also seek to derive credit toward promotion and tenure with their scholarly activities. Ejournals currently do not fare as well in this regard. Publishers and editors need to pay particular attention to organizational acceptance as a critical factor in the success of electronic scholarly publishing.

IPCT Journal strives to build its credibility, permanence, and accessibility in much the same way a new print journal does. This is done within a technical environment that poses new challenges, yet offers vast opportunities. Still, the functions of journal publishing and editing remain the same in many significant ways. It is the earnest desire of the publisher and editors of *IPCT Journal* that we contribute to scholarly communication in ways meaningful to our authors and readers.

Notes

1 Parts of this paper are modified from an article to appear later this year in the *Journal of the American Society for Information Science.*

2 I am making a distinction here between an electronic journal, which is published in only electronic form, and an online version of a (parallel) print journal (e.g., an electronic version of the *Harvard Business Review* available through an online service).

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Page 1


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1. Letter from the Publisher
2. Retrieval Instructions for Articles
3. Table of Contents and Abstracts
4. Editorial Board
5. Copyright Statement

1. Letter from the Publisher

Dear IPCT Journal Readers,

This issue of Interpersonal Computing and Technology: An Electronic Journal for the 21st Century, marks the beginning of our second year of publication. It is with a renewed sense of our moving scholarship forward that the Editors and Publisher of IPCT Journal enter this new year. I would like to say just a little about our perceptions of the challenges of publishing an electronic journal at this time in history.

First and foremost, scholarly journals need top-quality submissions. Without that, no amount of marketing or persuasion is going to cajole busy people into reading the articles. Regardless of the longevity of a journal, or the medium in which it is published, people involved with publication are constantly aware of at least three characteristics that measure their long-term viability and success: credibility, access, and permanence.

The most significant aspect of credibility comes from the integrity of the peer review process. In this regard, the

professional merits that distinguish the Editors and reviewers of a journal are perhaps the single biggest factor. IPCT Journal has a world-class and international group of editors and associate editors who have diligently reviewed submissions to the highest standards.

It is my belief that the publishers of electronic journals (ejournals), need to do everything possible in the areas of ensuring access and permanence. With libraries, computer and technology facilities, and various consortia all working together with ejournal publishers, the problems involving lack of access and permanence will be solved sometime in the future. Until then, ejournal publishers do what they can to increase access to their journals, and to lessen fears authors have regarding the non-permanence of ejournals.

At one level, it is the ever changing technological environment that ejournals exist in that has an impact upon access and permanence. For example, earlier this month we announced the availability of IPCT Journal via gopher, (see instructions under Retrieval below). This certainly increases network users' access to the Journal. Yet it does nothing for increasing the awareness of IPCT Journal in the largest group of persons who may find the articles useful: those persons not on the Internet.

There are a couple of problems that are unique to ejournals and that hinder the establishment of their credibility. For example, ejournals are rarely abstracted and indexed on mainstream services. In seeking high quality submissions, the biggest obstacle currently is that most promotion and tenure committees don't recognize articles published in ejournals equally (or at all!) as those in a print journal. The solution to this problem may have to wait until the group of administrators and people on T&P committees changes to persons more familiar with technology and having increased understanding of ejournals.

Several traditional measures of a journal's value are not available to electronic publishers on the Internet. For instance, people ask me "how many subscribers does your journal have?" The response to even a simple question like that is confounded. Yes, I can say that there are 1514 electronic addresses on the IPCT-J@GUVM.GEORGETOWN.EDU subscription list. But a significant number of those subscribers are local NetNews servers. There is no way to tell how many times the IPCT Journal is exploded on these local servers, nor how often the Table of Contents of an issue is cross-posted to lists other than IPCT-J and IPCT-L, nor how many times an issue or individual articles are accessed via gopher or from the LISTSERV at GUVM.

Page 3

It is with sincere appreciation I thank all the Editors for a job well done this past year. We will continue to bring the best articles we can find to our readers in future issues. We again solicit your submissions. Please let me know what you find useful, what you would like to see more or less of, and how the Journal can be improved.

Starting with this issue we will be including page numbers. This should help when articles in the Journal are quoted and cited. Because we have no way of knowing how the pages will be formatted on screen (or when printed) on your particular system, we have arbitrarily set the page length at 50 lines. Each journal will be numbered from Page 1, starting from the beginning of the Table of Contents. Page numbers for all articles will appear on the Table of Contents and again in the heading of each article.

Turning to this issue of IPCT Journal, a new and noteworthy feature is a Book Review by John Laurence Miller of Seymour Papert's book, _Turning the Computer into the Children's Machine_.
I think you will find it interesting and the beginning of many useful book reviews to come in the Journal.

Regards,

Zane L. Berge, Publisher
BERGE@GUVAX.ACC.GEORGETOWN.EDU

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2. Retrieval Instructions for Articles

GOPHER
IPCT Journal, including all back issues, is available via gopher from GUVM.CCF.GEORGETOWN.EDU (or 141.161.71.1). Point your gopher to this location (port 70) and select from the top menu, "LISTSERV maintained Files and Notelogs/." Alternatively, coming in via Gopher menus, from "Other Gopher Sites" or "International Gopher Networks," follow the menus down: North America/USA/Washington D.C./Georgetown University/Information Systems/Listserv maintained Files and Notelogs. (Note: The IPCT-L Discussion List Notelogs can be found here, too.)

LISTSERV
Articles are stored as files at LISTSERV@GUVM.BITnet. To retrieve a file interactively, send the GET command appearing both before and after the article abstract to LISTSERV@GUVM.

To retrieve the article as a e-mail message add F=MAIL to your interactive message, or send an e-mail note in the following format:

To:listserv@guvm.georgetown.ed •

....

GET <FILENAME> IPCTV2N1

The GET command GET IPCTV2N1 PACKAGE will retrieve the entire issue.
Page 4

[WARNING: This will send all 7 files with a total of over 3100 lines.]

The listserv's Internet address is LISTSERV@GUVM.GEORGETOWN.EDU

Back issues of the journal are stored at LISTSERV@GUVM. To obtain a list of all available files, send the following message to LISTSERV@GUVM: INDEX IPCT-J. The name of each issue's table of contents file begins with the word "CONTENTS".

FTP

IPCT-J articles can be retreived by FTP (File Transfer Protocol. FTP to GUVM.CCF.GEORGETOWN.EDU or 141.161.71.1, logon IPCT-J, password is GUEST. All IPCT-J files are currently archived in ASCII format only.

If you experience difficulties with these instructions, please consult your local site administrator for specific instructions that may apply to your system.

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3. Contents

THE NEW BRUNSWICK NET: THE 21ST CENTURY NOW

Rory McGreal, TeleEducation New Brunswick, Canada

To retrieve this article GET MCGREAL IPCTV2N1

ABSTRACT

The New Brunswick Net: The 21st Century Now

The province of New Brunswick, Canada is implementing one big distributed electronic highway for the use of the public and private sectors in every part of the province. The strategic drivers for this action are the desire to attract high technology companies; to provide local companies with a competitive advantage; to improve government services and increase revenues while cutting costs; and to extend education, healthcare, justice and other government services. Stakeholders identified are: the provincial and federal governments, private sector companies including the telco and cable companies and local communities. New Brunswick has an advanced fully digital fiber optic infrastructure that gives it a competitive advantage over other

states and provinces, allowing it to implement 21st century technology province-wide now.

Lines: 573

Page numbers: 11-21

Page 5

To retrieve this article GET MCGREAL IPCTV2N1

AN EVALUATION OF THE ELECTRONIC CLASSROOM: THE AT&T TEACHING THEATRE AT THE UNIVERSITY OF MARYLAND

Kent L. Norman and Leslie E. Carter, The University of Maryland

To retrieve this article GET NORMAN IPCTV2N1

ABSTRACT

This report summarizes reactions to the AT&T Teaching Theater at the University of Maryland. The AT&T Teaching Theater is an electronic classroom outfitted with a high performance workstation at each student desk and the instructorUs podium. Networking and video switching allow for interactive communication, file sharing, distributed control, and collaborative learning experiences. In addition, large screen audio/visual displays are integrated with the system to allow for smooth transitions from one presentation to another. During the Fall Semester of 1991 six different courses were taught in the classroom. Instructors were asked to relate their best and worst experiences in the room in order determine what works, what doesnUt, and what needed to be changed. In addition to the use of the room for computing and audio/visual events, the best uses of the room included sharing of student work on the large screen monitors, collaborative note building, student polling, and collaborative problem solving. The major drawbacks had to do with the need for a more seamless flow of events, the need for pedagogical examples of how best to integrate technology and instruction, ackward and complex connectivity to out of class computer facilities, problems with computer software and hardware, and problems with room architecture.

Lines: 876

Page numbers: 22-39

To retrieve this article GET NORMAN IPCTV2N1

TEACHING LANGUAGES WITH NETNEWS

Terri Cononelos, Even Start Literacy Program, Salt Lake City, UT
and Maurizio Oliva, University of Utah

Page 6

To retrieve this article GET CONONELO IPCTV2N1
ABSTRACT

This paper describes an attempt at integrating computer network resources into language teaching. The case of Italian 401-1 taught in Spring 1992 at the University of Utah by Maurizio Oliva is discussed. In this course students improved their language skills by interacting with native speakers. The communication took place especially through postings on the Usenet newsgroup Soc.Culture.Italian, and by Email.

Lines: 499

Page numbers: 40-49

To retrieve this article GET CONONELO IPCTV2N1

TELEMATIC JOURNALS AND ORGANIZATIONAL CONTROL: INTEGRITY, AUTHORITY, AND SELF-REGULATION

David S. Stodolsky, University of Copenhagen

To retrieve this article GET STODOLSK IPCTV2N1

ABSTRACT

The peer-review journal is typically accepted as the most reliable format for information exchange in modern societies. Office automation now makes possible a reduction in delays associated with peer review. Advances in computer technology have also made possible the routine use of cryptographic procedures, including secure pseudonymous communication and secret sharing methods, that can safeguard personal integrity and improve adherence to procedural norms. These developments increase the applicability and importance of the journal as an authority structure, thereby making intra-organizational journals increasingly attractive. Such journals can also play a crucial role in combating threats to the organization exacerbated by the new information technologies. In the well functioning organization, information distribution

tends to dominate decision making, therefore telematic enhancements of this function can play an important role in organizational control.

Lines: 627

Page 7

Page numbers: 50-63

To retrieve this article GET STODOLSK IPCTV2N1

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CLINTON'S ETHOS: EXCHANGING IDEAS ON THE INTERNET

Frank Walters, Auburn University

To retrieve this article GET WALTERS IPCTV2N1

ABSTRACT

Exchanging notes on the Internet is a "great equalizer." People of all types, with all sorts of qualifications, can come together in discussions on a common ground. Presumably, this would mean we could concentrate on the message without "considering" the source. But people still keep requesting credentials and asking for qualifications, and the issue of anonymity in contributions often becomes a real issue in the arguments.

This concern about credentials and qualifications echoes loudly in current political affairs. Recent responses to President Clinton's programs have featured ad hominem attacks by various television commentators and comedians.

Bemoaning this state of affairs, Frank Walters, a network contributor to the LISTSERV discussion list, Clinton@Marist, expressed his thoughts on the elements of rhetorical credibility, equally applicable to face to face or virtual encounters.

Lines: 206

Page numbers: 64-68

To retrieve this article GET WALTERS IPCTV2N1

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BOOK REVIEW

TURNING THE COMPUTER INTO THE CHILDREN'S MACHINE

John Laurence Miller, York University, Toronto, Canada

To retrieve this article GET MILLER IPCTV2N1

Page 8

ABSTRACT

Over the last two decades, Seymour Papert has become known, not only for his pioneering work with the programming language, Logo, but also as one of the most important, and most innovative, thinkers in the entire field of education. His new book The Children's Machine represents in essence a refinement and an elaboration of ideas presented in earlier works, rather than a significant departure. The most important nev· idea, the concept of constructionism, offers an attempt to explain the role of concrete action, in connection with reflective thought, in the emergence of new forms of thought and new cognitive structures. Illustrative examples are taken from a wide range of contexts and domains of knowledge, from cooking and horticulture to cybernetics and elementary mathematics.

Lines: 322

Page numbers: 69-75

To retrieve this article GET MILLER IPCTV2N1

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4. Editorial Board

5. Copyright Statement

Contributions to IPCT-J can be submitted by electronic mail in APA style to: Gerald Phillips, Editor IPCT-J GMP3@PSUVM.PSU.EDU

Title:

Assessing Student Understanding and Learning in Constructivist Study Environments

Authors:

John B. Black
Robert McClintock
Clifford Hill

Teachers College
Columbia University

For the last couple of years, Teachers College, Columbia University and the Dalton School (an independent school in New York City) have collaborated on the Dalton Technology Project. This project aims to use networked multimedia workstations to produce an environment that supports student studying in groups using authentic materials and contexts. This approach to education constrasts sharply with the usual approach which has students working individually to passively receive knowledge from teachers and textbooks using artificial problems. The project shares many features with the developing constructivist approaches to instructional design (e.g., Jonassen, 1991; Bednar, Cunningham, Duffy and Perry, 1991; Collins, Brown and Newman, 1990; Cognition and Technology Group at Vanderbilt, 1990; Spiro, Feltovich, Jacobson and Coulson, 1991), but it differs from them in emphasizing design for ***study*** as opposed to design for instruction. Thus, we strive to create "a place for study in a world of instruction" (McClintock, 1971).

Seven Principles of Study Design

In addition to developing the particular study systems for different subject areas in the Dalton Technology Project, we have been trying to specify what the underlying design principles are for such an approach. In doing this we draw inspiration both from Cognitive Science (e.g., Brown, Collins and Duguid, 1989) and from hermeneutic interpretation theory (e.g., Palmer, 1969). From this effort, we have come up with the following seven study system design principles:

1. **Text:** Present students with particular cultural objects (events, writings, images, artifacts, scores, observations, experiments, etc.), the origin and meaning of which will confront them as obscure, a challenge to the understanding.

2. **Context:** Provide students with open-ended access to contextual materials that may help to clarify and interpret the cultural objects presented to them and provide pathways leading from the particular object to the comprehensive assemblage of pertinent materials. On the one hand, the context must be immediate, and on the other hand it should include everything.

3. **Engagement:** Situate the presentation of the text and context -- both the challenging cultural objects and their contextualizing resources -- in such a way that students will grasp strong ownership of the on-going effort to interpret the material.

4. **Cooperation:** Have students collaborate in their quest for interpretative understanding, learning to empathize with the interpretative actions of their peers.

5. **Inclusivity:** Use cogni·· ɜ apprenticeship to show students how to enlarge the scope and power of the contextual materials they bring to bear on interpreting the text, moving the interpretation toward that ideal condition in which all significant contextualizing materials have been taken into account.

6. **Abstraction:** Encourage students to bring significant contexts to bear upon multiple, different cultural objects to prepare them to transfer their interpretative skills to novel problems.

7. **Diversity:** Encourage students to situate complex cultural objects in many different significant contexts to prepare them to develop the cognitive flexibility of understanding things from many points of view.

An example program will serve to illustrate these principles, then we will discuss how to assess student understanding and learning in these kinds of study environments. In the *Archaeotype* program, students study ancient Greek and Roman history by using observations of simulated archaeological digs to construct interpretations of the history of these sites, while drawing upon a wide variety of background information. The *Archaeotype* program (implemented in Supercard on Macintosh computers), which is the earliest and most fully-developed of the Dalton Technology Project programs, presents the students with a graphic simulation of an archaeological site, then the students study the history of the site through simulated digging up of artifacts (the **text**), making various measurements of the artifacts in a simulated laboratory, and relating the objects to what is already known using a wide variety of reference materials (the **context**). The students work **cooperatively** in groups, while the teacher models how to deal with such a site then fades their involvement while coaching and supporting the students in their own study efforts (**inclusivity**). The students develop ownership of their work by developing their own interpretations of the history of the site and mustering various kinds of evidence for their conclusions (**engagement**). By arguing with the other students and studying related interpretations in the historical literature, they get a sense of other perspectives (**diversity**). By going through the process a number of times bringing each contextual background to bear on a number of differnt artifacts, the students learn and understand the general principles behind what they are doing (**abstraction**).

Assessing Student Understanding and Learning

So, what might students get from an educational experience like *Archaeotype* that they wouldn't get from a regular class, and what might they get from a regular class that they wouldn't get in *Archaeotype*? In a regular class on Greek and Roman history, the students would probably learn more facts about history (because they are devoting all their time to learning such facts) than the *Archaeotype* students would learn, but the *Archaeotype* students would probably remember the facts they do learn longer and have a greater understanding of them and historical reasoning. Thus if given an objective test of memory for Greek and Roman history facts at the end of the course, a standard class would probably do better than an *Archaeotype* class, but a year or two later the *Archaeotype* class would probably do better. More importantly, if we examined essays arguing for some historical conclusion, then we would expect the *Archaeotype* students to be much more sophisticated than the regular students (in fact, the reports from current *Archaeotype* students seem quite sophisticated in terms of language, argument structure, citations, etc.) -- and thus demonstrate a much deeper understanding of historical facts and reasoning. We are in the midst of conducting such an investgation of content learning, but do not have the results to report yet.

However, more than these particulars of the topic area for a class, an *Archaeotype*-type educational experience should teach students to examine any situation, make relevant observations and measurements, organize these materials, search out related bodies of knowledge, organize all this information and use it to draw compelling conclusions and make useful recommendations. Thus, the strongest test of student learning and understanding from *Archaeotype* would be to compare their ability to investigate and make conclusions and recommendations in an entirely different and unrelated situation to the ability of students who have not had an *Archaeotype* experience to do the same. That is what we did in the study reported here.

In the study we conducted, the students were given a booklet describing four psychology experiments examining how people remember lists of words. The students had to examine the basic obeservations, report on the results of the studies, find the patterns, devise explanations and argue for those explanations. They were also given some background readings in the psychology of memory. The Dalton students who had been through the *Archaeotype* program were compared to students from the Grace Church School (who also had some data-analysis experience from going through *The Voyage of the Mimi* program from Scholastic Publishers).

Method

Participants

The experimental group was 20 sixth-grade students who had participated in the *Archaeotype* program at the Dalton School, an independent school located on the east side of Manhattan. The control group was 20 sixth-grade students who attended the Grace Church School, an independent school also located on the east side of Manhattan.

Materials

Students in the two groups were given a ten-page document (the assignment booklet) divided into two parts. The first part described the results of four memory studies as follows:

(1) in study 1 subjects listened to 20 words spoken at the rate of one word per second and then immediately recalled them
(2) in study 2 subjects listened to the same words spoken at the rate of one word every three seconds and then immediately recalled them
(3) in study 3 subjects listened to the same words spoken at the rate of one word per second but recalled them only after performing an unrelated 30-second task
(4) in study 4 subjects listened to a different 20 words (many of which were semantically related) spoken at the rate of one word per second and then immediately recalled them.

The second part of the document provided background readings on technical concepts such as short-term memory and long-term memory. Students were asked to use these readings to interpret the results of the four studies and to present their interpretations, along with practical recommendations for improving memory, in a written report.

Procedure

Administering the Materials and Collecting Student Reports

The study was conducted in two 2-hour sessions (for a total of 4 hours) spread over two adjacent days. On the first day, the experimenter passed out the assignment booklets, the students paired up, the experimenter read the instructions on the first page of the assignment booklet, then the experimenter ran a demonstration of the kinds of memory studies described in assignment booklets. In the demonstration the experimenter read a list of 20 words then the students wrote down their recall of them and the experimenter conducted a short discussion of what the results were. This demonstration was done so that the students could see what the studies described in the assignment booklets were like. After the demonstration, the students proceeded to work on the assignment in groups of two. While doing the assignment the students were free to use any of the resources in the Dalton and Grace Church School buildings (computers, libraries, etc.) including asking the experimenter for clarification and information questions (the same experimenter conducted all sessions). At the end of the 2-hour period on the second day, the students handed in their reports and all the work they had done in folders. The experimenter then lead a half-hour discussion of the study.

Analysis of Student Reports

We devised a rubric for evaluating three dimensions of the student reports pattern recognition, argumentation, and data representation. Given the emphasis on data interpretation in the *Archaeotype* program, we accorded the most weight to the dimension of argumentation, as indicated by the following distribution of points:

(1) pattern recognition (20 points)
(2) argumentation (30 points)
(3) data representation (10 points)

In principle, students could receive a total of 60 points, though we should point out that the rubric was designed to reflect what might be described as expert responses to the task. This emphasis on high standards is in keeping with the larger movement in educational reform that is often referred to as *authentic assessment*.

Pattern Recognition. Students received 1-2 points for describing each of the following intra-study patterns:

(1) in study 1 the pattern of *last words/first words/middle words* (with *middle words* highly attentuated)
(2) in study 2 the pattern of *last words/first words/middle words* (with *middle words* more developed)
(3) in study 3 the pattern of *first words/middle words/last words*(with *last words* highly attenuated)
(4) in study 4 the pattern of *last words/words grouped in semantic categories* (with *last words* relatively attenuated)

In addition, students received 1-2 points for describing each of the following cross-study patterns that relate to number of words recalled:

(5) more words were recalled in study 2 than in study 1
(6) fewer words were recalled in study 3 than in studies 1 and 2
(7) more words were recalled in study 4 than in studies 1, 2, and 3

In effect, the number of words recalled in the studies can be ranked in the following order:
study 4 > study 2 > study 1 > study 3

Apart from these major patterns, students received 1-6 points for noticing other significant patterns (i.e., 1-2 points up to three patterns): for example, in studies 1 and 2 when middle words were recalled, they often formed associative pairs (e.g., *cup/water*); or in study 4 the most salient semantic categories were those involving fruit and animals as opposed to those involving furniture and transportation (i.e., words in these categories were recalled not only more frequently but earlier in the sequence); and within the various categories, certain words which function as prototypes, tended to be recalled first: for example, *coat* for the category of clothing and *chair* for the category of furniture.

Explanation and Argumentation. Students were expected to draw on the background readings to develop arguments supporting hypotheses about the patterns they observed in the four studies. As a consequence, arguments that drew appropriately on the background readings were awarded 1-4 points each, whereas arguments, which did not draw on the background readings, were awarded 1-2 points each. Here are local arguments that could be used in interpreting major patterns in the four studies:

(1) in study 1 short-term memory explains the fact that the last words are the first recalled
(2) in study 2 increase in time - and thus deeper processing in long-term memory - explains the fact that more words can be recalled (especially, the middle words that can be meaningfully associated)
(3) in study 3 the intervening 30-second task is used to explain not only the fact the last words are no longer recalled first (i.e., short-term memory is no longer operating) but fewer total words are recalled (i.e., long term memory is diminished as well)
(4) in study 4 the presence of semantically related words is used to explain the fact that not only are more words recalled but the sequence in which they are recalled (i.e., semantically related words tended to be grouped)

In addition to local argumentation, students were given credit for global argumentation (e.g., these four studies suggest that meaningful associations among individual words is the most powerful factor in word recall). They were given 1-2 points if such argumentation was presented without the background readings, 1-4 points if it was presented with the background readings.

As to the final recommendations in the report, students were given 1-4 points for grounding them in the data (e.g., ample time should be provided so that meaningful associations can be formed between the items to be remembered) and 1-4 points for grounding them in the background readings (e.g., meaningful associations should be developed so that material can be transferred from short-term memory to long term memory).

Students were also given 1-2 points whenever they displayed legitimate forms of alternative explanation for the same phenomena (for example, in study four the fact that *cat* tended to occur early among the recalled words could have been explained by the fact that it was among the last words presented (i.e., short-term memory) and/or the fact it serves as a prototype of the 'animal' category (i.e., members of such a category, as mentioned, tend to occur before members of 'furniture' or 'transportation' categories).

Data Representation. Students were given credit if they used numerical and/or graphic methods to represent major patterns in the four studies. With respect to numerical methods, they received 1-2 points if they calculated the means for significant patterns such as

(1) the total number of words recalled in each study
(2) the number of *first words*, *middle words*, and *last words* recalled in studies 1-3
(3) the number of words recalled in the semantic categories as well as the number of *last words* recalled in study 4.

Students received an additional 1-2 points if they used these means to establish significant proportions such as

(1) the relative weighting of *first words*, *middle words*, and *last words* that were recalled in studies 1-3
(2) the relative weighting of *last words* and associated words (i.e,. those in the semantic categories) that were recalled in study 4.

As to graphic methods of representation, students were given 1-6 points for appropriate use of such methods. These methods include bar graphs that represent the proportions of different kinds of words recalled in the four studies. With respect to studies 1-3, the line graph of proportion recalled ploted against serial position (usually called "the serial position curve") could have been used to represent the major patterns constituted by *first words/middle words/last words*. Alternatively, they could have used a flow chart to represent the input/output relations for short-term and long-term memory in these studies. With respect to study 4, they could have used tree-structures to represent membership in the major semantic categories.

Results

We present the results in Table 1. The numbers in this table are the means for the *Archaeotype* group and the Control group. The total possible score overall was 60 points, although this represents all that could conceivably be found, not what any pre-college student could attain -- only a specialist in the psychology of memory would have a chance of getting all these points. Thus, the important aspect of these numbers is not their absolute value, but how the *Archaeotype* and Control groups compare. This comparison is striking: in total (the first column in Table 1), the *Archaeotype* group scored 31% higher than the Control group (25.2 vs 19.2 -- out of a possible 60), and this difference was very statistically significant, $t(38)=2.22$, $p<.02$. To do this statistical analysis and the others reported later, we assigned each student the score of the report created by the group (here, each group is a pair) that they were in, then calculated a t test to see how big the difference between the means of the *Archaeotype* student scores and the Control student scores were compared to the variance of these scores within the *Archaeotype* group and within the Control group.

Table 1
Quantitative Analysis of Reports Written by Students in the *Archaeotype* Group and the Control Group

	Total	Pattern Recognition	Explanation and Argumentation	Data Representation
***Archaeotype* Group**	**25.2**	**10.6**	**13.8**	**0.8**
Control Group	**19.2**	**9.6**	**8.0**	**1.6**

As described earlier, this overall total score breaks down into subscores for recognizing the patterns in the observations (Pattern Recognition), explaining the patterns and arguing for those explanations (Explanation and Argumentation), and converting the observations into forms that could provide insight (Data Representation). This breakdown shows that the overall *Archaeotype* superiority was almost totally caused by a 73% higher performance for the *Archaeotype* students in the important Explanation and Argumentation area (13.8 vs 8.0 -- out of a possible 30 points). Statistically also, this is a highly significant difference, $t(38)=3.34$, $p<.001$. There was also a slight difference in favor of the *Archaeotype* students in the Pattern Recognition scores (10.6 vs 9.6 -- out of a possible 20), but that difference was not even close to being statistically significant so we have to discount it, $t(38)=0.76$, $p>.2$.

The Data Representation scores held two surprises for us. The first surprise is that they were so low (16% and 8% of the possible, compared to 27%-53% of the possible in the other areas): neither the *Archaeotype* students nor the Control students used means, proportions, graphics nor diagrams in their discussions -- they merely talked about one condition described in the experimental materials being greater than another. The second surprise is that the Control students scored better than the *Archaeotype* students (1.6 vs 0.8 -- out of a possible 10) to a significant degree, $t(38)=1.95$, $p<.05$. However, the Control advantage was totally due to these students putting the observations into a database program on the computers (part of *Microsoft Works*, which they were accustomed to using) and calculating means. For example, one pair of students in the control group displayed the database shown in Appendix C, Figure 6. This use of databases was a potentially valuable move, but the control students did not exploit this analysis for Pattern Recognition and Explanation-Argumentation. The *Archaeotype* students did not show comparable use of database or spreadsheet programs and thus scored lower on Data Representation. Taken together these results show that the students both need to have experience using computer programs for manipulating data, but they also need practice using them meaningfully as part of their work in analyzing authentic tasks.

Discussion

The results showed an impressive ability on the part of the *Archaeotype* students to create explanations of observations and argue for the validity of those explanations using a mixture of their own terms and ideas, and the technical terminology and concepts provided by background readings in a research literature. They also did well in recognizing patterns in the observations, but not significantly better than the control group we compared them to. In fact, the similar performance of the Dalton School *Archaeotype* students and the Grace Church School Control students on the Pattern Recognition portion of the assignment provides assurance that the two groups were comparable, which makes the much higher performance of the *Archaeotype* students on Explanation-Argumentation all the more impressive. However, we need to also recognize that the basic patterns in the observations the students were analyzing were fairly easy to see -- particularly, after the demonstration and discussion conducted by the experimenter in the beginning of the sessions. It may be that if the patterns being searched for had been less apparent then there would have been more of a difference in Pattern Recognition between the *Archaeotype* students and the Control students. In fact, a study we have done comparing performance on another program with a similar design (Galileo which teaches science to high school students through astronomy) found pattern-recognition differences when the patterns were much harder to see.

The *Archaeotype* students actually did worse than the Control students in Data Representation, although both groups scored rather low in this area. It is disappointing that the *Archaeotype* students did not use even such rudimentary ways of representing data as counts, means and proportions. At least some students in the Control group managed to do some counting and means through entering the observations into a computer database program they were accustomed to using. Ideally, the students would even have used visualization techniques like graphs and diagrams to reveal patterns in the observations and to argue for their explanations. *Archaeotype* would seem a natural context within which to introduce the powerful idea of representing information in different forms to gain insight.

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Title:

Constructivist Design of Graphic Computer Simulations

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Several proposals have appeared recently arguing that the design of educational systems should take a constructivist rather than an instructional approach (e.g., Bednar, Cunningham, Duffy, and Perry, 1991; Harel and Papert, 1991; Newman, Griffin and Cole, 1989). However, while there are established, integrative frameworks for guiding the design of instructional systems (e.g., Gagne, Briggs and Wager, 1992; Reigeluth, 1983; Romiszowski, 1981), there does not appear to be an integrated framework for guiding the design of constructivist educational systems. We take a first step in this direction by proposing six interrelated principles for constructivist design. Versions of the individual princples have appeared in a variety of places, but we have tried to formulate them in such a way that they work together.

The **six principles of constructive design** that we propose and their sources are:

1. Set the stage but have the **students generate the knowledge** for themselves as much as possible (Jacoby, 1978; Black, Carroll and McGuigan, 1987)

2. Anchor the knowledge in **authentic situations** and activities (Cognition and Technology Group at Vanderbilt, 1990)

3. Use the **cognitive apprenticeship** methods of modeling, scaffolding, fading and coaching to convey how to construct knowledge in authentic situations and activites (Collins, Brown and Newman, 1990)

4. Situate knowledge in **multiple contexts** to prepare for appropriate transfer to new contexts (Gick and Holyoak, 1983)

5. Create **cognitive flexibility** by ensuring that all knowledge is seen from multiple perspectives (Spiro, Feltovich, Jacobson and Coulson, 1991)

6. Have the **students collaborate** in knowledge construction (Johnson and Johnson, 1975)

We have created two graphic computer simulations for teaching high and middle school students about how business organizations and financial systems work (these programs are currently being used in a number of New York City public high schools). The two simulations are *Parkside*, which simulates managing a hotel, and *Guestwear*, which simulates managing a clothing manufacturer (formative work showed these topics to be motivating to the urban student population we targeted). Both of these simulations are implemented in the *Toolbook* hypermedia authoring environment running in Windows (3.0 or higher) on 386/486-based IBM and equivalent computers. Here, we use the design and use of these simulations to illustrate how the constructive design principles can be applied.

For example, in *Parkside* we set the stage for student knowledge generation (**Principle 1**) by providing an authentic hotel environment for the students to interact with, while providing supplemenatry information that the students can use to figure out how to accomplish goals and deal with problems that arise in this setting. As they sit in their simulated office or wander around the simulated hotel, various problems arise (through interacting with simulated people, reading memos, answering phone calls, etc.) that they have to deal with. They gather relevant information that they can use to figure out how to deal with the problems through a variety of information sources that the simulation provides (e.g., an icon-activated "Managers Guide" that whenever requested can provide context-sensitive advice and feedback; an icon-activated quantitative report that provide a variety of performance indices like occupancey rates, income, customer satisfaction, newspaper articles, advice from staff at simulated meetings that can be called at any time, etc.). This fairly-realistic graphic display and the underlying functional relations (implemented as a set of complex if-then rules and equations) provides the authentic situations and activites that anchor the material covered (**Principle 2**). Thus the students deal with business concepts like supply and demand or the importance of a trained workforce not in the abstract, but in terms of concrete actions needed to make their hotel work better.

The students get started on the *Parkside* simulation by having the teacher "walk-through" an initial portion of the simulation designed for this purpose (module 0) verbalizing how he or she is thinking through the situations and problems encountered. Gradually the teacher fades out their contribution to this "walk-through" and the thinking is taken over by the students in a class discussion. Then the students proceed through the rest of the simulation (modules 1-5) working in groups around computer workstations while the teacher walks around the room providing help (scaffolding) and advice (coaching). Thus the students are introduced to and guided through the simulation using a cognitive apprenticeship approach (**Principle 3**). Cognitve apprenticeship is also provided in the simulation program itself by the "Managers Guide" and other information aides mentioned earlier that the students can activate whenever needed.

The students work through the simulation in groups (generally four per group in the current sites) around each computer so that they can collaborate on exploring the simulated world and making decisions (**Principle 6**). Since the various group members each have their own perspectives on the material, the discussion in the groups and the later discussion between the groups provide multiple perspectives (**Principle 5**). Multiple perspectives are also provided by design in the comments and suggestions made by the simulated people of the hotel world. Most of the knowledge that we want the students to learn appears in more than one context in the *Parkside* simulation, and later is covered again in the *Guestwear* simulation, which provides them in the very different context of a simulated clothing manufacturer (**Principle 4**).

Problems with Initial Field Test

For an initial test of the effects of the *Parkside* and *Guestwear* simulation programs, we placed them in two New York City public high schools using computer laboratories donated for this purpose by IBM. These schools were quite happy to accept this computer equipment and have us run our simulations there as part of their *Introduction to Occupations* course, and the students received the programs enthusiastically (e.g., attendance skyrocketed to virtually 100%), but the school adminstrations balked at moving beyond this superficial involvement.

The first sign of trouble was the school administrations refusal to give the teachers release time to receive training in how to use the program and the teachers were unwilling to devote their own time to this. In fact, the depth of teacher training needed soon became apparent: the teachers not only had no experience using simulations (and not much using computers in general), as part of their teaching but, the mode of thought embodied in the simulation was completely alien to them. In particular, the simulations were designed to inculcate a mental model style of thinking (e.g, Gentner and Stevens, 1983; Mandinach, 1989) about business and financial systems. Thus we wanted the students to learn that making decisions can affect a system of interacting entities in various ways (e.g., increasing hotel room rates might increase initial revenue but depending on circumstances might decrease occupancy rates and change the image of the hotel, and so forth). The teachers never did grasp this style of thinking: they kept insisting that there was no way they could teach using the simulation unless we told them what the "right" answer is at each decision point. In the end, our project team had to take over the parts of the class using the simulations.

Even worse, when the time came for us to administer a test (presenting a new business case and having the students make decisions and explain their decisions), the Principals of the schools refuse to let us test their students. It seems at the point they had gotten what they wanted from the project (e.g., new computer labs) and did not want to chance our revealing any weaknesses in their students. Thus, we were not able to evaluate the effects of the simulations, but we were left with an appreciation of the difficulties of accomplishing anything within the current organizational structure of the New York City Public Schools.

A Quick-and-Dirty Field Test

Fortunately, we were able to use an *Applied Economics* class in a Connecticut public high school to do a pilot pre-and post-test using our assessment instrument with a class that used the *Parkside* simulation. The teacher of this class is a graduate student in our department and thus has the requisite understanding of computers, simulations and cognition to make meaningful use of the simulation. The tests administered described new business cases (e.g., managing a pizza parlor) and required the students to make a series of decisions about the business (choose from a set of alternatives), acquire new vocabulary about business and economics, and explain their reasoning in essay questions. the class was composed of 16 students, and 12 of them completed both the pre-test and the post-test (which were equivalent but with different content). These 12 students improved form the pre-test to the post-test 10% on the multiple-choice decisions, 13% on the vocabulary (being able to explain what the terms mean) and 22% on the quality of reasoning expressed in their essay answers. Thus, while far from definitive, these results suggest that the students are indeed learning from the simulations and improving most in higher-level thinking (the essays). Particularly interesting was the teachers report that 2 of the 12 students had been uninvolved in the classroom part of the course, but became enthusiastic leaders during the simulations. This suggests that simulations like Parkside may reach students who do not relate to other methods of instruction.

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Title:

Applications of an Adult Motivational Instructional Design Model

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Abstract

Using an adult motivational instructional design model, the authors demonstrate the application of prescribed strategies into instructional software designed to teach basic statistics concepts. The basic software is compared to the enhanced motivational version. Important motivational strategies are explained and implications and applications of motivating design of instruction for adults are discussed.

Introduction

Many researchers (Aslanian & Brickel, 1980; Cross, 1981; Galbraith, 1990 & 1991; Houle, 1961; Knowles, 1980; Wlodkowski, 1985; Zemke & Zemke, 1981) have proposed that adults have specific and rather unique motivational needs in instructional settings. These needs may be due to any number of changes that take place over time: (a) life experiences (Knowles, 1980), (b) transitions in life (Cross, 1981), or (c) learned attitudes over time as a major factor in adult learning (Wlodkowski, 1985). As a result, it would seem that motivating instruction for adult learners should be designed with special considerations in mind.

Motivational Instructional Design

Instructional motivation increases the learners' effort and attracts learners to the instructional content and methods (Keller, 1983). This means that instructional motivation has two components, it is appealing and effort generating. Motivational instruction, therefore, facilitates an appeal or interest within the learner and it also stimulates an increase in the effort or time on task of the learner. This dual characteristic of instructional motivation has been supported in previous studies (Bohlin, Milheim, & Viechnicki, 1990a & b).

Keller (1987), Keller and Suzuki (1988), and Keller and Kopp (1987) specifically identify four categories of motivating strategies in learning situations: attention, relevance, confidence, and satisfaction (ARCS). The ARCS Model proposes that motivating instruction contains strategies from some or all of these four categories. The instructor/designer, therefore, can promote motivation by using appropriate strategies.

The attention of the learner can be promoted through procedures that increase curiosity, interest, or arousal by using humor, variety, enthusiasm, etc. The relevance of the instruction refers to the personal needs of the learner and can be facilitated by matching the instruction to learners' goals, making the benefits clear, keeping the challenge level appropriate, etc. The confidence of the learner, defined as the learner's expectancy for success. can be increased by strategies such as clearly indicating the requirements for success, providing a low risk environment, and giving accurate attributional feedback. The learners' satisfaction depends upon the extent to which the rewards gained are perceived as appropriate and consistent with their expectations, and can be promoted by providing appropriate recognition for success, giving informative and corrective feedback, etc.

This model was developed through inductive and deductive methods focused on K-12 classrooms. But if theorists are correct, these data may not generalize to adults. In order to better match motivating strategies to adult instruction, we must go beyond the ARCS look at the needs of adults.

Previous studies (Bohlin, Milheim, & Viechnicki, 1993a & b) have identified specific strategies from the ARCS categories and from adult learning theory that are especially motivating for adults. These strategies have been integrated into an adult instructional motivation design model, which has been referred to as the "Golden ARCS Model." The strategies from this model should provide a better match when designing motivating instruction or materials for adult learners. Many of these strategies can be easily integrated into instruction and materials in ways that will increase the interest and effort of older learners.

Integrating Strategies into Instruction

Based on the above research, the authors have developed a number of suggestions for incorporating motivational strategies into instructional materials. While the majority of the strategies listed below are focused primarily on their use within computer-based instruction, many could also be easily adapted for use with other forms of instructional media.

Attention

In terms of attention, specific computer-based materials could begin with several facts that contradict the learner's previous perceptions concerning the material included in the program (Keller, 1987). In addition to reducing the overall anxiety of the student, this strategy may gain the attention of the learner since the material is somewhat unexpected based on previous experience. Similar unexpected events (within reason) can also be integrated throughout other parts of the program to help engage the learner in a deeper level of interest and attention (Keller & Suzuki, 1988).

Content-related anecdotes, case studies, and biographies are also appropriate (Keller, 1987), since they provide variety within an instructional program and help maintain a level of interest in all of the included material. Attention based on specific instructional screens can be facilitated through the use of traditional strategies such as animation, inverse text, or the use of sound (Keller & Suzuki, 1988; Rieber & Hannafin, 1988), although the overuse of these strategies can interfere with the learning process (Rieber, 1990). The integration of problem-solving activities within the lesson (Keller, 1987) also assists in breaking up the potential monotony that can occur within instruction delivered by computer.

Figure 1 shows one method for increasing attention within computer-based training, where animation (a flashing arrow in the computer program) indicates an important point on the screen. While this type of attention-getting device should obviously be only one part of an overall motivational strategy, it can be quite effective for directing a learner's attention to a specific aspect of an instructional program.

Insert Figure 1 about here

Relevance

For this component in the model, instructional designers should focus on showing learner how the instructional materials relate to specific, current needs. Keller (1987), for example, suggests showing how specific instruction relates to future learner activities in addition to building on current or existing skills. Demonstrating significant enthusiasm for the content within the program can also indicate to the learner that the material is important and therefore relevant to their potential future needs.

More specific suggestions for increasing the relevance of an instructional module include:

- the use of personal pronouns as well as the student's actual name to provide a friendly and familiar atmosphere (Keller & Suzuki, 1988),
- the consistent use of examples from a student's everyday job or general environment, and
- a description of the application of the content to the real life of the learner where it can be transferred after the program is over.

Figure 2 indicates the opening screen of a computer program where the learner is asked for their social security number as well as his or her first name. While the number is used for tracking purposes, the name can be used throughout the program for personalized feedback and reinforcement as well as to increase the friendliness of the experience.

Insert Figure 2 about here

Confidence

In terms of confidence, learners need to be consistently reminded of their own intrinsic abilities and their overall potential for success within a program. In this respect, the content within an instructional module should be organized on an increasing level of difficulty, with the student also being shown that the material can be learned through personal effort even though the content may seem somewhat complex. Moderately difficult self-evaluation tools can also be provided to the involved learners (Keller, 1987) so they can assess their own competence as they move through the overall program.

With respect to navigation within the program, the learner should be permitted as much control as possible, including at least the ability to page forwards and backward from screen to screen and to escape to a menu at any time (Keller & Suzuki, 1988). This type of control will provide users with the ability to progress at their own pace (with limited intervention from the instructional program) and hopefully increase their confidence in their ability to use the program and learn the appropriate content.

Several of these suggestions are illustrated in Figure 3 which shows a simple problem which can be easily mastered by the learner based on the skills and concepts previously mastered. This screen also shows the availability of 'Next' and 'Previous' choices as well as a button that can return the user to the Main Menu at any point during the instructional program.

Insert Figure 3 about here

Satisfaction

Finally, satisfaction can be enhanced by a number of different strategies. Keller (1987), for example, suggests providing praise for successful progress through an instructional program as well as verbal reinforcement for a student's intrinsic pride in their own task accomplishment. He suggests varying the schedule of this reinforcement, with frequent praise provided when a student is learning a new task and intermittent reinforcement as the student becomes more competent with the material.

In addition, Keller and Kopp (1987) suggest allowing learners to use their newly acquired knowledge or skills in a real or simulated setting following their instructional experience, since the successful utilization of these skills would increase the student's satisfaction with the learning process and their potential ability to use their newly acquired knowledge. This type of utilization could also increase the confidence level of these students (see above) since they would be more comfortable in their potential use of these new skills.

Discussion

Adult instructional motivation is becoming increasingly important as more adult learners are returning to instructional settings, through schooling, training, and retraining. The vary nature of students in higher education is changing as nontraditional students are returning to colleges and universities. Also, as societal changes accelerate, progressively more adults are forced to learn new skills and processes. There is a great need of motivating materials for this population.

The instructional materials highlighted in this paper were developed by integrating strategies and components from a model for the design of motivating instruction for adults. It is expected that these can compensate for a lack of interest, relevance, or confidence of adult learners. This is especially important for such topics and statistics, which for many carries with it feelings of anxiety and low self-efficacy.

These kinds of materials can also be used conduct research of such questions as:

- What is the minimum amount of motivational strategies to have achievement effects?
- What is the minimum amount of motivational strategies to have affective effects?
- At what point does the use of excessive numbers of strategies become demotivating?
- What combination of strategies are best for adults from underrepresented populations?

Whether the focus is on development or research, more applications and investigations must take place in order to assess the real needs of adults in various settings. In addition, more ways to meet those needs must be examined.

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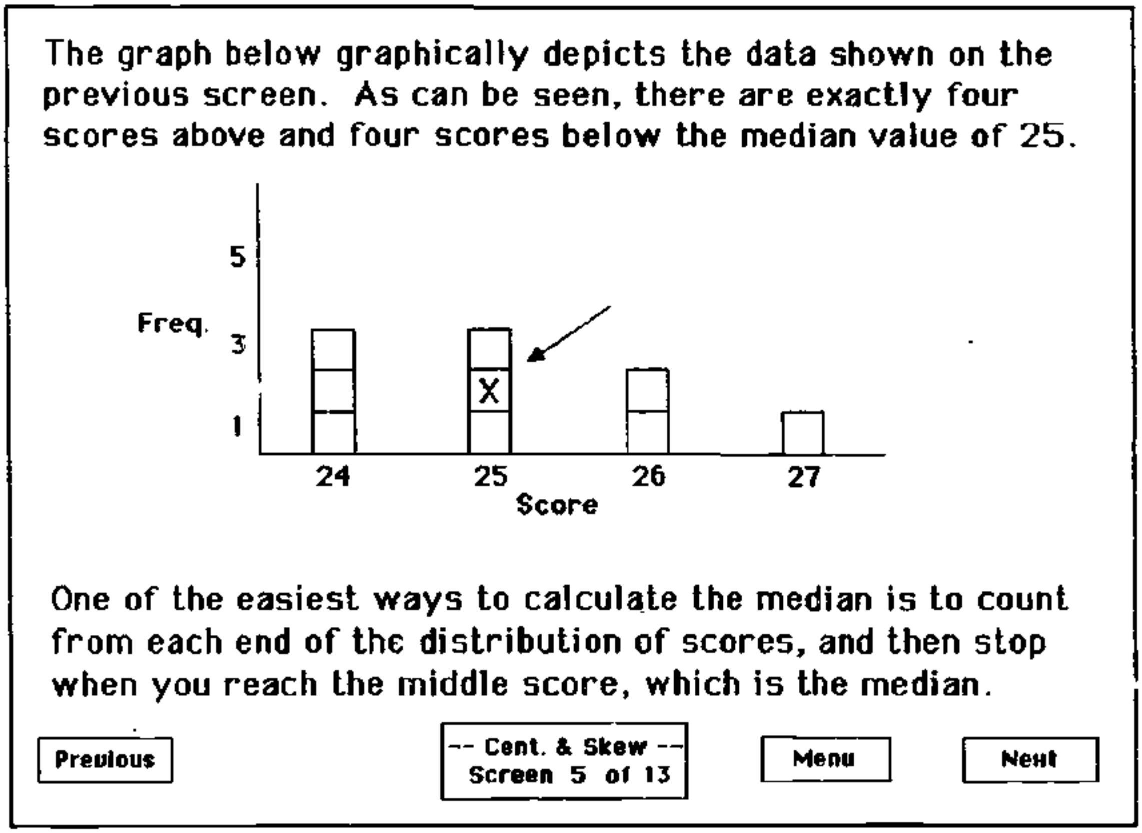

Figure 1. Animation as an attention strategy

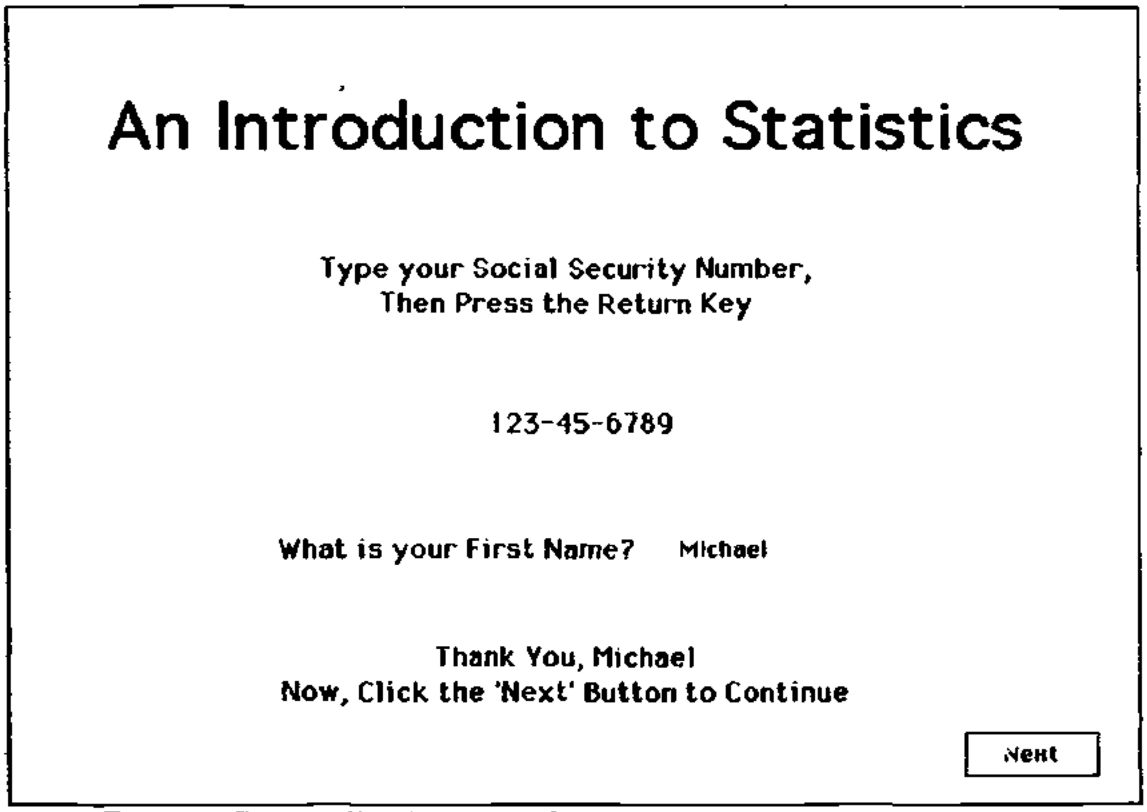

Figure 2. Personalization as a relevance strategy

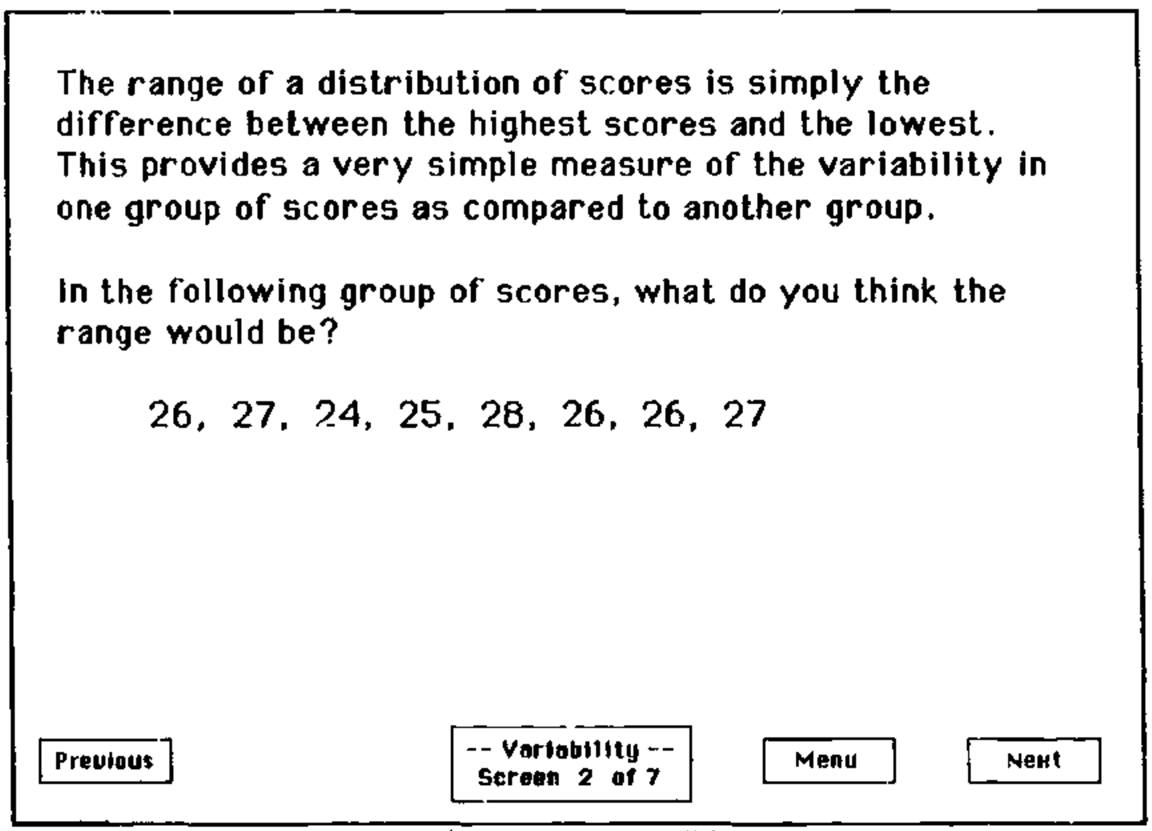

Figure 3. Learner control options as a confidence strategy

Title:

Improving the Effectiveness of Professional Education: Learning Managerial Accounting via a Complex Case

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Professional Education and Case-Based Instruction

Educators in various disciplines such as medicine (e.g., Association of American Medical Colleges, 1984), teacher education (e.g. Shulman, 1986), business (e.g., Mason, 1992) and engineering (e.g., Albright & Albright, 1981) have expressed increased dissatisfaction with the quality of professional preparation students receive at universities. Key concerns are students' lack of problem solving and critical thinking skills. Content coverage often is the primary criterion for success in professional education programs (Kennedy, 1990), but students are criticized for being unable to transfer content knowledge to real situations (Kennedy, 1990; Feltovich, Spiro, & Coulson, 1989).

In an effort to give students more experience with real situations, many professional schools use case studies in their courses. Originating in law schools during the late 19th century, case-based instruction has been adapted in many disciplines, including business, medicine, and teacher education. Educators in these disciplines began using cases to give their students a more field-based, realistic education. Frustrated by the abstractness of lectures and the inconsistencies of apprenticeship (let alone the logistical difficulties), educators turned to actual court rulings, business interviews, patient transcripts, etc. to help bring into the classroom the environments for which they were training their students. In case-based instruction, students read case studies taken from actual events, analyze those events, hypothesize about problems in the case, and recommend alternative solutions. Students engage in a dialogue with their professors about cases rather than merely taking notes about what professors espouse in lectures.

There are several benefits often associated with learning via cases. Cases put information in a realistic context for students. By contextualizing information, students can examine and compare situations and come to a better understanding of the information. Because cases represent real events, the concepts and skills learned in analyzing cases are more easily transferable to the real world than those learned abstractly. Cases also tend to promote higher levels of learning such as analysis, evaluation and problem solving. Furthermore, case-based instruction can be helpful in bridging the gap between theory and practice, promoting higher-level objectives, and motivating students (e.g., Christensen, 1987; Barrows, 1985).

Despite the oft-cited benefits of case-based instruction and its widespread use, criticisms of professional education still abound. Some educators have become frustrated with traditional cases because they typically simplify situations, lack richness of detail, and are written to illustrate one particular point. While cases seem to do a good job of putting information in realistic contexts, they could be doing more to help students gain better, more integrated knowledge and skills and to help them transfer these to the working world. A possible solution is to create rich, complex cases — *case experiences* that immerse students in complex problems rather than *case studies* that merely require armchair analysis.

This paper will discuss the need for complex cases in higher education, particularly business education. Issues about designing, implementing, and learning from complex cases will be examined and an example of a complex case will be described.

The Case for Complex Cases

Many recent influences in educational psychology (e.g., Brown, Collins, & Duguid, 1989; Lave, 1988; Spiro, Coulson, Feltovich, & Anderson, 1988) call for the design of learning environments that are much more contextualized (i.e., situated), authentic, and apprenticeship-like. Case-based instruction is usually considered a move in this direction. Cases are often recommended as an instructional method that preserves the cognitive authenticity of learning tasks without the necessity of actually being in the field (e.g., Shulman, 1992). The term "case," however, is often used to refer to everything from a two-paragraph scenario at the end of a textbook chapter to an extensive history with detailed descriptions of events, decisions, and people. In business education, cases are based on public financial records, management interviews, direct observations, and corporate communications; however, the wealth of data from all these sources typically is filtered, distilled, and summarized when written up for students. What results is typically a 10 to 30 page narrative document that may also include organizational charts, tables of financial data, resumes, and/or corporate memos. Thus, typical "Harvard-style" cases (Harvard is the largest publisher of business cases) usually lack the complexities of real work situations. Such cases may not allow students an opportunity to develop appropriate problem-solving skills. While students may be able to deal with neatly packaged problems within a case, they are all too often unable to deal with similar problems in a dynamic workplace. Another weakness of many business cases is that they are written to illustrate a specific concept, such as leadership, marketing strategies, or ethics. In limiting their scope, these cases may not adequately help students to see the interrelationships of these concepts in the real world. In analyzing business cases, students usually approach them as having all the information needed and that all included information is pertinent. Cases may present puzzles, but students assume that all the pieces of the puzzles are there. Often, traditional cases don't require students to go beyond the information given or to integrate other resources into their case analyses. Another problem with the way cases are typically taught is that they are used in one class, discussed, and then rarely referred to again. Few connections are made across cases.

Based on our study and practice, we recommend the creation of cases that offer more experiential, integrated, and authentic opportunities for learning. We've called such cases "complex" cases, though they could also be called experiential cases, rich cases, enhanced cases, or case experiences. Complex cases are cases that present real issues and problems for analysis via real materials. The materials may include print, video, or other media. Complex cases use media to enable large numbers of students to participate in many of the cognitive activities involved in actual field experiences. In a complex case, critical information is embedded in an authentic context of documents, reports, memos, conversations, and other organizational artifacts. Putting information into neat categories — an approach that overguides students to a "correct" answer — is avoided. Thus, complex cases are more realistic and messy than traditional cases. While complex cases present layers of detailed information, they avoid intentionally including red-herrings, statements that lay open traps for particular lines of faulty thinking. In addition, complex cases pose problems that have many possible answers and that can be looked at from multiple viewpoints. Complex cases necessitate discussion and thus should be group activities.

Complex cases, in essence, compress real information and communication. They are most like field research in that to be successfully completed they require students to seek out information, determine the value of information given to them, and analyze and synthesize their knowledge with new information. In a typical field experience, however, students spend months gathering the types of company documents, memos, and interviews that are presented in a complex case. While presenting these within a complex case instead of field research causes students to lose practice in consulting with companies, many efficiencies are gained. It is difficult to provide field experiences for students on a regular basis or for large number of students. In addition, many students do not have adequate time and resources for a semester-long field project requiring travel and other expenses.

The goals of complex cases, much like the goals of professional education, are ambitious. The key cognitive goals of using complex cases are to provide opportunities for students to develop flexible structures of knowledge, transition from novice to expert, think more like professionals, acquire the skills and language of their field, and deal with ill-structured information.

As business students build the advanced knowledge required to become managers they must grapple with increasing conceptual complexity and ill-structuredness. In order to grapple with this successfully, instructional activities should foster cognitive flexibility (Spiro, Feltovich, Jacobson, & Coulson, 1991; Spiro & Jehng, 1990; Spiro, Coulson, Feltovich, & Anderson, 1988). Spiro defines cognitive flexibility as the ability to quickly restructure one's knowledge in response to radically changing situational demands (Spiro & Jehng, 1990). Cognitive flexibility is achieved through avoiding oversimplification, striving for interconnectedness of concepts, promoting multiple representations, and active learning.

Spiro et al. (1988, 1991) claim cognitive flexibility is particularly important in ill-structured domains, i.e., areas of knowledge that have concept- and case- complexity as well as across-case irregularity. They note that the more ill-structured the domain, the poorer the guidance for knowledge application that "top-down" structures will generally provide. Such structures lose their usefulness because of the great variability from case to case and the great variability in which the same concept is used across cases. This irregularity works against the use of knowledge structures that assume "routinizability" across cases. One of Spiro's major arguments is that one has to 'criss-cross' complex material in order to understand it — similar to the way one has to criss-cross a landscape in order to get familiar with it. By criss-crossing through cases and concepts, students establish many alternative paths to get from one part of their knowledge base to any other part. Useful knowledge must be learned, presented, and tried out in many ways.

Typical professional programs, particularly medical programs, have been criticized by Spiro et al. (Feltovich, Spiro & Coulson, 1989) for oversimplifying content, being too theoretical, decontextualizing concepts and principles, and heavily compartmentalizing the curriculum. Such tendencies are major reasons for the lack of transfer of knowledge from university settings to the field. That is not to say that all learning must take place in the field. Collins, Brown, and Newman (1988) introduced the notion of cognitive apprenticeship which states that the learning of knowledge and skills must be embedded in the social and functional context of their use. There is an emphasis on authentic cognitive processes more than authentic physical environments. Complex cases attempt to use these understandings to provide students with rich, authentic tasks.

Recent research on expert-novice distinctions suggest that the cognitive schemata of experts are more elaborate, more complex, more interconnected, and more easily accessible than those of novices (Leinhardt & Greeno, 1986; Chi, M., Feltovich, P., & Glaser, R. 1982). While expertise is developed through continued experience with a wide range of examples, case-based instruction can simulate some of this experience and provide problem-solving practice for students. It is intended that through complex cases students not only will increase their experience with new concepts and examples, but they will also increase their ability to see the interconnectedness of concepts and examples.

Automotive Armature: An Example of a Complex Case

In response to national criticisms of accounting education as well as research advocating more situated, integrative, and active learning environments, a professor at Indiana University's School of Business undertook the challenge of creating an authentic, rich case. The case is about a real manufacturing company, Automotive Armature (AA), that was experiencing a variety of financial difficulties and operational problems. The AA case was originally used as a field research experience for a class of 25 undergraduate students in an upper-level accounting class. In teams, the students analyzed AA's accounting system. They found the experience highly motivating and that working with an actual company made accounting concepts and business issues much more relevant for them. While on-site field research had many learning benefits, it posed logistical problems when the professor decided to integrate AA into a core course in managerial accounting for 250 MBA students. While this number of students could not be sent to the company, the company could, at least in part, be brought to them.

The AA case was designed with several learning and technology goals in mind. First, the case was intended to promote students' discovery of problems in a complex, realistic business environment. In designing the case, an attempt was made to create a learning environment that contextualized managerial accounting concepts and integrated traditionally compartmentalized business curricula (e.g., accounting, marketing, operations). Unlike most Harvard-style cases, the AA case did not present information in a distilled, neatly organized manner. It was essential that this case lead students to experience the process of identifying important information, organizing it, and analyzing it, rather than having the case's organization, structure, or brevity do it for them. The students' task of determining key AA problems and recommending solutions was designed to be highly authentic.

On the technology side, the AA case had to provide textual, numerical, and visual data for students <u>and</u> it had to be "implementable." Forty groups would be working with the case, so the technology had to be available, accessible, and require minimal training. For Spring 1993, the AA case resources provided to the MBA students consisted of the following:

- 25-minute overview video of the company
- Eight 10- to 20-minute video interviews with the Chief Financial Officer (CFO)
- A 140-page document with company and industry data
- A live, one-hour Q&A session with the CFO
- The two class professors who served as case mentors
- A case consultant (an accounting MBA student) who served as a resource person for the case

To give students a good sense of the company, it was important to show them what the company looked like, how its products were produced, what the working conditions were, etc. An overview video was produced to do this. The interview videos gave students more detailed information about different aspects of the company as well as role-modeled effective interviewing techniques for them. The print documents provided students with real company information via spreadsheet printouts, plant diagrams, newspaper articles, organizational charts, interoffice memos, reports, and other artifacts.

In their regular classes of 65 students, the MBAs were introduced to the case by one of the professors. It was stressed to them that this case was intended to help them build their critical and creative thinking, communication, and problem solving skills as well as to help them better understand the role of managerial accounting in conjunction with other company functions. Their task, as explained to them by the professor, was to sort through the information presented in the case resources, identify four or five of the company's key problems, and recommend solutions that would be feasible for the company within a 6-12 month time frame. Their task was situated in the context of a consulting engagement in which students directed their recommendations to the company's Chief Financial Officer.

This was a team project in which students, in groups of five or six, had about 10 days to go through the case materials, determine their recommendations, and write a 12-page (plus appendices) group paper. While the members of each team shared a copy of the videotape, everyone purchased their own copy of the 140-page case document. Each team began the case by watching the AA videos together, usually at a team member's home, discussing the videos, mapping out an initial strategy for determining recommendations, and assigning individual responsibilities.

Most teams chose to assign tasks on the basis of members' expertise (e.g., "the finance guy" was assigned to focus on the company's financial issues, the marketing major on marketing issues, etc.). Throughout the next stage of information gathering and organizing the students worked individually and in groups, regularly putting forth ideas and questions, discussing them, and refining them. The final stage of their task was to pull their ideas together and write a cohesive, concise paper. In their group papers, students were required to include not only recommendations, but justifications and to write in a business format, meaning that brevity, clarity, and persuasiveness were key.

Student and Professor Reactions to the AA Case

A variety of data has been collected to document the AA case activity and reactions to it, including class and team observations, surveys, and interviews. Overall, both students and faculty felt that the AA case provided a useful, authentic experience that allowed students to develop their analytical skills.

In a survey after the AA case was completed (N=187), most students indicated that the case was a valuable learning experience (75%) and that it would be worthwhile to do more cases like it (70%). Eighty-five per cent of the responding students, most of whom had business experience, thought that the AA case realistically portrayed a business situation and that this case was more interesting than the Harvard-type cases they had done (61%). They also thought that it was more demanding than Harvard-type cases (82%). While 41% of the students indicated that they were overwhelmed by the amount of information in the AA case, most students (72%) said they were able to make sense of the information. The largest group of students (41%) reported that they spent 21 to 30 hours working on the case, while 23% reported 11-20 hours and 17% reported 31-40 hours.

The students reacted favorably to the videos and appreciated being able to see the company and its facilities. Many students thought the interviews were boring, although they acknowledged that they contained some valuable information. Some students were frustrated with having a large amount of seemingly disorganized data dropped in their laps. They wanted more context for some of the documents in the written materials, e.g., where they came from, why a consultant might request such a document, etc. Given the time pressure of the case, most teams worked in "survival mode." They divvied up tasks and focused on getting the required paper completed. There was not a great deal of time for reflecting on different perspectives, revisiting concepts, or revising their papers. From our group observations it was evident that a variety of problem-solving strategies were used. Students worked in their teams to figure out what information was most relevant, what information was missing, how they might get access to missing information, and how they could cross-validate different sources of information. Most teams ran additional calculations of financial data to project the impact of their recommendations. Some groups even consulted with sources such as a city chamber of commerce and an accounting firm to gather additional information.

The professors were generally pleased with the results of the AA case, though they had a variety of suggestions about how to do things differently the next time. Two primary suggestions were to allow more time for the case and to put it later in the semester after the concept of activity-based costing had been discussed. They felt that the students' papers were good, especially given the time constraints, though only a few were truly innovative. They noted that there wasn't a wide range in the teams' recommendations, with the key AA problems discussed in most papers being product proliferation, overly liberal core and warranty policies, poor inventory tracking, lack of product costing, and excessive inventory. While some of the recommendations were interrelated, most papers broke down recommendations into production, marketing, accounting, systems, or transportation issues. One professor commented that several papers failed to cover basic issues, such as cash flow. While these papers may have discussed related issues, they failed to adequately tie the issues together.

DesignIssues concerning Complex Cases

Cases, in general, are considered useful instructional activities for the development of higher level skills. Complex cases — case experiences as opposed to a case studies — may be most appropriate when advanced problem-solving skills, expert level of performance, and integration of concepts are desired. But how does one design a complex case? When creating rich learning environments for students, case developers (in our project, a team of instructional designers and subject matter experts) are confronted with several challenges. What should be included in the case? What should be excluded? How should it be presented? What should students be asked to do with the case? How much guidance should they be given? How will students' learning be evaluated? Three major dynamics should be considered when designing a complex case: authenticity, organization and duration (see Figure 1).

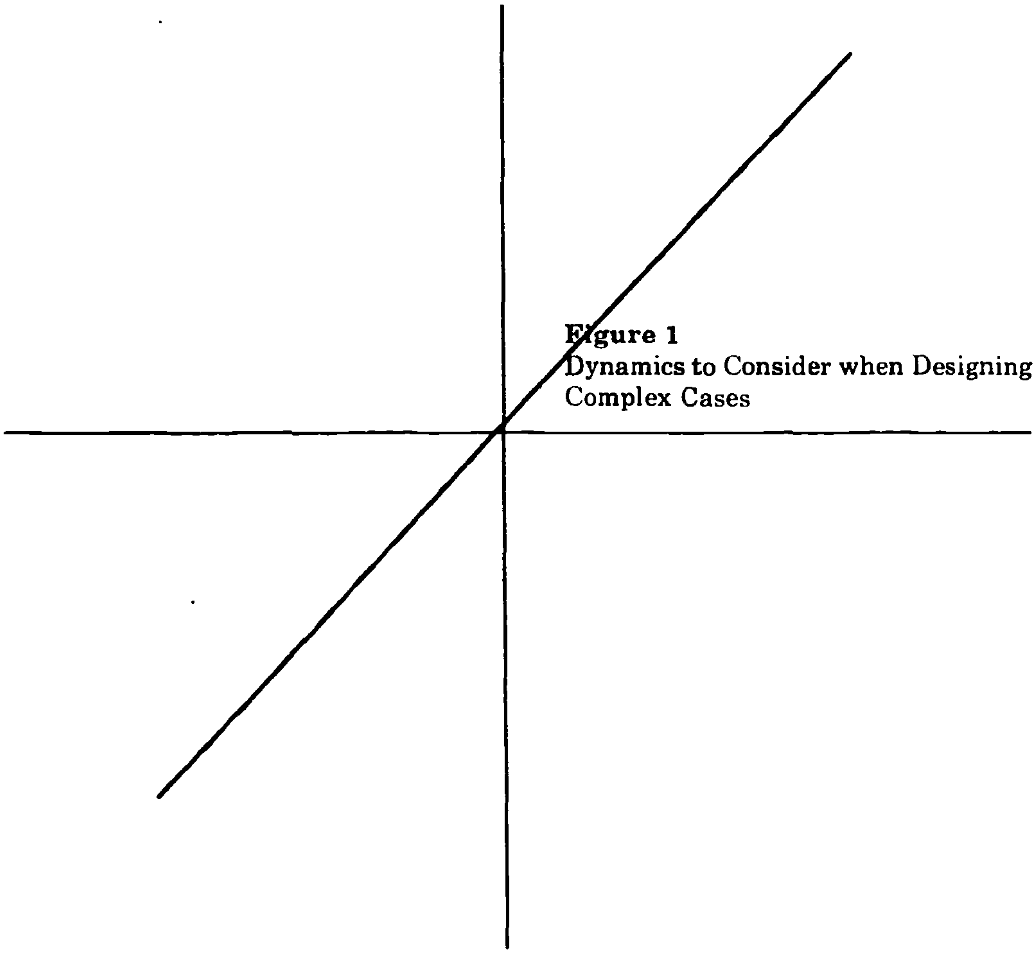

Figure 1
Dynamics to Consider when Designing Complex Cases

Authenticity

A high degree of authenticity is essential in a complex case, both in the case materials and in the case task. This can be achieved by creating tasks for students that are as close to field experiences as possible rather than fabricated experiences. Developers should use real situations for their cases not fictitious ones, raw data as opposed to narratives, and actual documents more than ummaries. In order to create a case that is demanding and engrossing, case developers must put students in the middle of dynamic, multifaceted scenarios that reflect the natural complexities of the real world.

Multiple sources of information are required to develop a complex case. To get the authenticity and richness desired in a complex case, case developers need to work directly with the entity that is the subject of the case, e.g., a company, agency, school, hospital, group, etc. That organization must provide a good portion of the case information and be willing to allow developers to sift through organizational documents and communications. The amount and quality of the data gathered is greatly dependent on who the key contact is with the organization. Additional information for complex cases may come from professional reports, newspaper or magazine articles, research databases, or interviews with company clients or competitors. In the AA case, access to the company grew out of a consulting engagement that a professor had with the company. Since the company was only 45 minutes away from the university, it was feasible to make on-site visits to meet with company personnel, shoot video of the plant, and attend company meetings. Having close proximity to the case source is not only beneficial for these reasons, but for motivating and involving students as well. In the AA case, knowing that the company was nearby helped increase the realism and relevance of the case.

In designing a complex case, students must be positioned as active participants in the case, not passive readers. Accordingly, the usual narrative style of most cases that creates a linear story must be substantially replaced by authentic documents. As much as possible, the language of the field should be used. Thus, spreadsheets and financial reports were used in the AA case. Children's drawings or test norms might be used in a psychodiagnostic case or blue prints and building models in an architecture case.

Case developers must also determine how the case will be presented to students. Typically, cases are paper-based. This is economical and easily distributed. In a complex case there is an effort to create a rich environment that has as high a fidelity with reality as possible. Thus, the use of video is recommended to bring the field environment into the classroom environment. Video adds another level of richness to the data students must work with in analyzing a case. Via video students can see a company's facilities, personnel, working conditions, and products. The use of video in the AA case was seen as important because it would allow students, like consultants in the field, to learn about the company through casual visual information, e.g., dirtiness of used parts, disorganization of barrels, mannerisms of management, etc.

Organization

Even a rich, complex case must have some sort of organization. The act of capturing a piece of reality and presenting it to students unavoidably involves structuring that reality. Case developers must determine the kind and amount of structure to give the case, yet at the same time avoid imposing undue analysis or interpretation to the materials. A flexible organization maximizes the students' challenge to determine their own organization and priorities for the case. An organization that is too structured tends to turn information into answers and, therefore, is less challenging and less authentic. Many organizing schemes are possible: chronological, alphabetical, hierarchical, functional, or topical. Usually it is best to choose a scheme that is authentic to the case environment. For example, in the AA case we organized the video interviews and print materials around the typical functions of a business; accounting/finance, management, production, marketing, and human resources.

The next organizational challenge is to determine the boundaries of the case; what to include, exclude, summarize, etc. If one decided to "include everything" a complex case would be huge to the point of being unmanageable. While a complex case should have broad rather than narrow boundaries, case developers have to make some decisions about what to leave out. Several factors guide such decisions. First of all, what is the level of the learners? Freshmen may be less able to deal with masses of unstructured, detailed information than graduate students. The less advanced learners are, the more developers should consider summarizing lengthy documents, omitting tangential materials, limiting the number of issues in a case and/or allowing more time for students to work with the case. More important than the case materials themselves, however, is the level of challenge in the students' task for the case activity. A complex case, including the data set from which it is derived, may be usable across a variety of student levels provided the learning goals are put at an appropriate level. When determining the organization of a complex case the boundaries shouldn't be limited to a particular area, for example in the business field to just management, operations, or marketing. While a complex case might be used in one particular class, it should include perspectives, issues and data from other "classes," i.e., areas or related perspectives, to give it realistic richness.

Duration

A third dynamic to consider when designing complex cases is duration, both in terms of the amount of time covered about the organization described in the case and the amount of time that students are intended to work on the case project. The time period described in a case could be a week or a decade as long as that time period contains enough rich information to engage students in a variety of issues. In the AA case we provided some general historical information about AA, but primarily concentrated on the company's most recent fiscal year (a typical framework for a business analysis). Originally, we'd intended that the AA case be used throughout the semester, but a variety of curriculum logistics prevented that. The students ended up spending approximately 10 days on the AA case which was later considered too short a period of time to achieve all the goals of the case activity. Complex cases are time consuming. Time must be allowed for students to visit and revisit the many different case resources, to "criss-cross the landscape."

Learning Issues concerning Complex Cases

Complex cases place a high learning demand on students, more so than with traditional cases. Three of the key challenges that students face are dealing with information overload, coping with a high level of ambiguity, and integrating information from multiple perspectives.

Dealing with Information Overload

When presented with lots of "raw data," most students are initially overwhelmed. "Where do I start?" and "How will I make sense of all this?" are typical questions running through their heads. From a learning perspective, students must find ways to organize the data in meaningful ways. We recommend that students start in groups, scanning the case documents and other materials and making some initial hypotheses about important issues or problems. What was once a mass of data now becomes data that is focused by specific problems. With a problem-based focus, students can more effectively sort useful from the less-useful information that is presented in a complex case. Depending on their problem focus, one student's information may be another student's non-information. As students read or view case materials, they examine the materials in light of problems and hypotheses about their solutions. It is essential that students discuss their hypotheses with others as they delve further into the case to both deal with information overload and to check their hypotheses. Through this discussion new hypotheses may emerge. The abundance of information in a complex case can also be managed by asking questions. The professor or case consultant can be useful resources in helping students pose and focus effective questions.

Coping with a High Level of Ambiguity

A complex case presents a scenario (or multiple scenarios) that does not lead students to a predetermined end. Students can take a complex case in many directions. Their task is somewhat ambiguous and lacks a precise algorithm to follow. When students are asked to solve problems in more traditional cases, they know the problems are within the boundaries of the case and more often than not focused on that week's topic in class. The danger in this is that the case may be no more than an illustration of a problem rather than a challenging intellectual activity. In a complex case the students' task is one of problem finding as well as problem solving. Ambiguity is a necessary component of a complex case because it is frequently a difficult aspect of professional work as well. Students have to struggle with the ambiguity in order to reach the higher learning goals. While this struggle is necessary, it may be appropriate to help students anticipate this struggle and acknowledge the difficulties of dealing with ambiguity. The tasks involved in a complex case activity may be very different from the activities in students' other classes so coaching students in new ways of working may be necessary.

Integrating Information from Multiple Perspectives

As students read a complex case, they gather and organize information from a variety of sources. As active participants in the case, students choose to go down many different paths that they may also choose to cross and re-cross. The students' challenges are to identify and assess different perspectives and to integrate them in order to make effective recommendations. The materials in a complex case should give students many opportunities to examine the same information repeatedly from different perspectives. To help students integrate information from multiple perspectives, they must be given opportunities to discuss these perspectives. Such discussion should include "what if" or devil's-advocate style questions to deepen students' understanding of different perspectives. In addition, it is helpful to integrate concepts from a complex case into other discussions. In the AA case this occurred both naturally and intentionally. The MBA students often brought up Automotive Armature as an example in class discussions after the case activity. The class professors also used the AA case again at the end of the semester for an activity-based costing assignment.

Implementation Issues concerning Complex Cases

Many issues must be considered and addressed when implementing complex cases. Three of the most important will be discussed here. The first revolves around the concept of appropriation, i.e., the process by which the design and the product are actually used by the professor and the students. The second implementation issue is how the complex case fits within the larger educational environment. A third major issue concerns the instructor's perspective on teaching.

Appropriation

Complex cases are intentionally designed to have a great deal of flexibility. This flexibility promotes appropriation. Case developers should be willing to allow users to assimilate the case materials and activities into their current ways of doing things, even if this means changing them from their original intent. All instructional products are appropriated in some way by the end users. For example, group work may actually be done by individuals outside of class; a case designed for a month may last a week; information designed for random computer access may be printed out and read. This actual use is fundamentally outside of the control of the designers. One of the traditional complaints within instructional design is that the designs are excellent but they are never "correctly" implemented. This frustration has led to the notions of getting rid of the teacher and that delivery through technology alone is preferable. But appropriation is a natural, and not necessarily negative, process. By observing how professors and students appropriate complex cases, developers can gain insight about how to improve the case materials and activities and how to build tools that capitalize on their natural use.

Fit

The second major issue in implementing complex cases involves how the case fits within the overall educational environment. How a case fits in with the rest of students' curriculum and educational demands affects the implementation. Complex cases should be related to at least other topics within the course if not multiple courses in a curriculum. They should not be seen as disconnected activities that have nothing to do with other things students are learning. Complex cases require group work. Teams may or may not be a part of the educational culture. If not, steps should be taken to introduce students to this way of working and to provide extra support for this during the case activity. Complex cases are very time demanding, so they should be scheduled at a time when students have fewer demands in their other classes or they should be scheduled for incremental use over a longer period of time. In the AA case activity, it turned out that some student teams had major presentations in another course and many students were worried about their upcoming mid-terms. Thus, some students did not devote sufficient time to the AA case activity and allowed their fellow team members to pick up the slack.

Instructor's Perspectives

A third major issue in implementing complex cases is the instructor's perspective on teaching in terms of having any one "right" answer to the case. Complex cases are considered to have a wide array of possible right answers. The amount of information and context is broad enough to allow for a large number of perspectives to be brought out as key concepts. This should allow for the possibility of the case being reused frequently with a change of student goal. If, however, the general attitude of students, professors, or the program in general is that cases have singular correct answers or are about single issues, the complex case may not be used frequently enough to be cost-effective. It's important that the case be designed flexibly enough that it not focus on a single issue. This way, the case provides sufficient information and context so that the activity can be substantively different each semester by changing the basic question. In this project, the same case materials were utilized twice in the semester by changing the focus of the problem and adding a limited amount of additional case materials.

A related issue with complex cases is the instructor's perspective on teaching in terms of being an authority. He or she must be willing to accept a teaching role that is one of a guide rather than a director. With complex cases, the instructor must hold back and allow students to find their own answers rather than telling them possible answers. It is important for the expert — whether that's the professor, the company visitor or the advanced student — to be careful of revealing too much to the students and to provide a framework that stimulates students to find things out for themselves.

Some Caveats for creating Electronic or Multimedia Complex Cases

A major point for implementing complex cases is to realize that they are not just for individuals. A common problem of utilizing an electronic or multimedia format requiring computers is that many people still see computers primarily for individual activity. Computer laboratories are set up with individual workstations. People have individual and personalized laptop or desktop computers. More often than not, converting learning materials into a computer format may itself contribute to a breakdown of team cooperation in the analysis and problem solving of rich cases.

Our recommendation is for a specific component designed to start the team discussion. In the AA case, the video — which early in the design phase was seen as reference material — ended up as a vehicle for interaction of the student team members. Each team received a videotape and they were encouraged to watch it the first time together. Certainly, a multimedia version of the case with random access to the video at a later time could be useful to students. However, the video as a social vehicle for examining the case and discussion case issues was probably more valuable.

Another major point of design in a complex case is to make sure that the materials are readily accessible. Here again, we confront the dilemma that turning a case into an electronic format may make it less accessible, not more so. In the AA case, a thick stack of 3-hole punched papers were the print materials provided to all students. Students put these papers in binders where they could write on the documents, rearrange them, highlight them or index them. If we had put the AA case into a computer format it would have required a high-end desktop computer which would not have been broadly available either at the university or by the students at home. Several stations in the MBA computer lab could have had the AA case on them, but this would not have been enough access for 250 students. Without appropriate accessibility, an electronic format may discourage people from the type of reading, review and reflection of the materials necessary for the problem-solving nature of the activity.

Conclusions

There are few examples of what we have been calling complex cases. More instructional activities based on complex cases need to be developed and researched to gain a clearer understanding of of their potential and optimal uses. As an example of a complex case, the Automotive Armature case had mixed success. While the students and professors found it more valuable than traditional cases, there were still problems with students compartmentalizing concepts and not integrating their recommendations. However, we still feel that complex cases are a step in the right direction in getting students to develop flexible structures of knowledge. A complex case alone cannot be expected to create an expert. It is a slow and difficult process to develop knowledge and skills in ill-structured domains (Spiro & Jehng, 1990). Students may well benefit from a series of experiences — in the field when possible and through complex cases when not — that allow for exploration and learning without compromising the fundamental complexity of ill-structured domains within professional disciplines.

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Title:

Designing Hypermedia is Hell: Metaphor's Role in Instructional Design

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Many writers suggest that one should employ metaphors in creating hypermedia/ multimedia products. For example, Erickson (1990) suggested that "metaphors function as natural models, allowing us to take our knowledge of familiar, concrete objects and experiences and use it to give structure to more abstract concepts" (p. 66). Rosendahl-Kreitman (1990) suggested that "metaphors, if they are appropriate, are quickly understood" and thus help to reduce the extent to which users need to learn to use the system completely from scratch (p. 1.7). Erickson (1990, p. 72) accounted for this "reduced learning curve" by suggesting that a metaphor, once adopted, brings with it "additional bits of structure that may be useful later on," a suggestion that finds support in the work of Allinson and Hammond (1989), Mitsch and Dubberly (1990) and Thimbleby (1984). Despite these proposed benefits, Semper (1990), Rosendahl-Kreitman (1990), and Vertelney, Arent, and Lieberman (1990), among others, have warned that inappropriate metaphors can cause confusion, misunderstanding, and both navigational and conceptual difficulties for users.

What is unclear, however, is how one can identify an "appropriate" metaphor. What are the key properties of a metaphor and how exactly does one operate? What makes one metaphor more appropriate than another? Is more than one metaphor appropriate for a given product? Can we use multiple metaphors in a product? If so, how do we determine if they interact in ways that contribute to the effectiveness of the product? This paper seeks to address these questions. It begins by examining what a metaphor is and how it operates. Next, it divides metaphors into two classifications and offers an approach for analyzing and selecting metaphors. Several metaphors are then analyzed and methods for evaluating the effectiveness of the selected metaphors proposed. The paper closes by considering whether employing metaphors is worth the effort.

WHAT A METAPHOR IS AND HOW IT OPERATES

Lakoff and Johnson (1980) defined the essence of metaphor as "understanding and experiencing one kind of thing in terms of another" (p. 5). A metaphor compares one thing to another without directly stating the comparison and "the likeness is suggested by terms not literally applicable to each other" (Walsh & Walsh, 1972, p. 165). Mac Cormac (1985) described metaphor in terms of mental processes. He suggested that metaphor is "the creative cognitive process of activating widely separated areas of long-term memory and of combining normally unassociated concepts" (p.147).

How exactly does the process of comparison occur? What brings together Mac Cormac's "widely separated areas" and "normally unassociated concepts"? Mac Cormac argued that "these concepts are juxtaposed in a meaningful manner because at least some of the semantic features of each concept are similar to one another" (p. 147). Mountford (1990) agreed, suggesting that metaphors, through comparison, convey "both superficial and deep similarities between familiar and novel situations" (p. 25). The interaction of similarities and differences, therefore, is the key to the effectiveness of a metaphor.

This seems closely allied with Black's (1979) division of the metaphor into two components, the primary subject and the secondary subject. Black argued that metaphors work by projecting upon the primary subject `associated implications' drawn from the characteristics and uses of the secondary subject. According to Searle (1979), once we identify something as a metaphor, we examine the secondary subject to identify its properties or values and then look for applicability to the primary subject. The impact of a metaphor arises from the interplay of these components (Kittay, 1987). Kittay suggested further that there is tension between the two components of a metaphor because Black's 'associated implications' may or may not seem appropriate to the primary subject.

This tension seems the foundation of Miller's (1979) three-step process in understanding metaphor: recognition, reconstruction, and interpretation. In the recognition step, we perceive the metaphor to be a statement of relation or comparison and not a statement of fact. In reconstruction, we start to rebuild the primary subject in terms of the properties of the secondary subject and to interpret how the reconstructed primary has changed in terms of properties and operations. According to Miller, we cannot separate reconstruction and interpretation because many possible reconstructions exist, some of which fit the context and the user's intent and some do not. Interpretation and reconstruction interact to help us identify and discard inappropriate reconstructions and retain and refine reconstructions that seem suited to the context but still have non-applicable properties. Thus, as Searle (1979) argued, we limit the number of applicable properties to those which we judge most appropriate. Lakoff and Johnson (1980) and Mountford (1990), among others, stressed the importance of this recursive refinement process and suggested that this interactive process plays a major role in reshaping an individual's understanding of the metaphor.

Kittay (1987) categorized properties of the secondary subject as having either affinity or contrast. Properties of the secondary subject that are appropriate to intent and context display affinity, while properties that do not appear to match intent and context display contrast. A property of the secondary subject that exhibits contrast is not automatically excluded, however. Instead, such contrast leads the individual to change his or her "frame of mind"; that is, to modify expectations and interpretations as part of the recursive refinement process. According to Kittay, multiple contrast sets exist and each provides a set of contrasting properties to consider. One might view these contrast sets as a semantic field of interconnected and associated words and concepts. This description of how a metaphor operates seems evocative of Erickson's (1990) definition of a metaphor as "an invisible web of terms and associations that underlies the way we speak and think about a concept" (p. 66).

Paivio (1971) considered metaphor in light of what he termed referential meaning and associative meaning. Referential meaning describes a relation between an image and a verbal label. In this relation, the verbal label and the image evoke one another clearly. They are matched exactly, one to the other. Associative meaning alludes to groupings of associations involving words, images, or both (pp. 84-85). According to Paivio, the semantic system and the imaginal system operate both separately and cooperatively. As the properties of primary and secondary subjects are considered in the recursive refinement process, spread of activation occurs in both systems. Both he and Kosslyn (1983) argued that much of our cognitive "knowledge" is actually dual coded. It exists in related forms in both the semantic and imaginal systems. Metaphor, according to Paivio (1979), may be a particularly effective way of stimulating interaction between the semantic and imaginal systems. Paivio (1986) used the term referential processing to refer to the stimulation of one system by a stimulus in the other system. Associative processing, on the other hand, is the process by which a stimulus subsequently stimulates other items within the same system. The two processes constitute the spread of activation within and across the two systems. These interconnections between systems "are not assumed to be one-to-one but, rather one-to-many, in both directions" (Paivio, 1979, p. 63).

Images may be more easily modified in the refinement process than are semantic items (Ambron, 1990; Bugelski, 1971). That is, the spread of activation within and across systems may enable one image to evoke another in a constantly changing pattern of relations and comparisons. de Bono (1967) labeled this property of imaginal modification "fluidity and plasticity" (p. 83) and suggested that one could modify images and their related properties more quickly than one could make similar modifications in verbal labels or expressions. According to Gibbs (1992), our mental schemata reflect metaphorical structures based on common cultural and linguistic experiences. We recognize, without formal thought, that a particular metaphor reflects these metaphorical structures, and our unconscious recognition stimulates us to focus on related associations within those structures.

THE RELATIONSHIP BETWEEN METAPHOR AND GRAPHICAL USER INTERFACE

If, as authors cited above have contended, a metaphor helps users -- particularly novice users -- understand how a hypermedia/multimedia product works, then how is the metaphor implemented? It is clear how writers of books and speakers employ metaphors. They can write, "He was a bear of a man," or state that "politicians are vultures feeding on lost herds of inattentive voters." Although computer programs are not necessarily written or spoken expressions, they are capable of using metaphors in the content they deliver. Hypermedia/multimedia's more likely use of metaphor, however, is as visual metaphor. The vehicle by which they convey visual metaphors is most frequently the interface. Today's interfaces are often graphical. That is, they employ pictures and illustrations that make the screen and interface appear to be something other than a blank screen on which text or illustrations appear. Graphical user interfaces (GUIs) often employ icons (little graphical images or pictures) to represents options and actions. They also often employ a general screen appearance that may resemble something other than a computer screen. These visual metaphors, then, represent the use of metaphor in hypermedia/multimedia products.

TWO CLASSES OF METAPHORS

For purposes of discussion, let us divide metaphors used in hypermedia/multimedia products into two classes: underlying (or primary) metaphors and auxiliary (or secondary) metaphors. An underlying metaphor is the principal or first metaphor employed, while an auxiliary metaphor is a subsequent metaphor employed by the product. Some hypermedia/multimedia products may employ only underlying metaphors, while other may employ one or more auxiliary metaphors in addition to an underlying metaphor. The trick, it would seem, is to select auxiliary metaphors that are consonant with the underlying metaphor. In the words of Kittay (1987), we need to look for auxiliary metaphors that exhibit a fairly high measure of affinity and do not exhibit excessively contrasting properties. How is this determined, however?

If we use Paivio's work as a basis, we may look for a combination of associative and referential processing. That is, we could look for auxiliary metaphors that stimulate images and semantic expressions related to those stimulated by the underlying metaphors they are intended to accompany. One may think of the underlying metaphor as establishing the general context into which the auxiliary metaphor must fit. Properties, operations, phrases, images, and types associated with the underlying metaphor may provide the imaginal and semantic links to related metaphors that might serve as auxiliary metaphors. Thus, one might begin by selecting an underlying metaphor and then begin systematically to identify related properties, operations, phrases, images, and types (POPIT). Once these were identified, in addition to helping to determine the key features and functions of the graphical user interface (GUI) based on that underlying visual metaphor, they might also suggest promising auxiliary metaphors.

APPLYING THE POPIT APPROACH

What does this approach offer us? Let's examine two frequently used underlying metaphors. Applying the process and generating ideas in each of the five areas is not necessarily a linear process. An idea generated in one of the five areas may stimulate ideas in other areas. This tendency to 'hop around mentally' is typical of brainstorming activities (Osborn, 1963) and perhaps offers some empirical evidence of Paivio's earlier discussed theses on the spread of activation.

The Book

Many hypermedia programs employ the book metaphor. That is, one thinks of the product as a book and each screen becomes a page. The GUI might well, therefore, portray the screen as a book, perhaps with binding on one side and pages of text on the other or with a page of text on the left side of the screen and a page of text on the right side and the binding down the middle of the screen . In fact, the book metaphor is the one employed by Asymetrix's ToolBookTM hypermedia/multimedia authoring tool to help authors understand how to build a product. Similarly, the graphics needed to implement the book metaphor are supplied by Apple with their authoring tool, HyperCardTM, although Apple actually uses index card (underlying) and stack of cards (auxiliary) metaphors in the accompanying literature.

First, let's consider the properties of a book. A book has a front and back cover. It is bound. It is printed on paper. A book has pages. Pages may contain text, illustrations, photographs, or a combination of the three. Pages are numbered. Pages may be organized into chapters. The table of contents comes after the title page but before the main body o text. The index comes after the main body of text. A book has an author or authors. It may have an illustrator. Books have publishers. Books are sometimes published in later editions.

Second, what operations does one perform in using a book? One picks up a book. We may take it from a bookcase or shelf and we may return it to that shelf or bookcase when finished. One opens a book. We may scan a page or we may read it. If there are illustrations or photographs, we may examine those. We can reread difficult passages. One turns pages forward and backwards. One may use a table of contents to determine what is to follow and an index to help locate references to any particular phrase, term, or name. One can look ahead in a book or look back to re-examine something read earlier. One can stop reading whenever one wishes. One can mark one's place with a bookmark. The text in a book may be read silently or aloud. If one owns the book, one can mark in it. One can copy material from a book, either by hand or using a copy machine. Some people moisten their fingertips before turning a page.

Third, let's note that phrases (or terms) associated with books and reading include: binding, pagination, tome, read aloud, read silently, turn pages, mark your place, open, close, begin reading, thumb through or page ahead, quit reading, fold the corner of the page down, underline, highlight, write marginal notes, margins, and read with your finger.

Fourth: Images associated with books include favorable ones like leather bound books, illustrations, onion skin paper, and the smell of new paper in new books; unfavorable ones like dog-eared or smudged pages, the smell of mildew or mold in old books, and trails from hungry silverfish; and neutral ones like hard covers, soft covers, hefty books and paperback pocket books.

Lastly, let's identify types of books. Reference works include dictionaries, encyclopedias, atlases, thesauruses, almanacs, and the like. Recreational books include the paperback pocket book, the mystery, science fiction books, fiction and non-fiction books, comic books, magazines, and others. Scholarly books include textbooks, the Bible, Torah, Koran, law books, and other similar works.

How do these five areas affect how we implement the book as the underlying metaphor? The book metaphor carries with it organization and sequence and a variety of implied assumptions about how one uses a book, and thus, any product 'like a book.' As suggested earlier, we would expect the product to use pages and we would expect to be able to "turn" pages -- that is, to move forward or backward by pages. We might well expect pages to be numbered and organized into chapters. We might expect to see a table of contents and to be able to use an index to locate particular material. Since books contain primarily words, illustrations, and photographs, we would expect to see these in a product using a book as the visual metaphor for its GUI. We might well expect to open and close the book. We would hope to be able to stop whenever we wished and to use a bookmark to mark our place. Many readers might like to be able to mark in their books. If so, the product would need to permit underlining or highlighting. If it wished to allow the user to write marginal notes, logically, it must first have margins. To avoid a "smudged" look, any underlining, highlighting, or marginal notes would need to appear in a fashion that did not reduce the readability of the page. If the product were to echo associated phrases, perhaps the last page one read before stopping would have its page corner "folded down" until one started reading again, at which time the page corner would "unfold," thus avoiding the problem of dog-eared pages. Similarly, might the product permit thumbing through or paging ahead?

What auxiliary metaphors might accompany the book metaphor? One auxiliary metaphor might be the tab. Some books -- usually reference works (taking our cue from types) -- have tabbed sections. These tabs permit the user to move quickly to important or frequently used sections of the book. In many books, tabs are cut into the pages and are rounded to accommodate the tip of the human finger. Other times, the tabs project beyond the edge of the page so that they act as dividers separating the sections of a book. A product using the tab metaphor would be expected to present the user with similar appearances and properties.

This suggests a second auxiliary metaphor (this one derived from phrases): the finger/thumb metaphor. Perhaps the product could employ images of a finger in some way as a pointer, a place marker, or an indicator. Perhaps the product could use the image of a thumb in some way to indicate the ability to thumb through or thumb ahead. The auxiliary metaphor here is one of making the interface in some way parallel the use of fingers and thumbs in reading.

A third auxiliary metaphor, this time based on operatio- ,ht be the copy machine. Might the product in some way facilitate copying, using images that mirror the way books are actually copied? Could the operation resemble the process by which one uses a copier, including such features as variable number of copies, enlargement and reduction copying, collated copies, and two-sided copying for bound copies? Would the book be opened faced down on top of the copier? Would copies come out one side of the copier?

The identified types of books offer another suggestion. Perhaps a fourth auxiliary metaphor might be the overlay metaphor. In encyclopedias one may find a set of transparent overlays bound into the book. These overlays enable the reader to "build" an image out of several layers or to "uncover" lower or internal levels by removing layers. The most frequently encountered example of such a constructed image is probably the 'visible' human body: One layer shows the skeleton; one shows the internal organs; and one shows the skin. We would expect the layers to "flip" in the direction of the binding. In most cases, for books written in English, we would expect to uncover by lifting from right to left and to build by placing transparent overlay pages from the left on top of similar pages on the right. If the binding were at the top, we would expect to build by lowering overlays from the top and to uncover by lifting pages from the bottom. A product employing the overlay metaphor would be expected to have some pages that permitted the user to build and uncover images in keeping with this metaphor.

A fifth auxiliary metaphor -- also drawn from types -- might be the pronunciation key. Dictionaries and similar reference books often include a printed pronunciation key. This is a set of letters and phonetic representations that are intended to help the user figure out how to pronounce a word properly. A product implementing this auxiliary metaphor might provide the user with the ability to hear the word pronounced. This is clearly the first auxiliary metaphor that goes beyond the normal capabilities of the object or device to which the GUI is being compared. Books do not normally speak to their readers. For the present, however, let's accept this implementation as valid. We will consider in the next section of this paper whether this is a legitimate addition or a violation of the underlying metaphor.

A sixth auxiliary metaphor based on operations is the shelf/bookcase metaphor. If a hypermedia/multimedia product is a book, then it can be part of a shelf of books, perhaps organized by topic, time period, or some other common trait. If related books reside on the same shelf, then perhaps a bookcase houses shelves of related volumes. Perhaps one could draw books from different shelves as needed. Perhaps, as is the case in research libraries, users could "read" the shelves for interesting books, confident that they are "in the right section" because related books are shelved together. Among other functions, this auxiliary metaphor might be used to help organize related products in the same line.

The Map

Another visual metaphor for a hypermedia/multimedia product's interface might be the map . Thus, using the map metaphor, the screen becomes a map of a place.

Properties of maps: Maps generally focus on contiguous areas or locations. Maps have legends that explain the symbols they use. They have locations that are spatially related to one another. Maps may represent various properties of the places they represent. Individual maps often fold. Maps are often hard to refold. Many maps fold out to be large. Maps are often complete on one side of the page. Some maps, particularly those in atlases or book form, will have notes at the edges of individual maps to inform the user of where that map connects with a related map. Maps often use very small print. Many maps use color to help users distinguish features and relations. Maps, particularly those that depict routes, usually provide an index of street or location names. Route maps often supply tables of distance or travel time as aids to users. Some maps include enlarged views (insets) of important areas, such as cities.

Map operations include unfolding and refolding, reading the legend, getting the map oriented in terms of what you're looking for, marking your route, and noting interesting locations along a route.

Phrases include getting one's bearings, figuring out which way is up, reading the map, finding the best route, plotting a course, getting the lay of the land, calculating distances or times, no one could refold this thing, men never use maps or stop to ask directions when lost, 'x' marks the spot, you are here, and putting your finger right on it.

Among the images that come to mind are maps covering table tops; the difficulty of reading a map in a constricted space like a car, the difficulty of reading the small print; the difficulty of refolding a map without creating an awkward bundle; and the colorful and pleasing appearance of well produced maps.

Types of maps include topographical and geophysical maps, geosocial and geopolitical maps, directional or route maps, maps that depict demographics -- characteristics of the people who live in the places depicted -- and maps that describe properties of the region represented, such as economic maps. Maps may be presented individually or as a set (atlas).

What are the implications of our POPIT analysis? We would expect any hypermedia/multimedia product that used a map as its underlying metaphor to use the map to depict spatially related locations. It should include a legend to explain any symbols involved and should indicate which way is up (phrases). Color might serve to help define relationships. Products using the map metaphor might offer indexes to street or place names or tables of distance or time.

From operations: An accompanying auxiliary metaphor here might be the inset. A product that implemented the inset metaphor might be expected to include enlarged views on screen. Another option here, drawn from properties and images, might be to think about how users obtain enlargements when none is provided: the magnifying glass. Perhaps the magnifying glass metaphor could serve as an alternative auxiliary metaphor to the inset. The product would then make available to the user a magnifying glass that, when passed over the surface of the map, revealed greater detail. In a typical mouse- directed GUI, one might expect to see the traditional pointed arrow mouse pointer replaced by a magnifying glass. The images on the map would then become enlarged as the user moved the mouse and its correlated magnifying glass over the surface of the map on the screen. In the case of the magnifying glass, as in the case of the pronunciation key, we have shifted slightly from the original device (the inset). We have not changed the intention. What we have changed, however, is how that intention is accomplished.

From properties: Since individual maps fold and unfold, products could use the folded map auxiliary metaphor to make it possible to have access to many maps from the same screen. Maps could be unfolded and refolded. Noting the difficulty many people have in refolding maps and the sense of frustration that act can produce (see properties, phrases, and images above), the product could attempt to automate the process in a visually -- and perhaps auditorially -- satisfying way.

From types: A collection of products based on the map underlying metaphor might be clustered together using the auxiliary metaphor of atlas. Like the shelf/bookcase metaphor, the atlas metaphor makes it possible to organize an entire line of products in a way that makes clear to the user their relationships to one another. Taking a cue from properties, these relationships might be clarified further by notations on the edges of maps stating which other maps connect to those edges.

EVALUATING METAPHORIC INTERACTION: COMPLEMENTARY OR CONFOUNDING

We have attempted above to derive a network of related or associated elements that help to define and describe an underlying metaphor. We have then used those elements to help us identify how we would expect a hypermedia/multimedia product employing that underlying metaphor to operate. In addition, we have examined a number of possible auxiliary metaphors one might use in a product based on a specific underlying metaphor. In Kittay's (1987) terms, we have attempted to use an analysis of these elements to help us identify implementations of the metaphors that exhibit high degrees of affinity and acceptable levels of contrast. Stated in simpler terms, our goal is to implement visual metaphors that operate in ways that are consonant with the experiences of our users in working with the object or device to which we are comparing our product's interface (our underlying metaphor). Thus, a product based on the book metaphor should (1) bear some visual resemblance to a book and (2) operate in ways very similar to (consonant with) how a 'real' book operates. Similarly, auxiliary metaphors should complement -- add to, enhance, help make complete -- the underlying metaphor. When contrast occurs, it should be of a type that encourages users to reinterpret and reconstruct (Miller, 1979) their understanding how the interface operates. If users finds that the contrast is too great, however, one might expect them to reject the comparison. When this occurs, we may term the interaction between the underlying and auxiliary metaphors as confounding. The
interaction between underlying and auxiliary metaphors is, therefore, either complementary or confounding.

Since our earlier examples have all attempted to be complementary implementations, this seems a logical time to examine some implementations that seem confounding. Consider a product having as its underlying metaphor the book. An auxiliary metaphor of a videotape player seems clearly confounding. A book may not contain a videotape player. When users are faced with such an auxiliary metaphor they are required to reconstruct the environment radically, envisioning a book that is unlike any that the user has ever seen. Users seem unlikely to make such radical reconstructions. Instead, what they will probably do is to decide that some parts of the product act 'something like a book' and others act like other things. When users come to this conclusion, the benefits of the underlying metaphor are greatly reduced. The dynamic tension inherent in the metaphor (Kittay, 1987) is removed; the user no longer feels compelled to interpret and reconstruct to make the metaphor fit.

Consider a product that employs an underlying metaphor of the map. While the earlier discussed auxiliary metaphor of folding seems complementary, an auxiliary metaphor of a toolbox seems confounding. We would not expect maps to contain toolboxes. No reconstruction that the user may perform can create a map capable of offering boxes of tools. Instead, the user will most likely decide that some parts of the interface operate 'like a map' and other parts operate in some completely different way.

Earlier in this paper we considered two auxiliary metaphors that seemed perilously close to confounding. The first, the pronunciation key, offered users a chance to hear a word pronounced when they clicked on it. The second, the magnifying glass, offered users the chance to pass a magnifying glass over a portion of the screen in order to see an enlargement of what appeared on the screen. Why are these two metaphors not confounding? Let's examine them.

It is worth noting that there are published books -- mostly for children -- that do offer the reader the chance to hear recorded sound played back. In fact, one can buy greeting cards that play tunes or messages and picture frames that, in the words of their marketers, "allow your loved ones to hear your recorded message each time they touch your picture." Thus, users may well be able to reconstruct their interpretation of the product as a book that -- like those children's books and the greeting cards -- is capable of allowing them to hear a recorded sound. Another reason that this metaphor may work is that readers using a printed pronunciation key in a book usually attempt to use that guide to pronounce the word aloud as they read it. Users may, therefore, be accustomed to hearing the pronunciation as they read the key. While the product's implementation changes the source of that aural stimulus, it does not seem excessively dissonant with users' own experiences (Brown, 1988).

It is also well within most users' experiences to use a magnifying glass to read printed materials that are small. In addition, when reading a map, one might well lay the magnifying glass down on the map outside the area one was currently examining and then lift it and pass it over any area one wished to see enlarged. Thus, although maps do not contain or offer magnifying glasses, the use of the one with the other can easily be reconciled, and the user can reconstruct the metaphorical comparison in consonant ways that enhance the interaction.

How then do we handle our need to include such functions as video segments and tools in hypermedia/multimedia products? One way would be to select as underlying metaphors ones that permit us to include a wider range of auxiliary metaphors. While a book cannot offer a videotape player, many settings could offer such a device. For example, it would not be unreasonable to find a videotape player in an entertainment center or production studio. It also would not be unusual to find books in such settings. By selecting a broader underlying metaphor, one can include more auxiliary metaphors. A second way to include needed functions might be to consider ways in which the subject of the underlying metaphor might offer similar functions. For example, an electronic journal might be handled in the form of marginal notes or notes written on a separate pad while reading. A third possible solution might be to think of the metaphor less in terms of places and things and more in terms of events or chains of events. That is, one could use a metaphor that involves a sequence of events, like traveling, where location and function change in predictable ways that invite the use of multiple auxiliary metaphors. Thus, in traveling, one might get tickets or make reservations, board the method of transportation (embark), travel on board -- with whatever events occur thereon, arrive at one's destination disembark), have experiences at the new location, re-board transportation, travel back, and disembark at the original location. Since the concept of traveling is predictable and yet varied, traveling may prove a useful underlying metaphor. Traveling on a plane offers its own set own events that differ from the events available on a cruise or in a car. It is not difficult to think of other similar sequential metaphors. One that come quickly to mind include chronology (particularly in terms of birth to death), production (perhaps from raw material to finished product), and construction (for instance, foundation to roof) or its inverse, demolition.

METAPHORS RECONSIDERED

By now, it should be clear why this paper's title compares the process of selecting appropriate metaphors to the damnation of the underworld. The process is neither uncomplicated nor free of risk. It is difficult to decide how much or how little metaphor to use. While an interface devoid of metaphor may require more effort from its users because it does not permit them to use other, non-computer experiences to assist in understanding and predicting the actions of the interface, an interface encumbered with too many metaphors may overwhelm users, leaving them confused, irritated, and worse off than in a many chunks of information one can handle and Furukawa's (1970) research on cognitive load, designers may wish to choose one underlying metaphor and no more than five to eight auxiliary metaphors. The more closely these auxiliary metaphors are related to the underlying metaphor, the less additional cognitive load their presence should place on the user (Andre & Phye, 1986; Oren, 1990). That is, the less difficult it should be for the user to recognize how they relate to the underlying metaphor and to one another and the easier it should be for the user to incorporate them into a unified interpretation of the interface.

Not everyone supports the use of metaphor in hypermedia/multimedia products. For example, Nelson (1990) argued that dependence on the use of metaphors for all aspects of a multimedia system could kill a product. Extensive use of metaphor is undesirable, according to Nelson, because the relationship between the product and the object or device to which it is being compared is usually tenuous at best and, once a metaphor is implemented, everything has to become a part of it. He suggested instead that designers identify "well-thought-out unifying ideas, embodied in richer graphic expressions that are not chained to silly comparisons" (p. 237).

While anyone who has had the opportunity to observe a large enough sample of hypermedia/multimedia products can attest to the existence of numerous examples of just such misuse and overuse of metaphor, this fact may be more reflective of inadequate analysis of the metaphors employed and lack of attention to the relationship between underlying and auxiliary metaphors than of the weaknesses of metaphorical thinking itself. Nelson's argument that we should use 'richer graphic expressions' seems reasonable, but those graphic expressions are themselves rooted in metaphorical thinking. Few things on a computer screen are what they appear to be, particularly in a GUI. As Langer (1958) noted, a label is not what it describes, nor, as Magritte pointed out, is a picture that which it represents. Recognizing this, an earlier work proposed a model for considering the properties of the graphics used as icons (Cates, 1993). It seems unlikely that we can -- or should -- avoid metaphors in hypermedia/multimedia products. As Lakoff and Johnson (1980) suggested, metaphorical thinking is so pervasive in our society that we cannot avoid it. If dual coding plays a major role in the operation of our cognitive processes (Paivio, 1986), users cannot easily separate the image from the related verbal label, nor can they isolate themselves from the associated spread of activation that occurs naturally when they are exposed to either verbal labels or images.

Laurel (1990) suggested that, "People transform their interfaces. Interfaces also transform their users" (p. 91). As designers, we face two choices: (1) We can ignore the spread of activation in the users of our products and pretend that interfaces are not affected by this spread of activation, or (2) We can do our very best to analyze metaphors, predict the likely types of activations, and consider the ways in which users interact with our interfaces. The latter choice seems the only reasonable one. Making this choice calls for a commitment, however. In order to produce the most effective interfaces, we will need to analyze our metaphors carefully before we decide to include them in our products and we will need to collect and analyze data on how users interact generally with our products and specifically with the metaphors those products contain.

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Title:

New Directions for Research on Graphics Design for Interactive Learning Environments

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INTRODUCTION

The relationships among graphical, motivational, and learning variables are complex in any instructional method, but especially in interactive learning environments. Whereas media such as textbooks and television basically provide graphics or video images for passive viewing, computer-based media incorporate graphics that engage learners in more dynamic ways (Nishida, 1992; Alesandrini, 1987). The two (and sometimes three) dimensional integration of graphics with text as an integrated whole in interactive learning environments has the potential to motivate students to interact more directly and voluntarily with graphical information. This potential is greater than in printed materials in which graphics often play a more ancillary role.

Some maintain that computer graphics design has entered a new era with the advent of 3-D animated graphics and virtual reality systems (Wooley, 1992). The principles underlying the role of graphics in motivating students and supporting their knowledge and skill acquisition must be incorporated into the design of all types of interactive learning environments, especially if these environments are expected to support higher-order learning such as the construction of mental models (Friedman, 1993). If the hypothesis that graphics play an important role in helping students to acquire knowledge and skills and/or in increasing students' motivation to persevere in computer-based learning, then guidelines for the design of interactive learning environments should include prescriptions for the use of graphics that maximize motivation and learning.

There is a body of literature that addresses design guidelines for integrating graphics into computer-based instructional materials (e.g., Alesandrini, 1985; Alesandrini, 1987; Faiola & DeBloois, 1988; Marcus, 1992; Morrison, Ross, O'Dell, Schultz, & Higginbotham-Wheat, 1989). However, the guidelines are mostly concerned with how the technical aspects of graphics (e.g., color or realism) can be integrated into the design of computer-based instruction. Although the integration of technical innovations (more colors, more pixels, faster access times) provides a wide variety of new opportunities for instructional designers to dazzle their audiences, the justification for using specific graphic representations and treatments should be based upon a "learner-centered" perspective, rather than a "technocentric" one (Rieber, 1989a). In other words, instead of evaluating interactive materials based on how well the capabilities of the hardware and software are utilized, it is much more important to assess the roles graphics play as instructional dimensions that enhance learning and motivation.

Despite the widespread use of graphics in instruction, the psychological literature about "how" people acquire knowledge and make inferences from graphics is sparse. How learners integrate text and graphics and whether their ability to learn from graphics varies with their level of visual literacy, experience, or expertise within a specialized domain are also unresolved questions (Friedman, 1993). There is some evidence that people with different experience in a specific knowledge area employ different strategies in viewing and interacting with graphics (ChanLin, 1993; Horton, 1991). For example, given specific instructional objectives, the use of abstract graphics to present scientific information to more-experienced viewers might be contradicted with less-experienced viewers. Unfortunately, there are few empirically-based guidelines about how best to convey a specific graphic image to learners that have different levels of familiarity with the content of the graphic. Instead, research in graphics in interactive learning environments (and other media for education and training) has focused on the physical variables of graphics, such as pictures vs. drawings or color vs. monochrome or large vs. small displays (cf., Friedman, 1993). What we really want to know is how graphics enhance motivation and support learning across many different individual characteristics, objectives, media, and other instructional dimensions.

The main objective of this paper is to review research that has been conducted related to the use of graphics and how various design variables interact with graphics in influencing the process of learning within individuals. It is also the intent of this paper to describe research directions and approaches that may provide enhanced guidelines for integrating graphics into future interactive learning environments.

PREVIOUS RESEARCH ON GRAPHICS

In the past, graphics research focused extensively on the effects of graphics in various media (e.g., in books versus computer-based instruction) or in various formats (e.g., static versus animated). The primary methodologies employed in these studies involved comparing different types of instruction with different graphical treatments. The findings of this research are not always in favor to the use of graphics or specific graphical formats. For example, a specific graphic format might be found to facilitate memorization among a specific group of learners engaged in a specific recognition task, but fail to achieve the same instructional intent among another group of learners or with a different task (Dwyer. 1987). Although it is dismaying that so many of the graphical design guidelines have been issued in the absence of empirical evidence (Friedman, 1993), this tendency simply reflects the complexity of establishing the effects of graphics in interactive learning environments. The situation is further complicated by the fact that what limited research base exists was established in relatively simple computer-based displays (e.g., forty characters, line drawings, and eight colors on one screen) rather than in the multi-windowed, photo-realistic, full-spectrum computer presentations that are the hallmark of contemporary interactive learning environments.

Following precedents set by traditional graphic researchers, many recent studies have tested hypotheses using interactive systems that were already examined in text and other media. Each of these studies has taken a slightly different perspective on how to improve learning from graphics. For example, some studies focused on comparing the relative learning effectiveness between computer-based instruction (CBI) with graphics and CBI without graphics (e.g., Alesandrini & Rigney, 1981). Other studies were carried out to examine the relative effectiveness of different degrees of realism in computer graphics (e.g., Gage, 1989). Still others compared the use of different graphic cues in guiding students' attention (e.g., Beck, 1987). These studies tried to support the assumptions and beliefs of proponents of CBI about the role of graphics in interactive learning. Example beliefs include: 1) pictures are effective because they are easier to perceive than verbal information; 2) learning is somehow proportional to degree of fidelity in graphics; and 3) pictures provide redundant codes for processing information.

Some of these studies have provided interesting results. For example, several studies have been conducted to compare graphical versus verbal instruction in guiding comprehension of science content within different scientific fields. Rigney and Lutz (1976) compared two versions of chemistry CAI tutorials, an all-verbal presentation and a verbal-plus-graphics presentation. The results showed that learners who studied the verbal-plus-graphics version scored higher on tests of knowledge, comprehension, and application of concepts. More favorable ratings of the learning materials were also obtained from the verbal-plus-graphics group.

To test the effects of graphics in CBI, two experimental studies were conducted by Alesandrini and Rigney (1981) in introductory psychology courses. In the first experiment students were assigned to either all verbal or verbal-graphic conditions; learning results favored the verbal-graphics presentation. The second experiment was conducted to test the effectiveness of a pictorial review task compared to a read-twice control. The results indicated that the pictorial review condition facilitated performance more than re-reading; pictorial review produced more favorable attitudes as well. If these studies were exemplary of most of the extant research, the hypothesis that pictures provide beneficial effects in terms of guiding and reinforcing learning in CAI would be strongly supported.

Unfortunately, the support for using graphics in interactive instructional materials is inconsistent. In a reading comprehension study, Edyburn (1982) found no significant increase in performance for a graphic CAI group compared with a non-graphic CAI group. In learning comma usage, the results of Smith's (1985) study showed that a graphic treatment was not significantly better than a non-graphic treatment. Surber and Leeder (1988) reported that provision of graphic feedback in CAI materials did not enhance either achievement or motivation in spelling. One explanation for the inconsistent results among these studies may be that related variables such as variation in learners' abilities, differences in the nature of the learning tasks, and variance in design quality across different CAI programs have not been sufficiently assessed or controlled in the studies. In short, the relationship between graphics and learning is probably much more complex than the relatively simplistic research designs employed to date can handle.

Whereas some designers of interactive learning environments seem to believe that graphics should be as realistic as possible to enhance motivation and learning, the degree of realism required in graphics may vary for different instructional tasks (Dwyer, 1970). Gage (1989), for example, used three different formats for computer graphics among three treatment groups. The three treatment groups used highly realistic graphics, moderately realistic graphics, and slightly realistic graphics. A control group received text instruction with illustrations. The analysis of posttest scores with the pretest as a covariate showed significant differences between treatments. The results showed that the treatment with the least realistic graphics had the highest achievement. Highly detailed graphics did not contribute to learning in this study.

Interpreting this study requires the researcher to consider cognitive and metacognitive process rather than simple perception variables. Perhaps the main function of graphics in some contexts is to help students learn by differentiating relevant cues. Therefore, excessive realism may actually interfere with the transmission of information because irrelevant cues might also be activated in processing the information from realistic images. From the standpoint of economy and instructional effectiveness, simpler graphics may interfere less and thus be more effective. Dwyer concluded that different graphical formats assist learning and comprehension differently (see reviews by Dwyer, 1970, 1988). According to Dwyer, if the purpose of instruction is to bring the students into close touch with reality, e.g., to encourage an emotional response, a realistic graphical format may be more effective than an abstract one. The appropriateness of realistic details in graphics is related to differences in the learning tasks given to the student, the time allowed for interacting with graphics, and the cognitive capabilities of students to process the information provided in the graphics.

GRAPHICAL, MOTIVATIONAL, AND LEARNING VARIABLES

Although the integration of new design elements (e.g., QuickTime movies) is a popular trend in producing graphics for interactive learning, the theoretical and empirical foundations for their use have not been established by research. It appears that many dimensions of graphics themselves are poorly understood with respect to their instructional effects and implications for design. Which format of graphics to use, when to use it, how to use it, what to use it with, and to whom to apply it are all reasonable questions that suggest the complexity of the relationships among graphics, motivation, and learning.

Some researchers and theorists have attempted to deal with this complexity. For example, Kaufmann (1985) found that the effects of graphics vary with task familiarity and problem-solving mode, with imagery being particularly useful in novel situations. Other studies have examined the effects of different elaboration of visual materials in different levels of practice in computer-based learning materials (e.g., Rieber, 1989b; Rieber, 1990a, b; Rieber, Boyce, & Assad, 1990; Rieber & Hannafin, 1988). Researchers also investigated the affective effects of graphics, such as in meeting emotional needs, as an essential element in supporting motivation and knowledge acquisition (ChanLin, 1993; Eisner, 1985). These studies assume that the relationships among graphics, motivation, and learning should not be studied unless both the characteristics of learners and the learning environment are well integrated into the research.

Task differences may also play an important role in explaining the effects of graphics. Cunningham's (1988) meta-analysis concluded that the most effective subject areas for employing computer graphics in learning materials are: geometry, physics, chemistry, and health education. Cunningham reported that representational graphics were the most widely used graphic level in these subjects, while animated graphics were the most efficiently employed graphic form.

Different tasks and different access conditions for interacting with pictures may also influence the level of understanding learners achieve from graphics. Thomas (1989) studied computer graphics integrated into a problem-solving activity. He found that task differences influenced the level of interaction with graphics. Computer graphics integrated into problem-solving activities improved students' attitudes and achievement in learning functional concepts, but not in learning transformational concepts. In addition, compared with a divergent approach (students allowed to change graphics throughout the activities), the convergent-task approach (select a picture to work with throughout the activities) resulted in higher levels of task-motivation and helped students develop a better understanding of functions.

Computer graphics may also be employed as a learning aid in terms of a memory organizer for formation of concepts. For example, Krahn and Blanchaer (1986) use computer-generated graphics as organizers to help students learn medical concepts. Steinberg, Baskin and Hofer (1986) and Steinberg, Baskin and Matthews (1985) used computer-generated graphics as a memory tool for students to employ in problem-solving tasks. Presenting key information in instruction together with visuals can serve as a memory cue for encoding and retaining the knowledge concepts.

There is also evidence indicating that graphics might have differential effectiveness with different types of learners. In a study of the effects of computer graphics in first year algebra CBI, Payne (1988) investigated the effects of instruction on solving equations graphically to instruction on solving linear equation algebraically. There were no significant differences between experimental subjects (using computer generated graphs prior to traditional instruction) and control subjects (receiving traditional instruction only). However, students with high general reasoning or computational learning scores who had the graphical treatment achieved more on higher level behaviors than their counterparts who experienced the algebraic treatment.

The use of different instructional strategies may also influence the degree to which students can benefit from specific types of graphics. To evaluate various strategies used together with graphics in an algebra word problem-solving program, four experiments were conducted among undergraduate students (Reed, 1985). It was observed that the effective use of graphics requires a "learning by coaching" condition, especially for low achievement students. From Reed's (1985) and Thomas' (1989) studies, it is suggested that the instructional strategies employed for presenting graphics may influence the way information is processed and encoded.

Although using pictures might promote deeper levels of mental processing during encoding, their presence may provide little facilitation of memory tasks in other contexts. Rieber and his colleagues examined the effects of computer animated graphics in physics instruction among different grade levels (Rieber, 1989b; Rieber, 1990a, b; Rieber, Boyce & Assad, 1990; Rieber & Hannafin, 1988). They speculated that animated presentations provide clear and precise external illustrations to help students visualize physical laws which involve changes in speed and the path of travel. However, they found that the optimal use of animated graphics was related to cognitive practice activities employed by learners. In short, learners' metacognitive processes play a much more important role in interpreting and reconstructing their understanding of concepts than graphics per se. More research investigating how learners interact with graphics metacognitively and how graphics should be presented to help the conceptual reconstructing process is essential.

In some quarters visual thinking is considered an important way of learning problem-solving and promoting creativity (O'Connell, 1992). Reed (1985) as well as Treadgill-Sowder, Sowder, Moyer, and Moyer (1985) have shown that graphic presentation of mathematical story problems can lead to improved performance. However, creativity and visual thinking are difficult to measure. Although some studies indicate that higher level learning tasks benefit most from the graphics enhanced instruction, the effects of graphical representations used in higher level learning tasks are elusive and immeasurable (Brown, 1992; Levie, 1987). Good reasoning skills depend crucially on the vigorous exercise of imagination (Perkins, 1985). Graphics may provide support for visually processing information to generate multi-dimensional links for imaginative problem solution. In any case, it should be clear that justifying graphics in interactive learning environments goes beyond the measurement of their effects on academic achievement (Levie, 1987).

DIRECTIONS FOR FUTURE RESEARCH

Empirical research in graphics has focused rather extensively on picture-text differences and physical variables (e.g., color vs. black and white) to the exclusion of other relevant factors, such as differences in instructional purposes, differences in graphical presentations, and the interactions among perception, learner characteristics, and knowledge level. The research cited above seems to suggest that the optimal use of graphics is determined by more than visual factors such as color cueing, labeling, realism, and animation. Research based principles are needed that describe the level of practice permitted with graphics, variations among the cognitive tasks required in various subject areas, and how learners actually employ their own strategies to mentally integrate the graphics and the images they generate when processing information.

Of course, research findings about whether graphical information is perceived and remembered better than text, or which format of graphics is more efficient than others, are always conditional. The condition is determined by variables specified by the group of learners tested, the types of tasks given, the kinds of strategies instructed, and the graphical treatments in the study. For example, although some studies have found simple line drawings more effective than other formats for promoting learning, considerable variation exists among researchers in defining graphic formats from simple to complex. How realistic must a picture be to be defined as a realistic representation or how simple must a picture be to be defined as a simple representation? More importantly, how can these research findings be applied in commonplace instructional settings? The same concern is observed with respect to the cognitive practice given to the learners. Studies have found that embedded questions promote the use of graphics in learning because they allow deeper levels of cognitive processing. However, how much practice is enough for different types of learners? Other questions persist. How should questions be presented with graphics to achieve a given learning task? What level of processing of graphics is actually employed by learners in a given learning task?

Our review of several years of research in graphics indicates that the effectiveness of visuals is not equally observed among different groups of learners for different kinds of objectives when integrated with different kinds of instructional strategies. The bottom line appears to be that even the research-based principles revealed by researchers in the past are specific to the testing situations in which they were found, with only limited potential of generalizability to different learning situations.

Graphics researchers try to study the complexity of the real world by testing hypotheses devised from a narrow range of literature (Levie, 1987). "An aerial view of the picture research literature would look like a group of small tropical islands with only a few connecting bridges in between." (Levie, 1987, pp. 26). People who conduct picture research usually ally their research to some field, and tend to focus on the literature in their own area, such as perception, picture recognition, picture memory, concept learning, or problem-solving. Much graphics research tries to answer questions from a single perspective. Dealing with the complexity in learning in interactive learning environments is a major challenge.

One of the problems with the existing research base is that it has been conducted according to what Salomon (1991) calls an analytical research approach, usually involving controlled experiments. These experimental studies have focused on assessing the effects of discrete graphical variables (e.g., color versus black and white or photographs versus line drawings) on a limited range of learning outcomes (e.g., memorization).

Salomon (1991) calls for increased systemic research in instructional technology and related fields to investigate the effects of instructional programs and products in realistic settings. Salomon says, "Without observations of the whole system of interrelated events, hypotheses to be tested could easily pertain to the educationally least significant and pertinent aspects" (p. 17). We argue that such has been the case with much of the research on graphics and computer-based learning environments.

Of course, years of experimental studies have yielded some generalizable principles. For obtaining/guiding attention, graphics are more easily perceived and more distinctive than words (Paivio, 1990). Graphics can extend the time readers are willing to spend on learning due to the capability of graphics to arouse certain emotions (Peeck, 1987). Based upon their familiarity, pictures have a "dual reality" for presenting objects themselves and for functioning as surrogates for other abstract concepts (Levie, 1987). Graphics can be direct representations or analogical presentations for relating the unfamiliar to the familiar (Alesandrini, 1985). Graphics can support understanding of the spatial features of an object or facilitate the learning of a sequence of procedures that might require an awkward or lengthy description solely through verbal communications (Hegarty, Carpenter, & Just, 1991). Graphics can allow a deeper processing of information, and thereby they can reinforce the process of encoding (Reid, Brigg & Beveridge, 1983). Dwyer (1970, 1987) concluded that different formats of graphics assist learning and comprehension differently. While these findings are encouraging, they provide an inadequate foundation for guiding design decisions in practical contexts, especially with respect to today's graphical intensive learning environments. We believe that future research should be directed to understanding "how" learners interact with graphics in using interactive learning environments that are pertinent to their personal and academic goals.

THE NEW IMPORTANCE OF GRAPHICS RESEARCH

New technologies abound (e.g., digital movies) and thus many new design elements are being integrated into the production of computer-based instruction. The uses of animation and video capture techniques, such as QuickTime, support learning by allowing students to view the dynamic nature of processes, a factor limited in even the best static graphics. Incorporating various types of animated graphics into interactive learning environments is expected to support motivation and learning.

According to Paivio's dual coding theory (Paivio, 1990), information is easier to retain when coded verbally and visually Within his definition of dual coding, visual input also refers to the dynamic features of objects and events. Integration of animation features and visual effects can be an effective way of arousing and maintaining the learner's attention during computer-based learning due to the distinctive cues provided in contrast to static forms of information and cueing stimuli (Rieber, 1989a; Hannifin & Peck, 1988).

Recent studies (e.g., Brown, 1992; O'Connell, 1992) have addressed the merits of sophisticated computer graphics in enhancing interaction and exploration. Various graphics treatments, such as three-dimensional modeling, color, and animation, allow viewing from different angles, so much so that students may perceive that they are in virtual environments. Without in-depth assessments using both qualitative and quantitative methods, research might not come up with guidelines for design of these innovative "high tech" learning environments.

Learners perceive graphical information and engage cognitive processes which requires them to select relevant elements from the stimuli to attend. The use of animation, three-D images, and/or digital video can help students extract the central concepts within a context, and at the same time conceptualize what might not be explained clearly in the text. However, issues about how graphics relate to the central context to be presented, how they guide learners to comprehend new concepts, and how they can reinforce the process of learning require more research efforts aimed at providing a better basis for incorporating state-of-the-art graphics into the design of computer-based materials.

In a review of instructional visuals, Dwyer (1988) concludes that visualization provides potential impact on increasing learning interest, guiding thinking, and supporting learning through reinforcement and discrimination of relevant cues. To differentiate the purposes of using graphics in CBI, four instructional functions are used below: gaining attention, relating areas of familiarity, guiding comprehension, and reinforcing what needs to be learned. If our main research goal is to help developers incorporate graphics into interactive learning environments, it may be worthwhile to look at these functions individually in order to help focus research directions.

Research on Obtaining/Guiding Attention Through Graphics Is Needed

Attention-gaining is an important initial event of instruction (Gagnè, Briggs, & Wager, 1992). Graphics usually convey non-verbal interactions through their own symbolic representations. Due to the differences between pictures and words in the sensory and physical features, pictures are more discriminable and more distinctive than words (Kobayashi, 1986; Paivio, 1990). In addition to the distinctive physical features of graphics versus words, graphics are also often used for arousing certain emotional impact or attitudes toward new content. Many pictorial studies (e.g. Levie & Lentz, 1982; Rigney & Lutz, 1976; Swell & Moore, 1980) support the emotional impact graphics have in reading. For example, Peeck (1987) argues that the affective effect of pictures is due to their features in maintaining a high level of concentration on symbolic response patterns. Pictures may often facilitate in extending the time readers are willing to spend on learning (Peeck, 1987). The emotional effects of images have been addressed in some studies, but little research has been done in this area with interactive learning environments.

Much research has been conducted to examine the factors that influence the processes by which pictures are noticed and attended (e.g., Beck, 1984; Butler & McKelvie, 1985; Jennings & Dwyer, 1985). Physical characteristics, such as color, position, contrast, motion, and the size of visuals to affect different communication levels are emphasized in these studies (Goldsmith, 1987). More research needs to be done to understand the reciprocal relations between graphics and perceptions of various learners in order to provide instructional designers with design guidelines for helping students to see what needs to be seen. Further, field-based research is required to study these variables within actual instructional contexts (in addition to laboratories) to determine how learners attend to information through the use of graphics.

Research on Relating Areas of Familiarity Through Graphics Is Needed

Graphic representations can convey information rapidly and can be recalled rapidly due to their "dual reality," i.e., they represent objects themselves, and they function as surrogates for other concrete objects or even abstract concept (Levie, 1987). When a picture is used, it is perceived and interpreted by viewers based on their own understanding and experience in constructing a meaningful representation. Pictures may be direct portrayals or analogical representations used to relate what learners already know to the understanding of new concepts. Although some fundamental skills for visual recognition are innate, decoding pictorial information is related with picture-viewing experience, culture-bound conventions, and knowledge experience (Levie, 1987).

Since we use images to communicate, we need to know how to choose the most valuable images to express ideas (Nanny, 1990). In interactive learning environments, one of the mainstays of graphical user interfaces is to use the appropriate graphical representation to present a resource, an option or an action (Cates, 1993). Using appropriate pictures for different audiences at the right time is challenging. More research needs to be done to observe how people from different fields, different levels of expertise in certain areas, or different age groups perceive, interpret, and interact with the graphics in a learning environment.

Research on Guiding Comprehension Through Graphics Is Needed

Using graphics for guiding comprehension is widely used among scientific and technical information. For examples, Rieber and his colleagues used animated graphics in presenting an introduction to Newton's Law of Motion (Rieber, 1989b; Rieber, 1990a, b; Rieber, Boyce, & Assad, 1990; Rieber & Hannafin, 1988). During recent years, there has been a growing interest and development effort for graphical innovations. These technical advances make the communication of the information available in a wide variety of approaches. The visual properties of graphics help learners understand spatial features of an object or a sequence of procedures that might require an awkward or lengthy description solely through verbal communication (Hegarty, Carpenter, & Just, 1991). However, it is also easy "to be superficial to dazzle someone with beautiful graphics" when using technology (Dam, 1992). Research on how graphics can be presented to make the abstract and complex concepts concrete and simplified is needed.

In addition to conveying information that is spatially related, the use of graphics also provides various types of assistance in organizing concepts and principles into elaborate networks (e.g., mental models). Mental models are used to integrate information into a holistic perspective or useful strategy. The use of graphics as an organizer has been shown to be an effective thinking tool and widely applied in various subjects for both inductive and deductive thinking (e.g., Clarke, 1991; Tajika, Taniguchi, Yamamoto, & Mayer, 1988; Krahn & Blanchaer, 1986). Graphics used for this purpose provide learners ways to visualize and control their thinking about content in the subject areas. However, studies designed to observe and contrast the visualization processes used by experts and novices as they construct mental models are needed (Friedman, 1993, Jih & Reeves, 1992).

Most research is conducted to compare and analyze the outcomes among specific graphical treatments and other types of treatments. Little research has been done to build understanding of the strategies students actually employ to construct understanding from graphics. More research needs to be done through documenting the processes employed by students to learn new knowledge, skills, and attitudes through the use of graphics.

Research on Reinforcing Learning Through Graphics Is Needed

Pictorial stimuli are used to help readers emphasize concepts to be learned (Beck, 1987). Pictures are often used in facilitating the encoding process (Levie & Lentz, 1982; Reid, Brigg & Beveridge, 1983). It is considered that when presented together with text, more cues are provided to allow deeper processing of the intended information. The provision of graphics also permits learners to interact with the materials with different dimensions, which encourages the information to be processed in a more elaborated way. Used as an encoding cue, graphic representations provide interpretation to given verbal information so that the information can be communicated more explicitly and accurately (Morris & Hampton, 1983; Alesandrini & Rigney, 1981). With denotation of concrete representations to textual materials, the information is more easily retained in memory because both verbal and image systems are activated in storing the information. Under the assumptions of dual coding (Paivio, 1990), when information is presented verbally and visually, it can be retained longer in memory because both memory systems are used.

To reinforce learning, students need to deeply process the information through the use of their own cognitive strategies to relate both verbal and visual information from the instruction. Research should focus on how information should be presented and what other instructional strategies should be included to promote the use of students' own metacognition for deeper processing.

NEW DIRECTIONS FOR GRAPHICS RESEARCH

Six recommendations are made to guide graphics research in interactive learning environments:

1. A variety of research paradigms should be explored in conducting graphics research (e.g., a. positivist, quantitative, b. interpretivist, qualitative, and c. critical theory, postmodernist). Studies employing multiple methods should be considered.

2. Researchers should attempt to ground their research in broad, comprehensive theories of human perception, memory, and learning. Further, research that does not reflect a deep appreciation of the theory and research on graphics that has built up over the past fifty years will likely rediscover what is already known or lead to irrelevant conclusions.

3. Subjects in graphics studies should be involved in learning that is personally meaningful and has real consequences for them.

4. Graphics research should employ commercially viable interactive products or products that are under development as opposed to the "nonsense" materials used in some earlier studies. The continued use of irrelevant or content-free materials is highly unlikely to provide us with useful principles for design of interactive learning environments.

5. Although laboratory studies can be useful, field-based research should be preferred to increase the generalizability of research findings.

6. Regardless of whether research is conducted in labs or the field (e.g., schools, training centers, businesses), the research protocols used by software usability testing laboratories may provide excellent guidance for the conduct of these studies (Nielsen, 1993). (The Learning and Performance Support Laboratory at The University of Georgia is establishing two facilities, one fixed and one mobile, to employ usability testing strategies in research on graphics, navigation, and mental models in interactive learning environments and performance support systems.)

SUMMARY

Substantial research on graphics using a wide variety of media has provided a foundation for further research that may provide an enhanced basis for guiding the design of interactive learning environments. However, we maintain that future research demands new directions in terms of both the questions asked and the methods used by graphics researchers. Questions should be focused on understanding "how" learners process graphics. Methods should be expanded to include a wider spectrum of research paradigms. All graphics research should be guided by in-depth understanding of theory and research related to perception, memory, learning, and other cognitive processes.

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Title:

1993 Survey of Compressed Video Applications: Higher Education, K-12, and the Private Sector

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Introduction

Compressed video is not a new technology. As early as 1970 AT&T produced its Picturephone which was based on its experiments with reduced bandwidth and the use of digitized video. However its cost and complexity thwarted growth and demand for the product until the mid to late 1980s, and now, "compressed video is a hot technology and will get hotter throughout the 1990s. Increased microprocessor speeds, decreasing costs and the ever increasing availability of bandwidth are all driving the usefulness and economics of the technology. The underlying technology of compressed video is complex, but so is computer and telephone technology. At the practical level, implementation and operation of compressed video is not more complicated than many computer networks , and a lot less complex than some." (Burton, 1993). This paper presents the results of three surveys about live, two-way interactive video (CV) and discusses some possible trends in utilization, applications and the technology itself. The surveys are drawn from an AECT survey done by the authors, the ***International Video Teleconferencing Source Book*** (hereinafter referred to as *The Source Book*), and the National Association of State Telecommunications Directors (NASTD) 1993 survey of the western region of the United States.

In February of 1993, AECT published *Compressed Video: Operations and Applications* by Barbara Hakes, Steven Sachs, Cecelia Box and John Cochenour. The book contains user profiles from some twenty different institutions, businesses and agencies. During the time the book was being published, and since its publication, the use of live, two-way compressed video (CV) has been increasing dramatically. As a result, a commitment to produce a supplement to the book was made with a target publication for 1994. In order to develop the supplement it was necessary for the authors to conduct a survey of compressed video users from higher education, K-12 and the private sector. This paper presents the initial results of that survey which is still in progress.

The first edition of the *Source Book* was published by AT&T Global Video Services and the International Teleconferencing Association in 1992; and the second edition in 1993. *The Source Book* was the first early attempt to compile a data base of compressed video information. The 1992 edition lists 1,600 entries world wide for video conferencing facilities. The 1993 edition lists 2,381 entries. Additionally, it provides the following information: 1) whether the facility is a private or public room, 2) the model of codec being used, 3) transmission rates, 4) encryption type, 5) carrier provider, 6) video phone number, if appropriate, and 7) a contact person and the contact person's voice phone number.

The NASTD survey was conducted by Dennis Nincehelser, Director of the Bureau of Administration in the division of Information Services in the state of South Dakota. The survey examined the compressed video operations and/or plans of the 16 states in the Western Interstate Commission for Higher Education cooperative: North Dakota, South Dakota, Nebraska, Montana, Wyoming, Colorado, New Mexico, Idaho, Utah, Arizona, Nevada, Washington, Oregon, California, Alaska and Hawaii. The results of that survey are discussed in this paper as well.

Procedure

The findings of the aforementioned sources are reviewed and apparent trends in compressed video utilization, applications and the technology itself are noted. For the AECT survey, the authors used the 1992 edition of the Source *Book* published by AT&T Global Video Services and the International Teleconferencing Association as the population base.

In June 1993, surveys were mailed to the 938 entries listed in *The Source Book*. In July of 1993, follow up letters were mailed. This letter requested a reply by September 15, 1993. In November another survey was mailed to those not responding by the September deadline. During December, various smaller mailings were made to additional institutions as the authors became aware of their uses of CV through a variety of other sources. Surveys were also completed via telephone interview during December 1993. A total of 44 surveys were completed via these processes

Multiple sources to examine trends for this paper were used for the following reasons. The AECT survey is not yet complete and response rate has been low. Data for *The Source Book* , although voluminous, was collected in 1990 to 1991 for the 1992 edition and 1992 to 1993 for the latest edition. Compressed video technology has changed dramatically since the time of the first edition and new users and applications are emerging as this paper is being written. In fact, "the anticipated growth of video teleconferencing in the 1990s is similar to the FAX 'explosion' of the 1980s" (Burton, 1993). Also information on data collection for *The Source Book* is sketchy, and the authors admit that it may represent a biased picture in unknown ways. For example, while the 1993 edition lists the state of Wyoming as having two video conferencing facilities equipped with CLI it in fact supports twelve video conference facilities equipped with VTel codecs. The NASTD survey is restricted to the Western region and may also reflect some bias because of its geographic restrictions. Because of possible inaccuracies in each survey, we have triangulated the surveys reported here in order to identify possible trends.

Findings

AECT Survey

While the authors are not yet finished with data collection, the information that has been obtained reveals some interesting trends and possible patterns for the future direction of compressed video conferencing and networking. Among 22 questions responded to in the survey were the following.

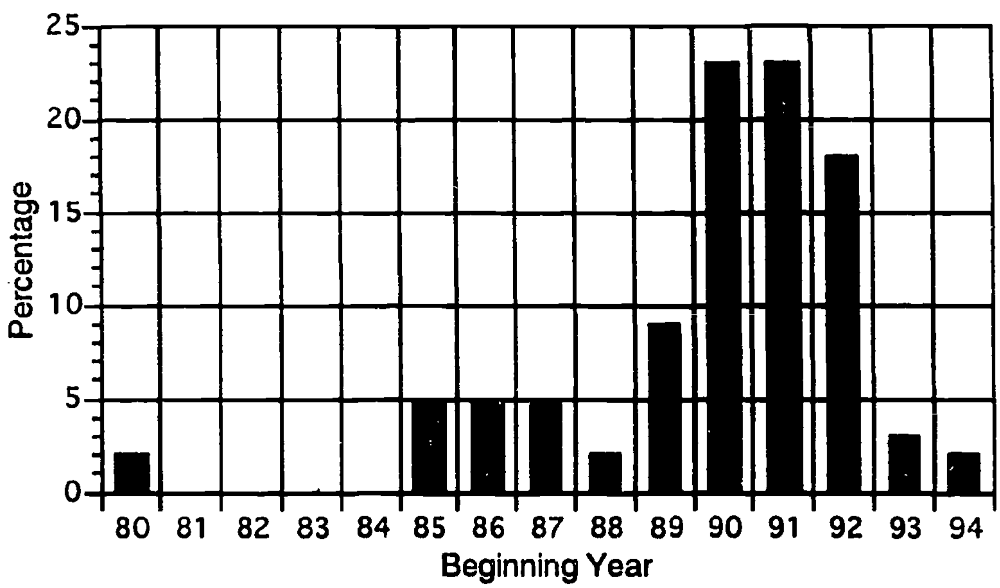

Figure 1: Year in which respondents began using compressed video.

When did you start using compressed video? The earliest start date was 1980. Most of the respondents began in either 1990 or 1991. This probably reflects the use of the first edition *Source Book* as the population base for the basic survey. The first edition used data compiled in 1990-91 and the institutions listed therein would have begun prior to its publication. The institutions starting in 1992-94 as shown in our data come from a smaller database compiled by the authors own networking. (see figure 1)

How did you decide to use compressed video as opposed to other telecommunications systems? Eighteen percent of the respondents did not provide an answer to this question, but those that did had an interesting variety of reasons for choosing compressed video. Fifty percent of the group listed cost as the primary reason for selecting compressed video. The other two major categories were the higher quality of the compressed video (23%) and the existence of a system (18%) where the system was inherited and original reasons were unknown. (see figure 2) It should be noted that in some cases compressed video and other telecommunications systems are used in conjunction, and it is not necessarily a decision to use only one system.

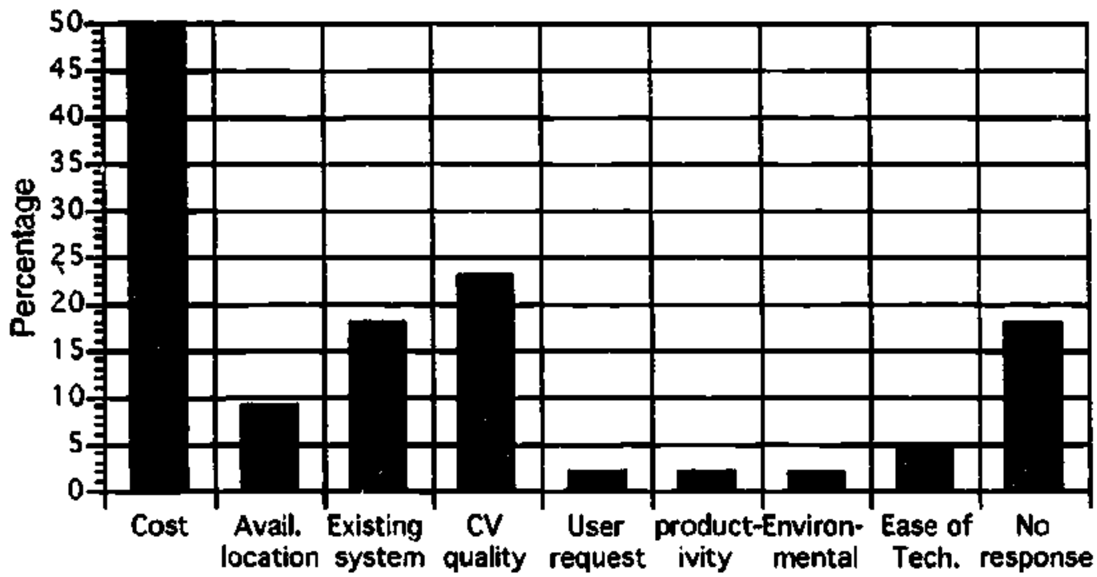

Figure 2: Reasons for choosing compressed video over other telecommunication systems

What delivery system(s) do you use (i.e. satellite, land line (fiber, T1 etc.)? Many of the systems described by our respondents used more than one delivery system, so the percentages listed here exceed 100 percent. Eighty four percent of the respondents stated they were using T1 as a delivery system. Twenty three percent were using satellite delivery; eleven percent were on land line, and five percent were using switched 56. This five percent are primarily represented by institutions that began using compressed video during 1993.

How many sites are included in the network? Two of the responses listed only one site, or essentially not part of a yet established network. One response listed 1400 sites in the network. However, the majority of the respondents listed sites that numbered between six and twenty. (see figure 3)

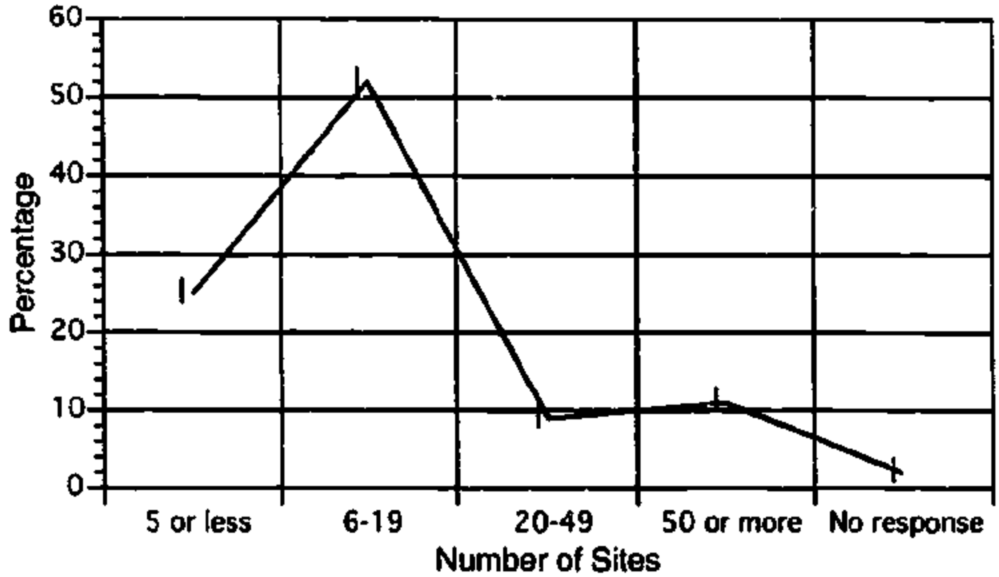

Figure 3: Number of compressed video sites in the network

<u>Please describe each application that is presently using the compressed video network.</u> Several different applications were listed. Most of the respondents had more than one application. The applications have been categorized and the percentage of respondents using the application are shown in figure 4.

<u>Who operates the facilities?</u> Again, this was not an either/or question and many of our respondents had more than one means of operating the system. Sixty eight percent stated they used a technician at least part of the time to handle the operation of the system. Fifty seven percent stated the primary user or a participant operated the system at least part of the time. Seventy percent of the respondents indicated that the system operator had received some training regarding the operation of the system. The most common training was simply an audio/visual orientation, but two percent of the operators had electronics training and nine percent had video production training.

<u>What rate(s) do you use for transmission?</u> The most common transmission rate reported was 384 kbps. Several of the sites reported more than one rate was available for use depending upon the connecting network and the application need. (see figure 5)

Higher education	45
Sharing instructors	14
Training and delivery	34
Videoconferencin	59
Think tank	23
Planning	41
Advising	20
Administration	43
Depositions	18
Consultation	25
Student project	18
Research	14
Government	20
Private business	16
Grade school educatio	5
Jr./Sr. high educatio	5
Court hearing/arraignment	5
CPA reviews	2
No respons	2

Figure 4: Applications for compressed video and the percentage of respondents using such applications

<u>Are you presently using (or plan to use) the public switched 56 network for interstate or international communications?</u> Thirteen of the respondents failed to answer this question and fifty seven percent responded negatively. However, thirty percent of the survey respondents indicated they were, or had plans to, use public switched 56 network for interstate or international communications.

<u>What hardware model and brand are you using?</u> Our findings were similar to those in The Source Book. (see discussion below) The more popular codec brands were:

VideoTelecom - 48%, CLI - 34%, and PictureTel 11%. Sixteen percent of the respondents were scattered among other systems. The respondents were fairly evenly divided between stationary and rollabout systems.

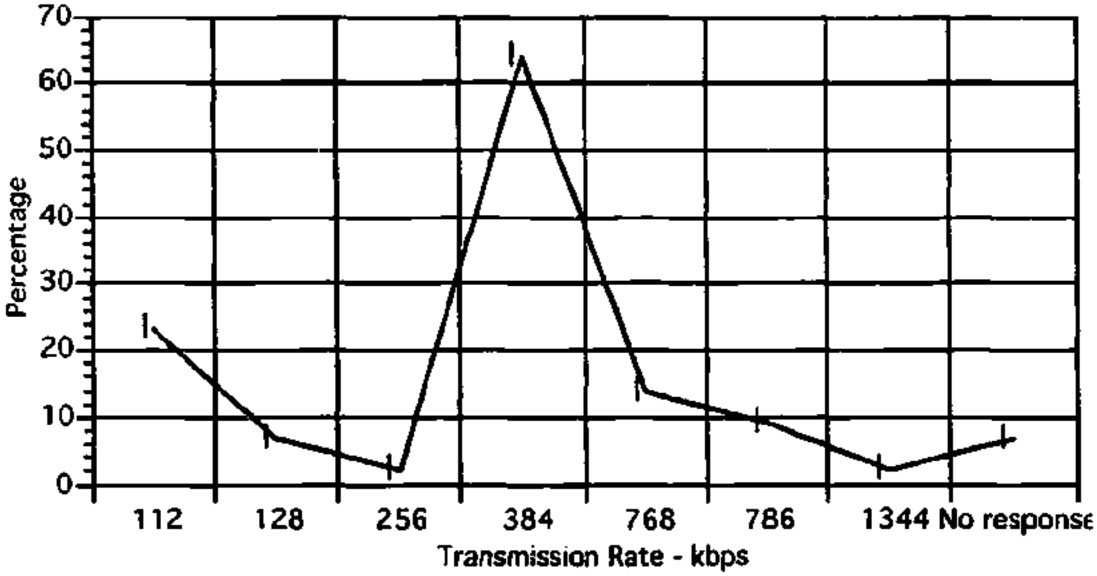

Figure 5: Percentage of respondents reporting use of a specific transmission rate.

<u>What peripherals are attached to the system?</u> Two popular peripherals were a VCR and the Elmo presenter, both were part of fifty seven percent of the systems. The most common peripheral, however, was a computer. Sixty four percent of the systems had a computer as part of the system, and the MS-DOS compatible computer was used seventy five percent of the time. Additional peripherals that were frequently listed included external cameras, fax machines, and the pen pal. Other peripherals that were less commonly mentioned included: slide projectors, overhead, CD-Rom, speakers, zoom box, black box converter, special effects switcher, and videowriter.

Source Book

<u>Educational institutions- 1992/3. The</u> *1992/3 Source Book* contains 1,600 listings for international facilities for compressed video. Facilites in the United States comprised about 938 listings for approximately 60% of the sites available world wide. 121 sites were not included in the authors' analysis due to incomplete information contained in the directory. Of the 938 sites listed in the United states 678 were listed as private facilities and only 260 locations were listed as public. (see figure 6) Educational institutions supported only 28 of the facilities listed in the directory for a little less than 30% of the total number of compressed video locations. The twenty eight educational institutions listed in the source book utilized 22 sites with Compression Labs Inc.(CLI) codecs, four with PictureTel (PCTL) Codecs and six with VideoTelecom (VTEL) codecs. (see figure 7) One site utilized a GPT codec and the 28th site utilized a VisuaLink codec. Six sites supported two different vendors' codecs operating at different transmission speeds. Transmission rates (see figure 8) at these sites ranged from nine locations which used a full T1 carrier (1.544

megabytes p ·r second), three locations which used variable rates from 384 Kbps to 1.544 Mbps, one site using 112 Kbps to 1.544 Mbps, two which used 768 Kbps, eight which used 384 Kbps, five which used 112 Kbps. Since lower transmission rates require less space on the carrier, whether it be land line, satellite or microwave, conferencing costs are reduced at the lower rates. Yet at the lower rates some quality in transmission is sacrificed. Transmission at 384 Kbps utilizes only about 1/3 of the capacity of a T1 carrier. In the sample of educational institutions contained in *The Source Book,* 40% utilized transmission rates at 768 Kbps or a full T1, 14% at variable rates ranging from 112 Kbps to a full T1, and 46 % used transmission rates at 384 Kbps or lower.

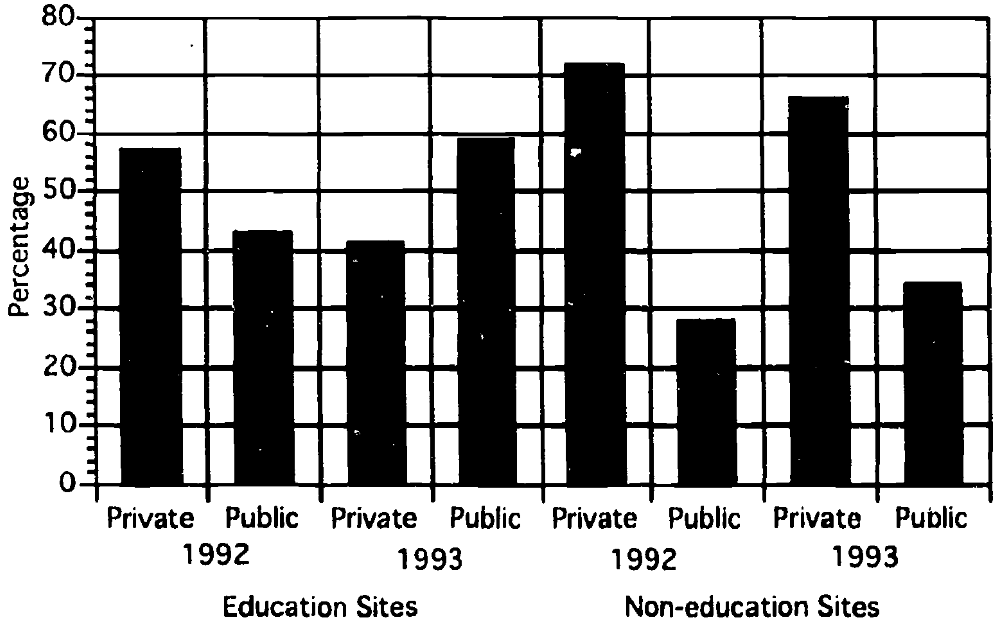

Figure 6: Percentage of private and public facilities for educational and non-educational compressed video sites, 1992 and 1993.

Educational Institutions-1993/4. *The 1993/4 Source Book* contains 2,381 listings for international facilities for compressed video. This represents an increase in listing of 38% over the previous edition. Facilities in the United States comprised 1,526 listings for approximately 64% of the sites available world wide. 64 sites were not included in the authors' analysis due to incomplete information contained in the directory. Of the 1,562 sites listed in the United states 1,004 were listed as private facilities and 521 locations were listed as public. (see figure 6) This increase in the number of public compressed video facilities is double the number listed in the previous year's directory. Educational institutions supported 49 of the facilities listed in the directory for a little less than 32% of the total number of compressed video locations. The forty- nine educational institutions listed in the source book utilized eighteen sites with Compression Labs Inc.(CLI) codecs, eight with PictureTel (PCTL) Codecs and thirty-seven with VideoTelecom (VTEL) codecs. Three sites utilized GPT codecs. (see figure 7) Seventeen sites supported two different vendors' codecs operating at different transmission speeds. Transmission rates (see figure

8) at these sites ranged from six locations which used a full T1 carrier (1.544 megabytes per second), two sites using 112 Kbps to 1.544 Mbps, four which used 768 Kbps, twenty-two which used 384 Kbps, thirte-n of which used 112 Kbps. In the sample of educational institutions contained in *The 1993/4 Source Book,* 20% utilized transmission rates at 768 Kbps or a full T1, 8% at variable rates ranging from 112 Kbps to a full T1, and 71 % used transmission rates at 384 Kbps or lower.

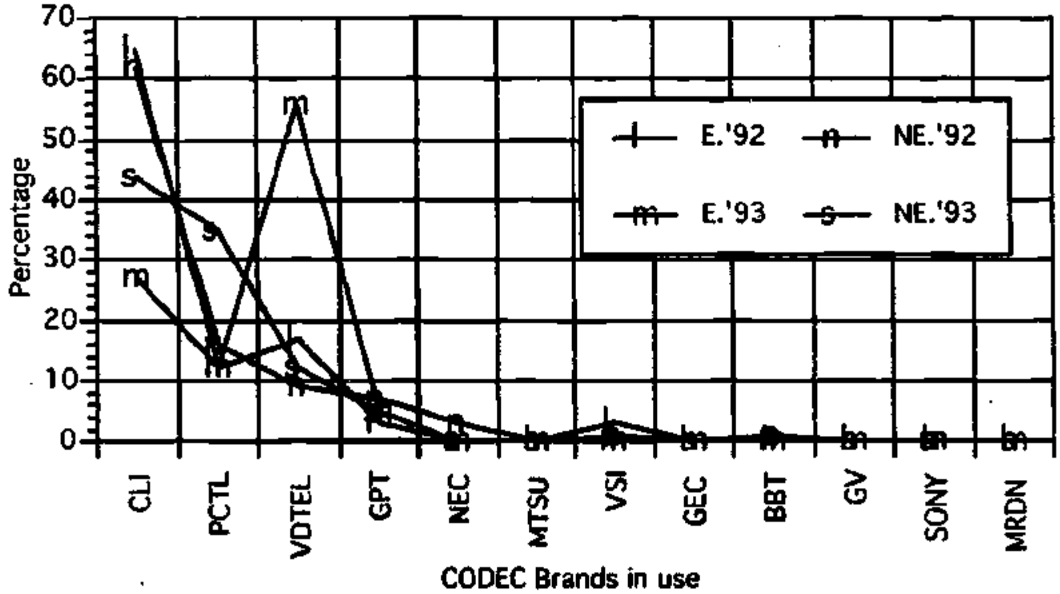

Figure 7: Codecs employed in educational (E) and non-educational (NE) sites, 1992 and 1993.

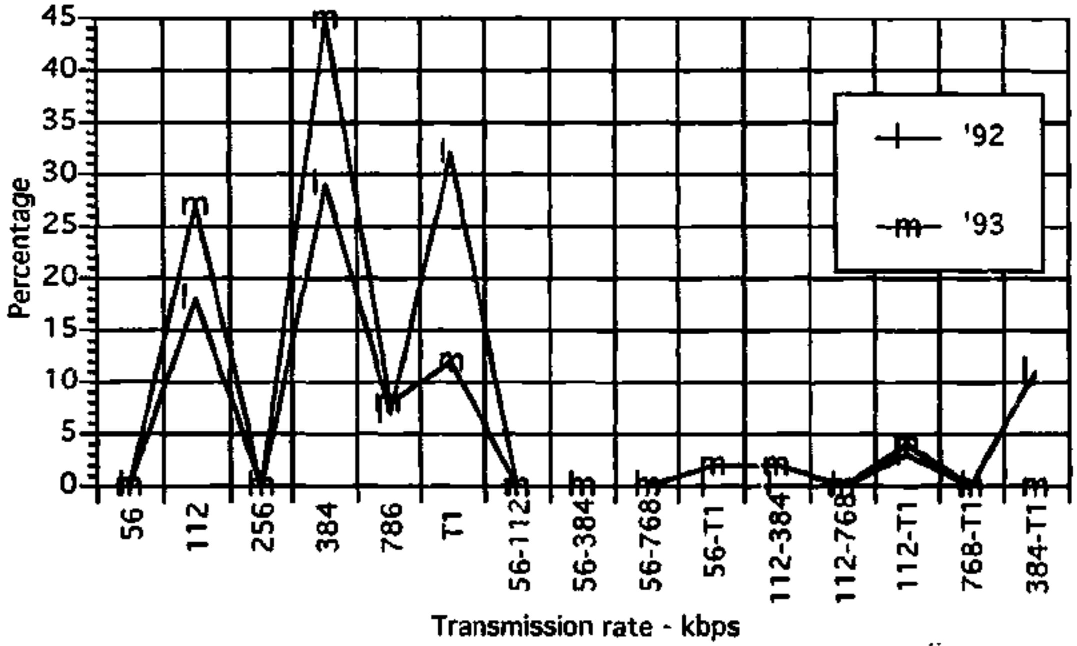

Figure 8: Transmission rates for educational compressed video sites, 1992 and 1993.

U. S. Non-education Compressed Video Sites-1992/3. In examining *The Source Book's* listings for all 938 compressed video installations in the United States the following observations were made. Some sites supported more than one codec operating at different transmission rates. According to entries made in *The Source Book* 121 sites did not provide information either on the model of codec or transmission rates being used. Of those providing complete information, 789 listed one or more brands of codecs. Thirty four sites supported at least two models of codecs and four sites supported three or more brands of codecs. The latter were primarily communications industries groups supporting public compressed video rooms. Of the 789 listings providing codec information 62% (581) supported CLI codecs; 16% (145) supported PictureTel; 9% (86) supported VideoTelecom; 7% (61) used GPT.; and less than 1% varyingly used Nec, Mitsubishi, Vistacom, BBT or GEC codecs. (see figure 7) Transmission rates (see figure 9) were reported in 836 of the entries. The following general pattern emerged after analyzing the entries. Approximately Forty-five percent of the CV sites transmit at 384 Kbps or lower, and fifty- five transmit 768 Kbps or higher

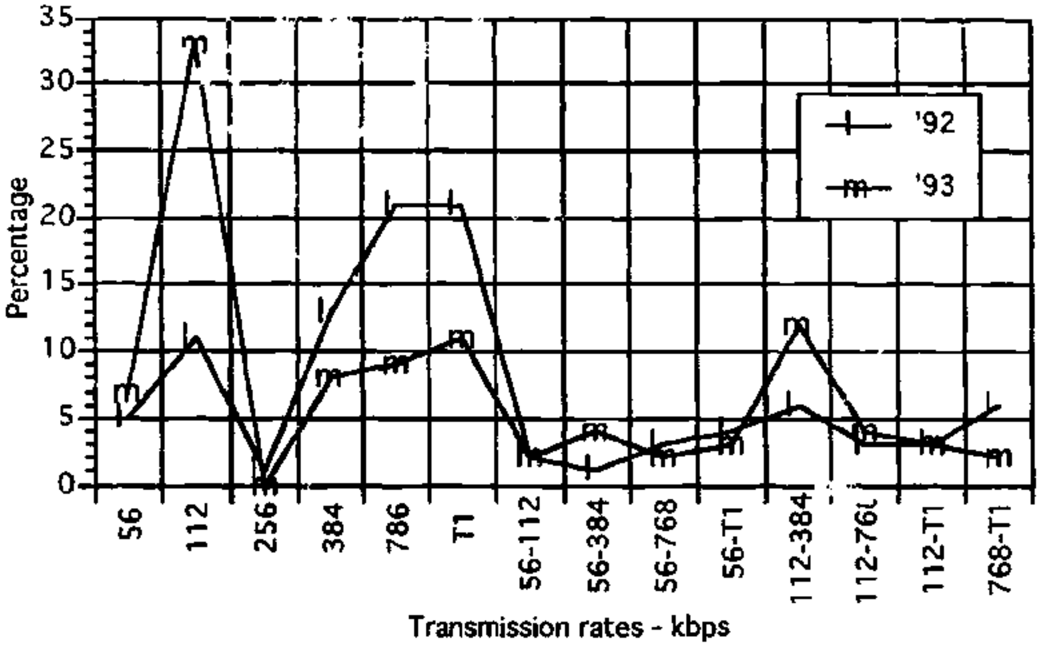

Figure 9: Transmission rates for non-educational compressed video sites, 1992 and 1993.

U. S. Non-education Compressed Video Sites-1993/4. In examining *The Source Book's* for the 1993/4 edition listings for all 1,526 compressed video installations in the United States the following observations were made. Many sites supported more than one coder operating at different transmission rates. According to entries made *The Source Book* 64 sites did not provide information either on the model of codec or transmission rates being used, but 1428 sites listed one or more brands of codecs. Fifty-one sites supported at least two models of codecs and eleven sites supported three or more brands of codecs. The latter, again, were primarily communications industries groups supporting public compressed video rooms. Of the 1,428 complete listings providing codec information 44% (644) supported CLI codecs; 35% (524) supported PictureTel; 12% (86) supported VideoTelecom; 5% (74) used GPT; and less than 1% varyingly used Nec, Mitsubishi, Vistacom, BBT or GEC codecs. (see figure 7) Transmission rates (see figure 9) were reported in 1,428 of the entries. The following general pattern emerged after ana.,zing the entries. Approximately Sixty-six percent of the CV sites transmit at 384 Kbps or lower, and forty-four percent transmit 768 Kbps or higher.

NASTD 1993 Survey of the Western Region

During the spring and summer of 1993, Dennis Nincehelser, Manager of Data, Video and Telecommunications in the Bureau of Administration in the Division of Information Services for the state of South Dakota conducted a survey of compressed video operations or plans of the 16 states in the Western Interstate Commission for Higher Education cooperative. Dennis granted permission to include the results of that survey in this paper.

A summarizing discussion of the data is provided here. Of the 16 western states represented in the survey, Three are planning for the use of video teleconferencing and seven are already using it. Of the 10 states responding to the survey, two use broadband analog video conferencing. One of these states is in the process of changing to compressed digital video. Four states use CLI based systems operating at variable transmission rates while three states us VTEL codecs operating at 384 Kbps or lower and one additional state is planning to expand its use of two VTEL codecs statewide. Nine of the states either use or plan on using video bridges. Five of the states plan to use inverse multiplexers, three are considering the use of this technology and two are not planning to use it. Higher education represents the majority of use in all but three of the states where state government is the biggest user. However, those networks with a preponderance of use from higher education also share the network with state government and in some cases with K-12 and the private sector.

Trends and Results

Educational Institutions. Based on the data contained in two editions of *The Source Book*, it would appear that there is a trend toward the use of lower transmission rates among educational institutions. There were increases of 9% and 22% respectively in the use of 112 Kbps and 384 Kbps transmission rates. There was a decrease of 16 % in the use of T1 transmission. In the first edition of *The Source Book* only 46% of educational institutions used a transmission rate of 384 Kbps or lower. In the current edition, this percentage has increased to 71%.

Relative to the codecs being used at educational institutions when comparing the data presented in the two editions , there is an increase of 39% in the use of VideoTelecom (VTEL) equipment, a decline of 36% in the use of CLI and no change in the percentage of use of PictureTel codecs while GPT codecs rose approximately 2% and VSI declined by 3%.

Non-Educational CV Sites . Based on the data contained in two editions of *The Source Book*, it would appear that there is a trend toward the use of lower transmission rates among non-education CV users. There were increases of 2% and 22% respectively in the use of 56 Kbps and 112 Kbps transmission rates. There were decreases 5% in the use of 384 Kbps, and 12 % in the use of 768 Kbps and 10% in T1 transmission. In the first edition of *The Source Book* only 45% of the CV sites used a transmission rate of 384 Kbps or lower. In the current edition, this percentage has increased to 66%.

Relative to the codecs being used at these sites, when comparing the data presented in the two editions , there are increase of 19% in the use of PictureTel codecs; 3% in VideoTelecom (VTEL) equipment, and declines of 18% in the use of CLI; 2% in GPT and 3% in NEC and no change in the percentage of use of other vendors' products.

While CLI codes represent the largest number (644) in the latest directory ,any of these codecs were sold early to large clients such as SPRINT, Rockwell International, GE, Sears Technology, the U S Armed Services and others. Sales to these clients alone totaled some 250 units, all old model Rembrandt operating and 768 Kbps or full T1. PictureTel has temporarily gained a huge share of the market with its low bandwidth codecs. But CLI has countered with the Eclipse and VTEL also has announced low bandwidth products. In noting the higher percentage use of VTEL products in educational institutions the authors believe that the increased popularity of the VTEL line in education may be due to the integrated multimedia design of the System. In interviews with educational users they are quick to point out the advantages of a multimedia system in educational environments. But the trend does appear to be toward lower bandwidth technology.

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Global Conferencing Source Book: 1993-94 Edition International Teleconferencing Association & AT&T Global Business Video Services. Parsipanny, N.J. ($7.95 Phone 1-800-426-8686)

Title:

A Cognitive Model of Journal Writing

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Abstract

This paper presents a cognitive model of journal-writing as a metacognitive tool in understanding stories in an introduction to literature course.

The methodology was primarily qualitative. Data included students' journals and class comments; surveys of the helpfulness of journal writing ; individual learner characteristics (e.g., reading ability, field dependence/ independence, academic record, course grade, and confidence in journal-writing ability); and case studies of five students. Findings indicated that (a) students generally viewed journal writing as a flexible cognitive tool which helped them construct the meaning of stories, and (b) writing journals scaffolds (supports) students in attending to details, asking questions, and answering their own questions. Although high-ability readers tended to engage in different cognitive activities than lower-ability readers, frequencies of questions and self-explanations were not related to story difficulty. Students' valuations of journal writing were not significantly related to measures of achievement (course grades, semester grade-point averages, or cumulative grade-point averages).

Moreover, journal writing is a very dynamic process; no single cognitive model can describe journal writing either within or across students. A two-part model was developed to describe the process: (a) factors which influence journal writing (task difficulty, individual learner characteristics, teacher expe ations, student strategies, external resources, overt activities), and (b) components of journal writing (establishing a goal, constructing the textbase, constructing the situation model, predicting outcomes, identifying significant elements, reflecting on meaning, and assembling the schema).

Recommendations for research are included.

Introduction

Journal writing has been used as an instructional/learning strategy in a wide variety of educational settings from first-grade mathematics (Wason-Ellam, 1987) to teacher education (Bean & Zulich, 1989). The type of journals which are the focus of this paper are more precisely called "academic journals," which are "usually based on responses to assigned readings or topics presented in class, and are most often evaluated not for their style or control of formal writing abilities but for their reflection of students' learning and thinking" (Anson & Beach, 1990, p. 3).

Although there is a strong theoretical base for the use of academic journals as an instructional/learning strategy, there is little research to inform instructional applications. The literature on metacognition (e.g., Flavell, 1979; Corno & Mandinach, 1983) supports the use of strategies which promote comprehension monitoring. Schema theory (e.g., Anderson, Reynolds, Schallert, & Goetz, 1977; Norman, Gentner, & Stevens, 1976; Rumelhart & Ortony, 1977) leads us to expect that journals will reflect both assimilation and accommodation. At times students will impose schemata on new information, sometimes doing "violence...to the data contained in the text" (Anderson et al., 1977, 371). At other times, students will tune schemata or create new cognitive structures (Norman, Gentner, & Stevens, 1976). More recent perspectives imply that journals will reflect a dynamic process of schema assembly, with dynamic networks rather than stored mental structures (e.g., Clancey, 1992; Spiro, Coulson, Feltovich, & Anderson, 1988). These views are consonant with theory and research on conceptual change (e.g., West & Pines, 1985; Champagne, Gunstone, & Klopfer, 1985a & b; Novak, 1985; Strike & Posner, 1985; Wittrock, 1985) and with constructivism, with its emphasis on active rather than passive learners (e.g., Duffy & Jonassen, 1992; Jonassen, 1991; Wittrock, 1974).

Unfortunately, much of the limited research on the use of journals has failed to establish meaningful goals, to provide challenging tasks, or to control for individual differences. For example, Anson and Beach (1990) used length of journals as the sole grading criterion and Hynd and Chase (1990) failed to control for the difficulty level of textual materials.

Purpose

The broad purpose of this predominantly qualitative study was to construct a cognitive model of journal writing in an ecologically valid setting, where learner characteristics and task difficulty varied. This paper focuses on three of the research questions (for discussion of the complete study, see Cole, 1992).

- What strategies do learners use when they are encouraged to use journals as a cognitive tool (Derry, 1990), constructing intermediate stages of knowledge (Bereiter & Scardamalia, 1992)?
- How are these strategies related to variables such as content difficulty, reading ability, and cognitive style? For example, research on individual differences (Jonassen & Grabowski, 1993) implies that field dependent (FD) students will want more direction than field independent students in writing journals and that FD journals will reflect difficulty in attending to details. Miyake and Norman (1979) found that frequency of oral questions about text-editing tasks in a computer program (a well-defined domain) was related to expertise.
- Does this finding extend to questions and comments in students' journals in an Introduction to Literature course, which is an ill-defined domain (Spiro & Jehng, 1990; see also, Spiro, Coulson, Feltovich, & Anderson, 1988)?

Methods

Setting and Subjects

Qualitative and quantitative methods were used to study journal writing in an in tact group of 14 students in a night section of a Introduction to Literature at a large urban community college in the midwest. The class met 75 minutes twice a week for 15 weeks. The basic instructional approach combined whole-group discussion with elements of the cognitive-apprenticeship model (Collins, Brown, & Newman, 1989). On the first night of class, I told students that I would be collecting information that would help me improve instruction for them as well as for future students. The course applied toward the humanities requirement for the AA/AS degrees. Course objectives emphasized defining and applying literary concepts, applying rules and heur-istics, and problem-solving. During the previous seven years, I had used similar journal-writing strategies in 15-20 sections of that course, as well as in other courses. None of the students had previously written journals of any type. Students ranged in age from 18 to 41 (mean = 28 compared to the college mean of 31.2); 93% worked (67% worked full time or more, compared to the college mean of 44%). The average credit load was 8.4 (compared to 7.4). All of the students planned to pursue baccalaureate or graduate degrees (compared to approximately 60% in the college).

Procedure

The Nelson-Denny Test of Reading Comprehension (Form E, 1981 edition) and the Hidden Figures Test, Part 1 (Ekstrom, French, & Harman, 1976) were administered at the end of week three. Six of the students scored at or above the 16.9 grade level (the highest level on the exam) on all three measures: comprehension, vocabulary and total reading. Two read below grade 12.0 (11.8, and 11.1), with comprehension levels of 12 and 9.4, respectively. Two students were very field dependent; two were very field independent.

Students wrote journals on five stories and two plays (weeks 3 - 12). Before they wrote their first graded journal, students received written and oral instructions, in-class practice and feedback, three written descriptions of journal writing processes by former students, sample journals, and encouragement to view two HyperCard tutorials on journal writing that I had developed specifically for the course.[1] All instructions encouraged students to write any question or comment they thought would help them understand a work better. As incentives, the journals counted 22% of the student's course grade; grading criteria made it difficult for students to earn less than a C on each journal. Following are the instructions in the syllabus.

Write a journal for each story and play, at least a half-page long—but there is no maximum length. Write your journal in ink, using complete sentences—otherwise I will not be able to understand what you are asking or saying. Write any questions you have—except the definition of a word, unless you are unsure of the relevant definition—or any comments you would like to make about the work. The journal is not busy work, but is intended to help me know what you need help with in understanding the story. Write any questions you believe will help you understand the work now as well as later, for the examination—or any other questions you are just curious about. Journals are worth a maximum of 10 points each. If a journal meets the minimum requirements, you will receive 7.5 points—a grade of C; you will receive additional credit, depending on how much your questions and comments indicate that you are paying attention to all the elements as you try to understand the work. There are no *wrong* questions or comments (but there are questions and comments which ignore the details of a work). Journals are a tool for you to learn about what you don't know, not to show me that you already know everything. Even if you don't understand a work at all but ask questions about what you don't understand and indicate that you are paying attention to details, you can receive a 10.

I will collect your journals at the beginning of the class on which they are due. If you miss that class, you may submit your journal at the next class you attend.

I selected and sequenced the stories and plays generally in order of increasing difficulty,[2] using feedback I had received from students over the years. I abandoned my plan to rely on faculty ratings because interrater reliability of stories five faculty were all familiar with varied from -.76 to .88. I also rejected ratings from the Dale-Chall, Fog, Flesch, Flesch-Kincaid, Fry, and Smog reading indices; because they focus on factors such as sentence length and the number of syllables, they are not valid indices for college-level stories and plays, whose difficulty level is more strongly related to plot structure, historical context, and the use of irony, allusion and symbolism (this view was confirmed by two reading teachers at the college).

To establish a baseline for journal writing on a sufficiently challenging work, the first story was one of the most difficult. To examine potential differences in task difficulty after students had developed some expertise in writing journals, I placed the easiest story fourth out of five.

Data were collected throughout the semester in journals, questionnaires, interviews of five students selected to provide insight into many of the variables of interest (age, sex, reading ability, academic major, academic record, and field articulation), standardized tests, course examinations, and field notes (recorded after each class). I collected journals before class discussion of each work, responded in writing, made a copy of each journal, and returned them at the next class. Students completed a written questionnaire about journal writing after their first and last journals; students submitted the latter to my supervisor, with the understanding that I would not see them until I had submitted semester grades.

It is outside the scope of this paper to describe the complete study. Major variables of interest included cognitive activities; reading ability; field articulation; story-difficulty level; semester GPA; length of journals; frequency of questions and comments; topics of questions and comments; self-ratings of amount learned; and student ratings of journal helpfulness. Qualitative analysis focused on the content of the journals on the stories (particularly the easiest and the hardest story), interviews, and comments in class and on questionnaires. Students' journals were entered in a data base and each main clause was analyzed. After attempts to apply several existing taxonomies, including Bloom's and Gagné's, I developed a taxonomy intuitively (see Table 1). Statistical analyses included Pearson product-moment correlations and ANOVAs.

Results

Following are the most salient findings on the major research questions. (For a complete report, see Cole, 1992; examples of students' questions and comments are also in Cole, 1993.)

A Cognitive Model

No single cognitive model could capture the process within or across journals. Journal writing was a particularly dynamic activity, which students adapted to emergent needs. It appeared to include seven major components (see Fig. 1): identifying a goal, constructing the text base and constructing a situation model (Kintsch, 1989), predicting outcomes, identifying significant elements, reflecting on meaning, reconstructing schema(ta). As students read a story and wrote their journals, these components all appeared to interact with each other as well as with other factors, such as individual learner characteristics and task difficulty (see Fig. 2 and Table 2).

Students engaged in a variety of preparation and execution strategies. For example, all but one generally read a story more than once (up to 10 times); some read a story initially just to get "a feeling for the flow." Some stopped immediately to look up unknown words; some preferred to infer meanings. Some used the "Catechism for Stories," a set of questions on setting, conflict, etc.,[3] almost as a recipe; some, as a heuristic; some never read it. As students gained experience

Table 1. Taxonomy of Students' Journal Entries

1. Correct—i.e., a tenable inference/explanation
2. Incorrect—clearly contradicted by evidence from the story
3. Neither Correct nor Incorrect
4. Statement of Confusion—explicit
5. Question
6. Direct Open Question

An interrogatory sentence that can't be answered "yes" or "no."

Example: Why doesn't the author give us the names of the husband and wife?

7. Direct Closed Question

An interrogatory sentence that can be answered "yes" or "no."

Example: Are they talking about an abortion?

8. Indirect Open Question

An implied question which can't be answered "yes" or "no."

Example: I wonder why he was in this country to begin with.

[Why was he in this country to begin with?]

9. Indirect Closed Question

An implied question which can be answered "yes" or "no."

Example: I think they are talking about an abortion but I'm not sure.

[Are they talking about an abortion?]

10. Item Supporting a Question

11. Reviewing Content (Summarizing/Paraphrasing)
12. Self-explanation
13. Item Supporting a Self-explanation
14. World Knowledge—e.g., "The story takes place in Spain because it mentions Madrid and Barcelona [which are in Spain]." In a looser sense, many of the self-explanations drew upon declarative world knowledge; for example, "The man mentions that he loves the woman he is with, but the woman is never referred to as his wife. So I am going to assume they are not married [because descriptions of married people use terms such as *husband* and *wife*]."
15. Character
16. Says or does
17. Thinks
18. Feels
19. Has a Given Trait
20. Setting—explicit use of the term
21. Point of View—explicit use of the term
22. Theme/Subject—explicit use of the term
23. Protagonist/Antagonist—explicit use of the term
24. Plot Element—explicit use of the terms conflict, crisis, climax, dénouement (These were grouped because there were so few instances of each.)
25. Irony—explicit use of the term
26. Other Elements (e.g., foreshadowing, imagery, plausibility, symbolism, title)
27. Judgment
28. Character's Actions
29. Author's Actions or Story in General
30. What the author did—explicit reference to author
31. Why the author did what he/she did—explicit reference to author
32. Story Difficulty—explicit reference to difficulty
33. Statement of Affect
34. Other (items not classifiable; e.g., statements about the process or the student's life)
35. Story-specific Items

Figure 1 Cognitive Activities Supporting Journal Writing

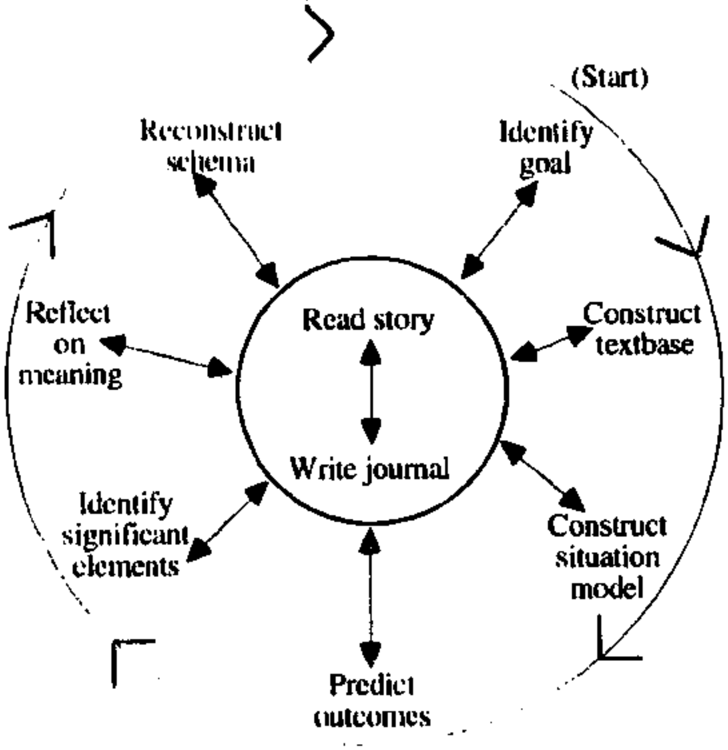

Figure 2. Major Factors Which Influence Journal Writing

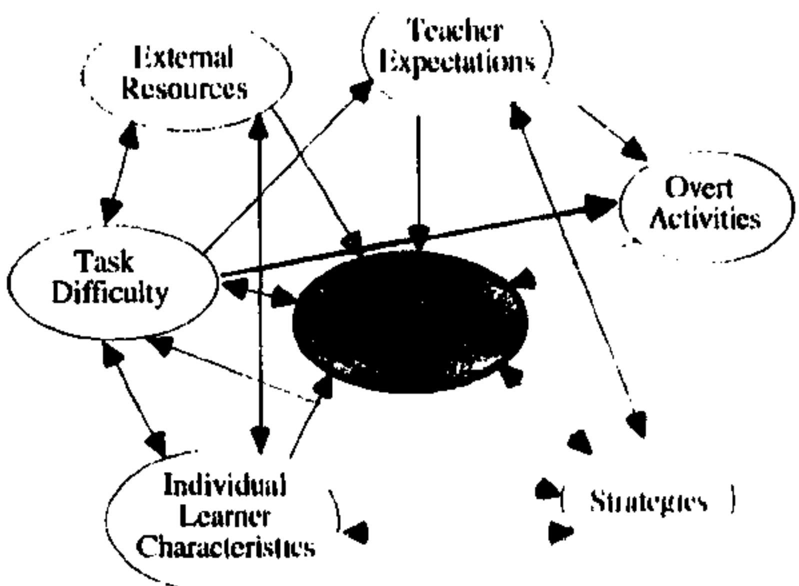

Table 2. Subdivision of Factors Which Influence Journal Writing

I. Overt Activities
   A. Read story.
   B. Write in journal.
II. Strategies/Activities
   A. Metacognitive Strategies/Activities
      1. Plan.
      2. Execute.
   B. Cognitive Strategies/Activities
      1. Review content.
      2. Problem solve.
         a. Ask questions.
         b. Generate self-explanations.
      3. Evaluate.
III. Individual Learner Characteristics
   A. Aptitude
      1. Reading ability
         a. Comprehension
         b. Vocabulary level
         c. Reading speed
      2. Domain knowledge
      3. General world knowledge
      4. Metacognitive/Cognitive Ability
   B. Memory Capacity
   C. Field dependence/independence
   D. Motivation
      1. Value of the activity to the student
      2. Student's confidence in ability to write journals
      3. Self-appraisal of ability to understand stories
   E. Understanding of the task (also related to motivation)
IV. Task Difficulty
   A. Frequency of unknown words in the story (from none to many)
   B. Use of conventions of grammar and of fiction (generally uses or disregards)
   C. Amount of irony in the story (from none to much)
   D. Clarify of the situation model (see Kintsch, 1989)
   E. Understanding of journal writing
      1. Purpose
      2. Criteria
   F. Time available to complete task
V. External Resources
   A. Reference works
      1. Dictionaries
      2. Encyclopedias
      3. Atlases
   B. Literary criticism
      1. Articles
      2. Books
   C. Other people
      1. Fellow students
      2. Family
      3. Friends/coworkers

In journal writing, they tended to rely less on the "Catechism" as an external guide and instead to be guided by their internal needs. Some said story difficulty influenced their strategies; for example, the best journal writer said she usually took notes as she read but that "Hills Like White Elephants" was so confusing she read it three times before she began taking notes, and then read it seven more times. However, most students generally activated a single procedure that was already in their repertoires. This seemed particularly true of the more field dependent students, who relied on external support in understanding the stories; they generally used a discussion strategy (asked friends or family what they thought the stories meant before they wrote their journals), or used the "Catechism" or adjunct questions to guide their journal writing.

In spite of repeated attempts, it proved impossible to identify the depth of cognitive processing, because journals are only cognitive artifacts, not records of students' thought processes. For example, in an interview, the most astute reader said he didn't really predict outcomes, but automatically ran several possible scenarios through his mind as he read, rejecting scenarios as new details made them untenable; yet he did not describe these activities (or any of the rejected scenarios) in his journals. And if a student wrote "What difference would it make if the setting were changed?," it was impossible to determine if the student was mindlessly copying a question from the "Catechism" or sincerely trying to problem solve.

The use of schemata in constructing meaning. The content of students' journals suggested that they attempted to construct meaning by activating relevant schemata, refining their existing schemata, and/or creating new schemata, as suggested by prior research (Anderson, 1977; Rumelhart & Ortony, 1977). In terms of this theory, when existing schemata readily accommodated story elements, students would not experience any cognitive dissonance (Osborne & Wittrock, 1983; Wilson & Cole, 1991) and therefore would not usually mention those elements in their journals. However, data from interviews and journals suggest that when students' existing schemata did not readily accommodate story elements, most students summarized, generated self-explanations, or asked questions. Furthermore, when students experienced too much cognitive dissonance (e.g., in trying to understand "Hills Like White Elephants"), they resorted to stating their confusion in general terms or blaming the author.

Assimilation theory (Mayer, 1975, 1979, 1980) provides additional insight into the students' use of schemata in problem solving. The theory suggests that meaningful learning (or, in this case, understanding) depends on three conditions: reception of material, and availability and activation of an assimilative context (Mayer, 1980). However, students did not always receive the material; they missed details. Nor did students always have an assimilative context. This was particularly evident in their journals on the most difficult stories. For example, most students did not have a context for assimilating the "operation" in "Hills Like White Elephants," an outdated mode of abortion which is described in the story as "letting the air in." Some students mainly asked questions or expressed confusion instead of trying to generate explanations (e.g., "What type of operation is the girl going to have?" and "The sentence 'It's just to let air in' I do not understand at all!!"—student's punctuation). Generally, however, the journal questions and comments did provide evidence that students were trying to use an assimilative context. In "Hills Like White Elephants," one field dependent reader initially missed the repeated use of the word "operation." In a subsequent reading, having noticed the word, he inferred that "operation" referred to the business operation of the bar at the train station. Later, when he was apparently cued by other students' imposition of a false assimilative context during discussion before class, he decided the operation was to restore the girl's hearing. By contrast, the best reader generated the following explanation: "The only thing that I can think of that would not really be an operation, that would relieve the tension or unhappiness that they both apparently feel, would be an abortion."

When readers activate schemata, they run the risk of imposing inappropriate schemata (Anderson et al. 1977). This was particularly evident in the journal on "Hills Like White Elephants." Apparently unable to make sense of some key details, several students attended to selective details that fit a schema they could understand; for example, because the girl could not understand the waitress and asked the man to tell her what the waitress said, several students concluded the girl was deaf (see related example in paragraph above). In a slightly different vein, all the students activated an incomplete schema for "white elephants." None of them had additional schemata for a white elephant as something precious which is difficult and expensive to maintain or an endeavor that is a failure.

<u>How are these activities related to individual learner characteristics</u>? The greater the students' expertise in reading, the less they tended to review content (summarize) in the easiest story. This would be expected if the purpose of summarizing/paraphrasing is to help students monitor their comprehension (Palincsar & Brown, 1989). However, on the more difficult stories, some of the best readers used summarizing to scaffold themselves in developing insights.

Students' cognitive activities were not significantly related to students' ratings (a) of journal helpfulness (at the beginning or end of term), (b) of how much they said they had learned about understanding literature, or (c) of the "Student Accounts of Journal Writing" (an instructional resource).

Although the lower achievers (as measured by semester GPA) tended to write as much as the higher achievers, they tended to write more off-task statements, for example, affective statements or statements about the subject or author. (The issue is not whether students engage in off-task behavior, but the extent to which that supplants their engaging in activities that support their achieving the stated goals of the assignment and the course.)

Types of Questions and Comments

An analysis focusing on the hardest and the easiest story revealed that students generally engaged in three types of cognitive activities in their journals: reviewing content (summarizing and paraphrasing), evaluating (making judgments about character actions, author actions, or the story), and problem solving (asking questions and generating self-explanations). The elaborated classification is reminiscent of the strategies "good students routinely bring to the task of studying texts": questioning, clarifying, summarizing, and predicting (Brown & Palincsar, 1989, p. 414). The classification is also suggestive of Chan, Burtis, Scardamalia, and Bereiter's (1992) declarative, interrogatory, and evaluative "response subtypes" (p. 103). However, those two classification schemes relate to what Ng and Bereiter (1991) called "extracting knowledge from text," while constructing meaning from short stories requires interpretation more than extraction.

There were significantly more self-explanations (comments) than questions in each of journals 2 through 5 (Tables 3 and 4). The similar frequencies in the first story may be related to a combination of factors: its brevity (170 words), its difficulty, and students' inexperience at writing journals. Small-to-moderate positive correlations (Table 5) between the frequency of self explanations in pairs of journals suggests that certain students habitually engaged in generating (many or few) self-explanations, regardless of story difficulty. However, there were no patterns in frequency of questioning and of reviewing content. There was a small significant relationship between question frequency ($r = .613$, p

< .05) in journals 4 and 5, suggesting that some students might have been developing a habit of generating or not generating questions.

Focus of cognitive activities. Preliminary analyses indicated that students' cognitive activities focused on three categories: (a) the textbase (Kintsch, 1989); (b) the situation model (Kintsch, 1989), which in a literary work involves elements such as setting; characters' actions, thoughts, and feelings; conflict; outcome; and subject, gist, and theme; and (c) literary principles, which might be called the aesthetic model (e.g., why the author included a particular character, and what would be gained or lost by changing the point of view or setting). The majority of cognitive artifacts were attempts to understand the situation model, even in the journals on the easiest story. Students admitted confusion, asked questions, generated self-explanations, judged characters' and authors' actions, and discussed elements that teachers might not point out in class; some also responded affectively. The findings are generally consonant with Wilson's (1989) description of journals in an 11th-grade high school literature class. Most of the students' questions and comments were directly related to the stories, particularly elements relating to character. Students wrote significantly more ($p < .05$) about the story elements (e.g., conflict, crisis, climax, theme) in the easiest than in the hardest story.

Table 3. Mean Numbers of Cognitive Activities in Journals on Stories

	Problem		Solving			
Journal	Self-explanations		Questions		Content Reviews	
1 hard*	3.58	(3.87)**	3.58	(3.45)	1.08	
2 easy	10.75^a	(11.44)	1.83^a	(2.17)	.25	
3 hardest	10.58^b	(9.56)	2.83^b	(3.76)	3.17	(2.67)
4 easiest	12.92^c	(12.56)	2.33^c	(4.03)	6.83	(8.21)
5 hard	14.25^d	(9.49)	3.25^d	(2.83)	8.58	(6.57)

n = 12 (Only students who completed all 5 journals were included.)
* story difficulty
** Standard deviations are in parentheses.)
a, b, c, d: $p < .05$

Table 4. Effect of Story Difficulty on Average Number of Items in Journals 2 - 5*

	Questions		Self-explanations		
Reading Level	Easy Stories	Hard Stories	Easy Stories	Hard Stories	Total
High Ability (6)	5.00	6.50	23.17	26.83	61.5
Lower Ability (6)	3.33	5.67	24.17	22.83	56.0
Total (12)	10.25^a		48.50^a		
Std. Dev.	9.54		38.14		

* For this analysis journal 1 was treated as practice.
$p^a < .001$

Table 5. Correlations of Numbers of Self-Explanations Between Journals

Journal	2	3	4	5
1	$.868^a$	$.806^a$	$.671^b$	$.638^b$
2		$.742^b$	$.576^b$	$.649^b$
3			$.944^a$	$.666^b$
4				$.693^b$

n = 12 (Only students who completed all 5 journals were included.)
$p^a < .01$ $p^b < .05$

The role of difficulty level. Story difficulty level was significantly related to only two journal variables: journal length and number of story elements addressed. Students wrote significantly more for the easiest story (fourth) than the hardest story (third). However, this difference might be explained by the fact that students tended to write more as they gained more experience; the average length of the five journals on stories increased steadily: 182.8 (std. dev. 128.2) , 349.7 (328.2), 398.8 (325.2), 539.9 (511.4), 644.5 (327.1). An ANOVA and post hoc analyses revealed significant ($p < .05$) differences between journals 1 and 5 and 1 and 4. More important than the difference in length is the fact that students addressed significantly more story elements (particularly classical plot elements) in their journals on the easiest story than on the hardest. This difference suggests a hierarchical relationship, with construction of the situation model being requisite to identifying all but the simplest plot elements; because most students could not construct the situation model in the hardest story, the only plot element they tried to identify was the setting.

Miyake and Norman (1979) found that on easier material novices asked more questions, but on harder material trained subjects asked more questions than novices. In the current study, because most of the cognitive artifacts in the journals were attempts to understand the situation model, I decided to examine the frequency of questions and self-explanations in terms of reading expertise rather than knowledge of literary principles. Using reading grade level as an index of expertise, analysis did not support these hypotheses (Table 4). This might be explained by the fact that students in the high-ability group all read at or above the 16.9 grade level, but only one or two students in the lower-ability group might truly be described as low-ability, and none could be described as novice readers.

However, sev al differences between this study and the Miyake-Norman study are worth noting. One of the most important differences is the procedure for identifying questions. In the earlier study, students were asked to verbalize their questions aloud as they studied instructional materials, while in this study students *wrote* their questions and comments, often over the course of several hours or even days; they answered many of their questions before they began to write their journals. Second, "prior knowledge" proved to be a much fuzzier term in this study than in the Miyake-Norman study, where students had a common goal in a well-defined domain (learning three text-editing tasks); thus relevant prior knowledge was clearly defined. In the current study, students were encouraged to adapt a very generalized task to their own needs in an ill-defined domain. Although the long-term goal was to help students develop their skills in understanding stories, they were encouraged to use the journal to address their immediate needs (as *they* defined them) in understanding a given story. Thus, the immediate goal (and perceived relevance of prior knowledge) differed for each student.

Third, several types of prior knowledge played a role in this study, from prior conceptions of journal writing to general world knowledge. I measured students' reading abilities, but I did not attempt to formally measure several other types of prior knowledge, such as students' prior knowledge of fiction (declarative and procedural). Perhaps the most critical prior knowledge was students' general world knowledge, which Anderson et al. (1977) and Brown, Campione, and Day (1981) suggested may be one of the most important factors in students' abilities to comprehend expository prose. General world knowledge would logically seem to play an even greater role in comprehending college-level literature. But there was no way to measure all the general knowledge that directly or indirectly had bearing on the various stories students read. Nor was there a way to identify all the knowledge that might have interfered with understanding a story, with students' assimilating information into inappropriate schemata.

Three additional points are worth noting about the relationship between story difficulty and questions. First, if the point of interest is not *quantity* (number of questions) but *quality* (the type of elements addressed in questions and comments), then this study does provide some evidence of a relationship. Analysis of journal content revealed two qualitative differences. Compared to lower-ability readers, the high-ability readers tended to generate higher-level inferences (e.g., inferring that the operation in "Hills Like White Elephants" was an abortion, and commenting on the *role* of the setting vs. the setting itself), and they tended to address their own questions and points of confusion. Future research should investigate whether these tendencies are related to other factors, such as confidence, willingness to take risks, or knowledge of reading strategies.

Second, students' goal orientations (Ng & Bereiter, 1991) may have been related to the frequency of their questions and self-explanations. This possibility warrants future research, particularly since total student load (academic plus work) correlated negatively with length of journals (e.g., $r = -.681$, $-.675$, and $-.801$ for the last three story journals; $p = < .02$), although average length of journals increased steadily. Third, the higher frequency of self-explanations than questions suggests that they deserve equal attention and that research in ecologically valid contexts should not restrict students to one or the other.

<u>How are questions and comments related to individual learner characteristics</u>? Field articulation and reading ability were the major learner characteristics of interest. As the literature predicted (Jonassen & Grabowski, 1993), there was a significant relationship between scores on the Hidden Figures Test and reading comprehension, vocabulary and total reading levels ($r = .58$, $.59$ and $.57$, respectively, with $p = < .05$). A relationship between reading ability also correlated strongly with semester GPA (e.g., total reading level, $r = .81$, $p = .001$). The reason for the latter must be further explored. Other correlations suggest two possibilities, both of which involve metacognitive skills of planning and execution. The first involves the student's carrying a load (academic and work) too heavy to master with his/her reading ability (and perhaps study skills, etc.). The second involves engaging in off-task behavior that supplanted behavior that was required for mastering objectives (see correlations in research question 2).

Neither reading ability nor field articulation were significantly related to any other major factor. Failure to obtain statistically significant relationships may have been a function of the small sample sizes (less than six field dependent and field independent students). However, tendencies consonant with prior research on field dependence and field independence (Jonassen & Grabowski, 1993) suggest the need to explore several issues with larger sample sizes, particularly since the ability to perceive parts of a whole is essential in the analytical and critical thinking required in the course. Analysis of journal content and in-class comments suggested that field dependent students were less likely than field independent students to perceive key elements/significant details, particularly as story difficulty increased. Moreover, when they were confused, field dependent students often attended to superficial details and meanings, while field independent students tended to utilize details to help them generate self-explanations. Reflecting a reliance on external guidance and/or a preference for social contexts, the field dependent students also tended to rely on the "Catechism" (and the adjunct questions included in the text for one story) and/or rely on interpretations of family and friends. In contrast, field independent students seemed to attend to internal cues, which allowed them to address their own needs; they either ignored the "Catechism" or used it just "to get my wheels rolling."

Two field dependent students were classic examples of the inability to perceive details. For example, in his journal on "Hills Like White Elephants," Todd said he initially missed the word *operation*, even though it was used several times and was the focus of the story. After he finally noticed the word, he missed other details that would have restricted its meaning, and instead thought that it referred to the business operation of the bar. His journal comments suggest that a discussion before class made him realize that the word referred to a medical operation, but he still failed to identify significant elements of the story that would have helped him correctly identify the operation as an abortion. By contrast, he appeared to be guided by adjunct questions in his journal on the previous story; he addressed three significant issues, all in the order they appeared in adjunct questions.

Taxonomy

A taxonomy (Table 1) can describe students' questions and comments only in very general ways in this ill-defined domain. Having to work with cognitive artifacts made it impossible to determine levels of cognitive processing and to confidently classify all the entries in journals. Students generally did not address the critical elements that are the focus of most instruction and critical analyses. Instead, content of journals reflected intermediate stages of knowledge construction (Bereiter & Scardamalia, 1992) which was highly idiosyncratic. The idiosyncrasy within and across sets of journals is consonant with chaos theory: The sensitive dependence on initial conditions—e.g., learner knowledge—can result in large, unexpected effects—e.g., the specific questions and comments—(Gleick, 1987).

Student Perceptions of Journal Writing

Twelve students evaluated journal writing during the third and thirteenth weeks of the semester, knowing that I would not see their comments until I had submitted course grades. High ratings (mean = 3.9 out of 5 on each; std. dev. = .996 and 1.17) were supported by responses to open-ended questions on the survey, interviews, class comments, and analysis of journal content. In the second evaluation, nine students described the most helpful aspect of journal writing in terms of a cognitive tool (Derry, 1990; Jonassen, 1992). They said it (a) stimulated/facilitated their thinking, including articulating or clarifying thoughts, formulating opinions, examining all of a story's points; (b) forced them to think about what they read, instead of reading passively or just for pleasure; (c) made them look at a work in more than one light; (d) taught them to concentrate or focus thoughts; and (e) forced them to read more carefully, including looking for details. Yet some of the students who rated journal writing most highly said they would not have done it if it had not been required.

<u>How do ratings of journal helpfulness relate to other variables</u>? Ratings were not significantly related to reading ability level, field articulation, average grades on journals, or grades in the course at the time of the survey. Initial ratings of journal helpfulness had a moderate positive correlation with final ratings ($r = .699$, $p = .01$), and a moderate negative correlation with self-ratings of skill in understanding stories at the beginning of the term ($r = -.766$, $p = .01$).[4] At the end of the term the correlation between journal helpfulness and skill in understanding stories had decreased slightly ($r = -.657$, $p = .02$). The findings suggest the

importance in quickly identifying students who rate their understanding of stories highly and helping them discover how to use journal writing as a cognitive tool.

Several other factors significantly correlated with students' ratings of journal helpfulness at the end of the term (see Table 6). For example, the more they thought they had learned, the higher they rated journal writing. The fact that neither journal grades nor course grades correlated significantly with ratings of helpfulness may suggest that students were learning strategies and skills that examinations were not sensitive to (e.g., development of metacognitive strategies). Since no attempt was made to measure learning gains in terms of the material on the examinations, it is possible that students who thought they had learned a lot had indeed done so.

Table 6. Factors Correlated with Ratings of Journal Helpfulness After Last Journal

Factor	r	p
1. self-rating of how much was learned about reading literature	.902	.001
2. rating of helpfulness of journal writing, after first journal	.699	.01
3. academic load	-.680	.02
4. self-rating of skill in understanding stories, beginning of term	-.657	.02
5. improvement in confidence in ability to write journals, last day of term	.640	.02
6. rating of helpfulness of Student Accounts of Journal Writing	.594	.05
7. semester GPA	.588	.05

Summary

Findings indicated that (a) students generally viewed journal writing as a flexible cognitive tool which helped them construct the meaning of stories, and (b) writing journals scaffolds students in attending to details, asking questions, and answering their own questions. Moreover, journal writing is a very dynamic process; no single cognitive model can describe journal writing either within or across students. A two-part model was developed to describe the process: (a) factors which influence journal writing (task difficulty, individual learner characteristics, teacher expectations, student strategies, external resources, overt activities), and (b) components of journal writing (establishing a goal, constructing the textbase, constructing the situation model, predicting outcomes, identifying significant elements, reflecting on meaning, and assembling the schema). Although high-ability readers tended to engage in different cognitive activities than lower-ability readers, frequencies of questions and self-explanations were not related to story difficulty. Students' valuations of journal writing were not significantly related to measures of achievement (course grades, semester grade-point averages, or cumulative grade-point averages).

Discussion

A Flexible Tool

The data from surveys, journals, interviews, and comments suggest that journal writing can be a flexible cognitive tool for a wide range of students in a college Introduction to Literature class. The fact that students of diverse ability and achievement rated journal writing as helpful supports empirical data of Chi, de Leeuw, Chiu, and LaVancher (1991) that high-ability and average-ability students benefit equally from being prompted to generate self-explanations in physics classes.

Although most students said they found journal writing helpful, even students who said they "enjoyed" journal writing did not write optional journals. This might reflect the fact that they had not had enough experience with journal writing to incorporate it into their repertoire of study strategies; Duffy and Roehler (1989) found that high school students needed at least six months of frequent practice with a new strategy. Here, the new strategy had to compete not only with presumably highly automatized strategies, but also with personality factors (such as self-described "laziness") and demands of work, other courses, and spouse/family. Furthermore, students may have needed guidance in applying journal writing to the study of poetry, which most students find intimidating on its own. Several people have argued that each literary genre requires knowledge of its own conventions (e.g., Culler, 1975; Pressley, Goodchild, Fleet, Zajchowski, & Evans, 1989).

Task orientation. Some students may have had task-completion rather than personal knowledge-building orientations (Ng & Bereiter, 1991). This seems particularly likely for the student who rated journal writing "Not at all Helpful." (Note: This student was not included in many analyses because she missed class the night students took the reading and HFT tests and refused to make them up.) Helping students become "intentional" learners is likely to require more than strategy instruction (Bereiter & Scardamalia, 1989), particularly for adult learners, who have such highly developed schemata for school learning.

Self-explanations and scaffolding. One explanation of the mechanism of self-explanations is provided by Chi and VanLehn (1991), who conjecture that "the act of self-explaining may make the tacit knowledge...more explicit and available for use" (p. 101). Students' open-answer descriptions of the most helpful aspect of journal writing, as well as analyses of journal content, support this interpretation. Relationships between memory capacity, speed of processing, learner ability, and cognitive development may also provide insight into the mechanism by which journal writing appears to scaffold learning. Snow and Swanson (1992) report that higher-ability learners have a larger memory capacity and faster processing speed than do lower-ability learners. Since research shows that memory search speed is critical in associative learning and in forgetting, learning tools, such as journal writing, which focus on reducing the demands on memory capacity and on maintaining attention, should indeed scaffold the learner in constructing meaning.

Students' ability to conceptualize questions. Recently, David Merrill said: "[S]tudents are not good at conceptualizing questions....One of my favorite strategies in class is to say, 'Ask me a question.' Once in a while I get asked a good question, but most of the time I don't. Consequently, I don't think students know what to ask anyway" (Gagné & Merrill, 1991, p. 36). If we expect students to ask the questions that experts would ask, the current study supports Merrill's conclusion—the students asked questions (and generated self-explanations) about few of the elements that experts target as important in the stories. But more importantly this study supports the theory that learners construct intermediate stages of knowledge (Bereiter & Scardamalia, 1992). Students' questions, statements of confusion, and self-explanations provide the data which allow the teacher to adapt the instruction to the needs of individual students as well as the group. Thus, the teacher can work within each student's zone of proximal development (Vygotsky, 1978), helping them develop expertise—ultimately including the ability to conceptualize expert questions. (For an extended discussion of journals as an instructional tool, see Cole, 1993.)

Limitations of question-answering systems. While some people have tried to develop question-answering computer-assisted-instruction programs (e.g., Ferguson, Bareiss, Birnbaum, & Osgood, 1992; Graesser, 1992), these constrain the user to particular questions, expressed in particular language. Such a system (cafeteria-style, natural-language, or hypertext) cannot answer a question which has not been anticipated and incorporated into the database. The range of questions and comments in just 14 students' journals suggests that it would be difficult if not impossible to identify all the questions and misconceptions that can emerge as readers try to comprehend a college-level short story. Because literature is an ill-defined domain (Spiro & Jehng, 1990), the potential number of errors is almost infinite—a factorial function of the number of words, phrases, sentences, and uses of irony, allusions, symbols, etc.

But even if we *could* develop a comprehensive question-answering program for ill defined domains such as Introduction to Literature, the question is whether it is desirable. Helping students become independent learners requires that we encourage them to develop the skills and confidence to identify and solve problems. The positive relationship between students' ratings of journal helpfulness and of how much they learned about literature lends support to this view.

Individualizing instruction. Instructional/learning strategies which encourage students to express their naturally occurring questions and comments allow each learner to build naturally on whatever prior knowledge he/she has, while providing an opportunity for the teacher to monitor the student's comprehension, identify misconceptions, and adjust instruction accordingly. Gaining the type of information provided by journals in ill-defined domains seems to be particularly important when instruction must provide ideational confrontation to facilitate cognitive change (Champagne, Gunstone, & Klopfer, 1985b). In placing the learner at the heart of the instructional process (Resnick, 1983), this study demonstrated how widely learners' questions and self-explanations can vary. Moreover, the wide variation is consonant with chaos theory, which argues that the sensitive dependence on initial conditions—e.g., learner knowledge—can result in large, unexpected effects—e.g., the specific questions and comments—(Gleick, 1987).

Reading comprehension. The current study supports the hypothesis that prior knowledge may be the most critical aspect of learning and problem solving (Anderson et al., 1977; Brown, Campione, & Day, 1981; Novak, 1985; Rigney, 1978; Bereiter & Scardamalia, 1992). Many of the students' comprehension problems related to misconceptions about or lack of world knowledge. The most striking examples of this related to "Hills Like White Elephants." Students thought they knew what a white elephant is (they applied a literal meaning) and thus didn't think to consult the dictionary for additional meanings that might shed critical light on the story. Other comprehension problems related to world knowledge about human motivation, causes of heart disease, European history, roles of men and women at various points in history, representations of Death, etc.

Social or Individual Level of Knowledge Building?

Ng and Bereiter (1991) conjectured that instructional approaches which "promote a 'community of learners' (Brown and Campione, 1990)" would be the most likely ones to foster "personal-knowledge building" (p. 269). For many people, including Ng and Bereiter, a community of learners means having students work in small groups. However, for years people have done collaborative learning but not necessarily with results.

The current study suggests that a *community of learners* might be promoted in ways that do not fit the typical notion of collaborative learning. On one level, journal writing involves a community of two; although I generally respond as a coach, occasionally a student's journal leads me to new insights. On a second level, journal writing involves the whole class (and even former classes) since I draw on journal questions and comments to stimulate class discussion. In class, I model, coach, and scaffold learning, and occasionally students also lead me to new insights.

The mechanism by which students develop their understanding and their ability to answer their own questions seems related to Vygotsky's (1978) concept of mind as society. First, students engage in social dialogue, as part of a community of learners; then, in journal writing, they internalize the type of dialogue that they learned as part of the larger community, while maintaining access to the social dialogue. Journal writing seems to help students expand their own zones of proximal development, making their tacit interpretations explicit and thus available for reflection and analysis. Thus, journal writing can help learners make the transition from being dependent on others to being able to learn on their own. It helps them move from what Vygotsky (1978) called the *other-directed to self-directed* stages of understanding, a capability that satisfies goals of many educators (e.g., Brown, Campione, & Day, 1981; Duffy & Jonassen, 1992; Frase & Schwartz, 1975; R. M. Gagné, 1980; Jonassen, 1985).

Contributing to one's own understanding. Journal writing gives *each* student the opportunity to ask questions, try to answer them, and express their understanding of a story. A few students do not have the opportunity to come up with all the questions and answers and make it impossible for other students to contribute to their own understanding. (Even if they have the opportunity in class or in collaborative groups, some students don't take advantage of it because they lack confidence or fear peer ridicule.) In describing their Jasper series, the Cognition and Technology Group at Vanderbilt (1992) emphasized the importance of each student having the opportunity to contribute. Journal writing, even more than collaborative learning, guarantees such opportunities.

Recommendations for Research

This study was primarily a qualitative study. Although it suggests that journal writing can be a very flexible cognitive tool, it raised many more questions than it answered. A comprehensive research agenda on journal writing should include at leas the following issues.

Duration (see above). A longitudinal study of journal writing is warranted, preferably a full year of journal writing in more than one discipline, with follow-up studies for at least a year.

Group size constrained the types of statistical analyses as well as the statistical significance of results. Research with a larger group is needed.

Taxonomy. Feathers and White (1987) also found that journal writing by itself is an insufficient means of identifying levels of cognitive/metacognitive activities. Future efforts may have to sacrifice some ecological validity so that research is not constrained by the cognitive artifacts in journals. This might be done by debriefing students. Are the questions real, or do they merely reflect the style of low-confidence (or low-risk-taking) students who are anxious about expressing self-explanations? To what extent did the students generate self-explanations? Did they perhaps apply a generalization about the author from a head note, as some of my students did? Did the students discuss the story? If so, what cognitive activities did they engage in between reading, discussing, and journal writing? Are they reciting a question, self-explanation, or summary provided by another person; applying a concept suggested by another person; or perhaps problem-solving by building on the discussion? However, trying to identify the levels of cognitive processing may require the use of think-aloud protocols (Chi et al. 1989; Chi, de Leeuw, Chiu, & LaVancher, 1991; Chi & Van Lehn, 1991; Hayes & Flower, 1980) and shorter stories.

Achievement. Does journal writing affect achievement? Are there aptitude-treatment-outcomes interactions? Of particular concern is whether students may benefit in ways that are not directly related to stated course goals, especially in long-term development of critical reading, thinking, and metacognitive skills. One caution is important here. If learning involves construction of intermediate stages of knowledge, direct comparisons of journal content with end-of-term content objectives (as suggested by one critic of a manuscript on this topic) is unwarranted.

Transferability and domain. Is journal writing transferable to other educational settings and training contexts as an instructional/learning strategy which benefits teacher and/or student (particularly to situations in which learners have to extract meaning , undergo cognitive change, or solve problems)?

Research has yet to determine whether a journal-writing instructional/ learning strategy is potentially more beneficial in some domains than in others. Related research suggests that it might be. Identifying bugs in well-defined procedural knowledge such as arithmetic seems easier than in ill-defined domains (e.g., Spiro et al. 1988; Spiro & Jehng, 1990) such as understanding philosophy or complex college-level short stories. In arithmetic, computer programs such as J. R. Anderson's (1990) LISP Tutor can even monitor students' actions, intervene, provide gu dance, etc. Learning and teaching an ill-defined domain are much more complicated. For example, a complex college-level short story may not have a single "correct" meaning; moreover, the student may have inferred a "correct" or highly tenable meaning from wrong or incomplete evidence. (While a student may also get a correct answer for the wrong reason in arithmetic, it is much easier to identify the error.) Thus the teacher *needs* to know not only the student's conclusion, but also his/her reasoning. While solving arithmetic requires knowledge of a well-defined procedure, understanding a complex story is a dynamic process in which the meaning unfolds with each word, each phrase, each sentence, ... Comprehension is often complicated by the fact that the author of a college-level short story often delays or even withholds information for aesthetic or affective purposes.

Do teacher/instructional methods (e.g., discussion, lecture, discovery learning) affect journal content, learning outcomes, and students' evaluations of journal writing?

On a related issue, I have suggested that adjunct questions and CAI question systems could not adequately anticipate or address students' emergent needs in an ill-defined domain such as Introduction to Literature. However, since journal writing is time-intensive for both student and teacher, research should address whether sets of questions derived from student journals could be incorporated into effective adjunct questions or CAI question systems.

Effects of resources. How does use of resources (e.g., "Catechism for Stories" and the tutorials *Writing Journal Questions* and *Writing Journal Comments*) or discussing stories with others affect the content of journals, learning outcomes, and attitudes? On the final survey, most students said they would have liked more direction in journal writing; yet only one student took advantage of the opportunity to use the tutorials. Should use of such resources be required?

Learner control. To what extent does learner control influence achievement, attitudes, outcomes (e.g., independent learning), etc.? Journals which encourage the learner to identify and try to solve his/her own problems in comprehending an assignment give learners more control than journals which require students to respond to adjunct questions (e.g., Hettich, 1990) or engage in dialectical reasoning about terms which the teacher assigns (e.g., Jolley & Mitchell, 1990).

Metacognitive awareness. Findings suggest that journal writing may have helped develop students' critical reading/thinking skills and metacognitive awareness. For example, one of the students in the class was a 36-year-old woman who read at the 16.9 grade level; she had been in my second-semester composition course, where her probing intellect was evidenced in every essay she wrote. Nevertheless, in one of her last journals in this study, she wrote:

> Yes, these journals are a help to me....As much as I read I've never learned to read critically....The point of all this is that I never learned (bothered) to take a story apart and look at it. I've always accidentally picked out a phrase or image that was especially appealing, but now I'm doing it more often, and I'm spending more time contemplating the author's motive, even in my "fun" reading.

Although she was by habit reflective, she had not developed high-level skills to analyze lit erature. To what extent does journal writing contribute to such changes? What mechanisms are involved? Are there aptitude-treatment interactions?

Effect on class discussion. Several students observed that having to write journals made them think about assignments before they came to class. Does having to write a journal impact the quality and quantity of students' questions and comments during class discussion?

Field articulation. The current study suggests that journal writing may develop the ability to attend to details in learners who are extremely field dependent. Will empirical research support this finding, and if so, with what populations, in what domains, and under what conditions? Would field-dependent learners benefit more by having to respond to adjunct questions to help them focus on salient elements (e.g., a set of story-specific study questions; conflicting accounts of a person, event, or situation; or questions and comments derived from other students' journals)?

Reading strategies. What strategies do high- and lower-ability college readers use in Introduction to Literature, when, and why? How do these relate to journal content, learning outcomes, etc.? Can the strategies of high-ability readers be taught to lower-ability readers? Why do some students attempt to answer questions they ask in journals while others do not? How do differences relate to reading ability, goal orientation, confidence, willingness to take risks, world knowledge, etc.?

Feedback and grading. Do the type and timing of feedback and grading (e.g., rigorous grading vs. no grading; immediate vs. end of term) affect the content of journals, learning outcomes, students' perceptions of journal helpfulness, or their motivation to write journals? (See Cole, 1992, for discussion of these issues.)

Role of world knowledge. As discussed above, many have hypothesized that world knowledge plays a dominant role in comprehending expository prose. Findings in this study suggest that world knowledge also plays a dominant role in college students' comprehension of complex short stories. How can relevant world knowledge be identified and measured? What instructional strategies are most effective for providing world knowledge which is relevant to a given story (e.g., isolated teaching of knowledge before students read a story, footnote or marginal glosses, hypermedia programs to provide access to relevant knowledge on demand, or class discussion after students have read a story)? Are there aptitude-treatment interactions?

This paper has described journal writing as a dynamic and flexible tool that is valued by learners of diverse abilities. However, much research is needed before we have a clear understanding of the constraints which must inform instructional prescriptions for journal writing.

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[1]Since I provide written and oral instruction and practice in class, the main purpose of the tutorials in my classes is to increase students' confidence in their ability to write productive journals by providing opportunity for review, additional practice and feedback (particularly by allowing students to compare their practice entries to a wide range of responses from former students). The tutorials—*Writing Journal Questions* and *Writing Journal Comments*—identify the purposes and criteria of the types of journals assigned, and provide practice identifying productive journal responses, and practice writing responses to excerpts from stories. They also explain and illustrate many types of journal entries (e.g., state the effect of the story on the reader, paraphrase, summarize, predict, verify, relate story events to personal experience).

[2]The five stories were sequenced: (1) "Appointment in Samarra," anonymous; (2) "Story of an Hour," Kate Chopin; (3) "Hills Like White Elephants," Ernest Hemingway; (4) "Cathedral," Raymond Carver; (5) "The Cask of Amontillado," Edgar Allan Poe. Student feedback suggests that 2 and 4 are easiest to comprehend (4 being easier than 2) and that 3 is the most difficult.

[3]The "Catechism for Stories" also includes questions on atmosphere, character, point of view, crisis, climax, resolution, tone and theme (and related questions on keywords, subject, plot, and symbols). Following are the questions relating to "crisis":

a. At what point (scene or moment) can things get better or worse for the protagonist? (Often this is at the point of climax.)
b. What was the situation before this point?
c. What choices are involved?
d. What are the potential consequences?

[4]Occasionally I have had students with graduate-level understanding of literature; they have been the best journal writers. None of the students in this study had such an understanding.

Title:

How do Attitudes of Parents, Teachers, and Students Affect the Integration of Technology into Schools?: A Case Study

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Purpose of the Study

School reform often looks to "technology" to help improve education (Texas Education Agency. 1988; Main & Roberts, 1990; Salehi, Mullinix, Wode, & Dreighton, 1980). Troxel & Grady (1989) suggest that most reform agendas recommend the inclusion of technology within the educational process. For example, the Texas State Board of Education (Texas Education Agency, 1988) developed a long-range plan for the infusion of technology into instruction as a means to increase effectiveness of the curriculum. This Long-Range Plan gave schools with in local districts the charge to select and apply technology to meet local needs. Other school systems (state and local) have reported similar plans (Salehi, et al, 1989; Main & Roberts, 1990).

Burkman (as cited in Martin & Clemente, 1999)) suggested that teachers have strategic roles in what occurs in the classroom. A number of studies have investigated the relationship of attitudes and implementation and use of computers in educational settings (Savenye, Davidson, & Orr, 1991, 1992; Sanders & Stone, 1986; Canning, 1989). In addition, other reported results indicate that implementation and use of computers is also related to student attitudes toward computers (Campbell & Perry, 1989; Raub, 1981). However, in today's schools, teachers and students are no longer the only audiences that are involved in the decisions about implementation and use of computers. For a variety of reasons, parents are also becoming active participants in the planning and implementation of computers into the classroom (Policy Research Project on Education, Technology and the Texas Economy, 1989; Troxel & Grady, 1989). Thus it seems reasonable to postulate that perceptions of parents about technologies would also impact a school's plans for technology infusion. Yet little research investigating attitudes of parents toward computers has been reported in the literature.

The purpose of the study was to address the research questions: (1) How do the attitudes of teachers, students and parents towards computers affect the integration and use of computer technology in schools?; (2) Do these attitudes change (either positively or negatively) or remain constant after the implementation of technology into classroom?; and (3) What are the implications of involving parents in the planning of school curriculum and activities?

Background Information

Highland Park Elementary School, located in Austin, Texas, has slightly under 500 students and has a relatively new building in comparison to other schools in the district. The vast majority of the population is white (an estimated 5-10% were minority) and economically falls into a high middle to upper income area of the city. Class sizes are around 21 to 25 and there is low teacher turnover. Administrative support of teachers is high and, based on informal observation and conversation, mutual respect and cooperation among teachers and administrators is high. According to the Highland Park School report, the school has 29 local business and community organizations as Corporate partners (Adopt-A-School) and a minimum of 40 volunteers in the Community/Parent Volunteers organization.

As a means to continue their tradition of innovation, the school purchased 10 Macintosh computers through funds raised by collaborative efforts of the school, parents and local business adopters. The school joined in a partnering consortium with Apple Computer, Inc. to facilitate the purchase of additional computers (up to 25 Macintoshes) and collaborate on the applications of computers in classrooms. The school established a computer committee to develop plans for the integration and use of computers in the curriculum and other school activities. The computer committee was made up of teacher representatives from all grade levels and departments in the school, plus parents, and community leaders. The committee developed plans for computer training and lab access for teachers parents, and students.

The committee invited the principal investigator to the project meetings to assist them in the project. One outcome of these planning meetings was to develop a means to document and describe the experience level, attitudes towards computers, and computer use of parents, teachers, and students as the computer integration was occurring. It was determined that 1991 would serve as the baseline year for gathering data on experience, attitudes, and patterns of use. Then in subsequent years, similar data could be gathered and compared to the 1991 information, noting any significant changes in these areas. To identify these attitudes and perceptions, a survey study was formulated and conducted during the spring semester of 1991 and 1992.

Method

Study Site. The study was conducted using parents, teachers and students of Highland Park Elementary School in Austin, Texas (a medium size urban school district in Texas). The school site and the participants for this study were not selected at random. The study was conducted at the request of the school's computer committee and was based, in part, upon the willingness of the school personnel, students, and parents to participate in the study. The study involved approximately 475 students enrolled in kindergarten through fifth grades, 34 teachers, and 230 parents during both data collection periods.

Procedure. In January and February, 1991, a subgroup of the school's computer committee met with the principal researcher to develop the questionnaires for the three populations--students, teachers, and parents. In March, 1991, the final draft of the surveys were completed and reproduced for distribution. In late April, 1991, the instruments were distributed to all three groups. Teachers at each grade level were responsible for administering the survey to the students as well as completing their own survey individually. With the exception of kindergarten, first grade and special education classes, students read and responded to each item independently. Teachers in the kindergarten, first grade, and special education classes read the items and asked each individual student to respond as the teacher marked the response sheet accordingly. The parent questionnaires were sent home with the children. Care was taken to see that only one survey was sent to each home. Attached directions asked that only one parent respond to the questionnaire and return it . The surveys from all three groups were returned within two weeks, and then coded for analysis. One year later, the questionnaires, with some modifications were administered to the teachers, students and parents in a similar manner.

Instruments. The questionnaire instruments were developed for each subpopulation of the school (Davidson & Ritchie, 1992). The questionnaires were based, in part, on items from a preassessment questionnaire by Smith, Savenye and Davidson (1988) and an attitude instrument by Savenye, Davidson, and Orr (1991, 1992). These instruments consisted of demographic items, followed by items on computer experience and attitudes and anxiety about computers. The teacher and parent surveys also included items on perceptions about the impact of computers on teachers' roles and students' self esteem and issues about computer training and workshops specific to that particular school. Subjects responded to attitude anxiety items using a five-point Likert-type scale of strongly agree to strongly disagree. The student survey contained a total of 21 items; the teacher survey contained 45 items and the parent survey contained 43 items. In an effort to encourage frank responses to items, all respondents could remain anonymous. (Note: Not all of the items are discussed in this paper; for a full discussion, see technical report by Davidson and Ritchie (1992)). All subjects used a response sheet to record their answers.

Design and Data Analysis

Due to the conditions of anonymity, the surveys completed by the same individuals in 1991 and 1992 could not be correlated for statistical analysis. Therefore, the three sets of samples (teachers, parents, and students) were considered independent for all analyses of variance. Differences in the mean responses for each item related to computer attitudes and anxieties between the 1991 and 1992 survey groups were assessed with multiple t-tests. The results yielded statistically significant differences for some items within each of the three participant groups.

Reliability coefficients, calculated for each group based on the combined responses to the survey items from 1991 and 1992, revealed a few items of low reliability. As a result, item 37 from the teacher survey, items 35 and 37 from the parent survey, and item 9 from the student survey, were excluded from the factor analysis. The final reliability coefficients (Cronbach's alpha) were .79 for the student and parent surveys, and .87 for the teacher survey.

Questions 1- How do attitudes toward computers affect the integration and use of computers technology in schools?
Question 2 - Do these attitudes change or remain constant after the implementation of technology into classroom?

Student Group. The entire student body of Highland Park Elementary was almost equally divided between genders for both years 1991 and 1992. Based on the demographics collected in the survey, kindergartners and first graders comprised the greatest portion of the student population (37%) in 1991 and (48%) in 1992, with a relatively even split in the remaining grades. Almost all students had used a computer before the survey was taken in the spring, 1991. A little more than half of the student body had a computer at home (58%) in 1991 and this percentage increased to 68% by the end of 1992.

The strongest attitudes about computers among students were positively expressed in two items: Students (95% in 1991 and 99% in 1992) definitely believed that they could learn how to use a computer, and they (96% in 1991 and 98% in 1992) also expressed that they would like to use a computer at home. These responses (items 10 and 15, respectively) are shown in Table 1. Students (91% in 1991 and 95% in 1992) also indicated that they liked to learn using a computer (item 19) and they (92% in 1991 and 1992) were excited about new things in the computer lab (item 18). Students as a whole (93% in 1991 and 97% in 1992) generally agreed that computer lessons are fun (item 11). Most students responded that they liked to experiment on the computers.

The 1991 data indicated that most students were comfortable with computer interaction, but there were still some exceptions. For example, kindergarten-first graders (35%) responded that they were afraid to touch a computer in 1991. (However, only three percent of the 1992 respondents were afraid to touch a computer.) Kindergarten-first and fifth graders (30%) feared that they might break or damage a computer. Some Kindergarten-first graders (32%) also stated that they got nervous when people talked about computers. About a third of the student body did not like to read about computers. Interestingly, first graders expressed the most positive attitudes towards reading about computers in 1991. Students as a whole (87%) think that computer lessons are interesting and 84% of them would like to have more computer lessons each week. However, 21% of the kindergarten-first graders were not as interested in computer lessons in 1991. Similarly, 20% of the fourth graders did not want more computer lessons each week in 1991, and this percentage remained relatively stable (23%) in 1992 (item 14).

Most students (85% in 1991 and 1992) thought learning is more exciting with computers (see item 20). Although 21% of the second graders in 1991 did not necessarily agree with this response. Combining the responses of strongly agree and agree, a majority of students (72% in 1991 and 67% in 1992) stated that they learn "better" using a computer (item 21). The strongest disagreement came from 40% of the fifth grade students and 35% of the second grade students in 1991. In both years, more than half of the students responded that they would like to have a job working with computers someday (item 17). Complete descriptive statistics are available from the authors upon request (Davidson & Ritchie, 1992).

Table 1 presents the results of independent t-tests on each item for the entire school population as a whole. Items 5, 6, and 7 were intended to assess anxieties related to computers. For each of these items, the means indicate that the student population disagreed more strongly in 1992 than in 1991. Stronger disagreement with these items indicates less anxiety about computer use. Items 10, 13, and 15 were intended to assess general attitudes towards computers. The means of these items show that the student population was in even stronger agreement in 1992 than in 1991.

Table 1
Independent T-Tests for Student Group (K-5): 1991 vs. 1992

Item	1991 mean	1992 mean	*f*	*p*
5. I feel afraid to touch a computer.	3.48	3.75	2.37	*<.001
6. I feel afraid that I might break or damage a computer.	3.15	3.40	1.31	* .003
7. I feel nervous when people talk about computers.	3.45	3.71	1.90	*<.001
8. I enjoy reading about computers.**	2.20	2.16	1.06	.516
9. I feel that people who know something about computers know more than I do.	2.75	2.78	1.01	.873
10. I can learn how to use a computer.**	1.38	1.21	1.80	*<.001
11. Computer lessons are fun.**	1.64	1.56	1.05	.601
12. I would like to belong to a computer club.**	2.27	2.17	1.02	.867
13. I like to experiment on the computer.**	1.60	1.44	1.25	* .014
14. Schools should have more computer lessons each week.**	1.72	1.69	1.09	.371
15. I would like to use a computer at home.**	1.41	1.29	1.26	* .011
16. Computers are not interesting to me.	3.59	3.65	1.04	.640
17. Someday, I would like to have a job working with computers.**	2.25	2.21	1.17	.093
18. I get excited about new things in our computer lab.**	1.62	1.59	1.04	.676
19. I like to learn with a computer.**	1.65	1.55	1.04	.681
20. It is more exciting to learn with a computer.**	1.69	1.64	1.01	.925
21. I learn "better" using a computer.**	2.01	2.06	1.04	.657

*p<.05 scale: 1 strongly agree, 2 agree, 3 neutral, 4 disagree, 5 strongly disagree

Teacher Group. The faculty of Highland Park Elementary School was predominantly female (88%) with a relatively even mix of age groups. The demographic results showed that only one faculty member indicated being a beginning teacher with 64% of the faculty having had six or more years of teaching experience. Over half (52%) of the teachers reported that they had computers at home with 60% being Macintoshes. Of the remaining faculty who did not currently have a computer at home, half of them planned to purchase one within the next two years with 77% of them planning to purchase Macintoshes. All of the faculty member had used computers previously (with 97% in 1991 having used a microcomputer). The Apple II series of computers and the Macintosh were the computers most frequently used by the faculty, with a small percentage (6%) of faculty having used IBM, or IBM compatibles in 1991. Their responses to these items were similar in 1992. In 1991, 88% of the faculty indicated having taken a computer course or workshop (88%); this had increased to 97% in 1992. Even though teachers were experienced with computes, most teachers (91% in 1991) rated their experience with computers as only good or fair and 9% rated it as poor. In 1992, no faculty rated their experience as poor and 6% felt very experienced.

Faculty attitudes towards the use of computers in education were generally very positive in both 1991 and remained consistently high in 1992. Most faculty members (85% in 1991 and 94% in 1992) valued teaching with technology (item 21). The majority of the faculty strongly agreed or agreed that the use of technology will enhance teaching (item 22-97%), motivation of students (item 32- 97%), and improve student performance (item 34-88%) in 1991 and their responses were similar in 1992. The faculty were unanimous in believing that computer use is of value to students (combining responses of valuable, very valuable, and extremely valuable) in both 1991 and 1992. Computers were seen as a tool to further individualize instruction (item 58). One-third of the faculty believed that the use of computers will actually decrease their planning time and by 1992, 42% of them believed that computers would decrease their planning time. This faculty appeared confident that computers would not take over their jobs or diminish their roles as teachers. Nearly all teachers (97%) expressed confidence in their ability to learn how to use a computer.

A few aspects of computers were of concern to the faculty in 1991. A small percentage of the faculty (9%) were actually afraid to touch a computer (item 24). Some faculty (15%) expressed concerns that they might break or damage a computer (item 25). About one-third of the teachers acknowledged that they were uncomfortable with people who are knowledgeable of computers (item 28-30) and 12% were tense when people talked about computers (item 26). These concerns diminished somewhat in 1992, but not entirely. The area of greatest concern was the impact of computers on the role of the teacher. A majority (59%) of the faculty believed their role as teacher would be more complex when using computers (item 37). A large percentage of teachers (41%) expressed some concern that teachers may actually have to compete with computer instruction in the classroom. One-fourth of the teachers believed that use of the computer would increase their planning time. Teachers who expressed these concerns may believe that an increased complexity to teaching is inevitable, since the faculty was unanimous in believing that instruction by computer technology is here to stay. Responses for these items in 1992 were similar.

Table 2 below summarizes the independent t-tests for items 21 through 37 on the teacher survey. Even though teachers began the study showing positive attitudes, Table 2 shows that there were significant positive changes in items, 24, 32, 33, and 36, which relate to attitudes and anxieties toward computers.

Table 2
Independent T-tests for Teacher Group: 1991 vs. 1992

Item	1991 mean	1992 mean	*f*	*p*
21. I like to teach with computer technology.	1.65	1.73	1.63	.168
22. I think quality instruction using technology will only enhance my teaching.	1.44	1.61	1.02	.96
23. I value teaching with technology.	1.44	1.45	1.23	.559
24. I feel afraid to touch a computer.	4.50	4.64	2.21	*.027
25. I feel afraid that I might break or damage a computer.	4.03	4.30	1.44	.309
26. I feel tense when people talk about computers.	3.91	4.06	1.14	.715
27. I enjoy reading about computers.	3.03	2.82	1.10	.795
28. I feel intimidated by people who know something about computers.	3.47	3.91	1.61	.179
29. I think computers are dehumanizing.	4.32	4.39	1.26	.514
30. I fear that computers may take over some parts of a job that I enjoy.	4.26	4.30	1.49	.257
31. I feel confident that I can learn how to use a computer.	1.38	1.42	1.65	.157
32. I think students are more motivated when they can learn using computer technology.	1.56	1.76	2.39	*.015
33. I think instruction by computer technology is just another fad.	4.68	4.48	2.25	*.023
34. I think that using instruction via computer technology will help improve students' performance.	1.74	1.82	1.26	.512
35. I think teachers compete with slick packages and high tech machines.	3.85	3.76	1.42	.325
36. When utilizing computers, the teacher becomes guide/facilitator.	1.97	1.58	2.41	*.015
37. When utilizing computers, the teacher's role becomes more complex.	2.50	2.33	1.34	.410
38. When utilizing computers, the teacher is able to further individualize instruction.	1.94	1.85	1.05	.896
39. When utilizing computers, the teacher's role is diminished.	4.44	4.48	1.02	.960

*p<.05 scale: 1 strongly agree, 2 agree, 3 neutral, 4 disagree, 5 strongly disagree

Parent Group...Parents responding to the questionnaire were predominantly female (69% in 1991 and 73% in 1992) and between the ages of 30 and 49 (94%). The majority of respondents (85%) had earned a bachelor's degree or higher with 15% having earned a Ph.D. Approximately 61% had computers at home in 1991, and this increased to 67% in 1992. Almost all respondents (94%) had used microcomputers, with 46% being IBM personal computers in 1991, a figure which increased to 58% in 1992. Macintosh, the predominant platform at school, was second in use and the Apple II series computer as being the least frequently used. Nearly half of the parents (46%) considered themselves "good" or "very experienced" with computer technologies in 1991, and this figure increased slightly in 1992. Parents' attitudes toward computers were generally very positive. For instance, when asked to respond to the item "I feel afraid to touch a computer," 87% of the parents disagreed or strongly disagreed with the statement. With the statement " I feel confident that I can learn how to use a computer", 94% were in agreement. There remained a small number of respondents (7-8%) who expressed uncertainties or fears associated with computers. (See items 24, 25, 26 & 28.) The 1992 results indicated little change in these percentages.

The majority of parent respondents (74%) indicated that they thought that the teacher would become more of a guide/facilitator and they also agreed that a teacher would be able to further individualize instruction using the computer. The role of the teacher when using computers was viewed as more complex (47%) and not diminished by using computers (81%) by a majority of these respondents. And they also disagreed (24% strongly disagree and 40% disagree) with the statement that "teachers compete with slick software packages and high tech machines." Again, the 1992 results indicated little change in these attitudes.

Parental responses also reflected a general belief that students are more motivated and would have improved performance with computers. Of the total, 79% of the respondents either agreed or strongly agreed with the statement that students are more motivated when they can learn using computer technology (item 32). With item 34 which was related to improved students' performance using instruction via computer technology, 70% were in agreement. The parents placed strong value on learning to use computers as a part of their children's education (with 97% either indicating valuable, very valuable, or extremely valuable).

Tables 3 summarizes the results on independent t-tests on items 24 through 39. Only three items (items 30, 32, and 36) were found to be statistically significant. Interestingly, item 32, 'attitudes *towards instruction with computers*', helps explain over 16% of the variance between the parent responses in 1991 and 1992.

Table 3
Independent T-tests for Parent Group: 1991 vs. 1992

Item	1991 mean	1992 mean	*f*	*p*
24. I feel afraid to touch a computer.	4.43	4.47	1.08	.579
25. I feel afraid that I might break or damage a computer.	4.38	4.48	1.04	.765
26. I feel tense when people talk about computers.	4.17	4.26	1.01	.932
27. I enjoy reading about computers.	2.99	3.08	1.18	.212
28. I feel intimidated by people who know something about computers.	4.07	4.05	1.11	.445
29. I think computers are dehumanizing.	4.30	4.29	1.13	.337
30. I fear that computers may take over some parts of a job that I enjoy.	4.26	4.44	1.51	*.002
31. I feel confident that I can learn how to use a computer.	1.50	1.47	1.23	.109
32. I think students are more motivated when they can learn using computer technology.	1.89	1.72	1.34	*.026
33. I think instruction by computer technology is just another fad.	4.34	4.40	1.12	.402
34. I think that using instruction via computer technology will help improve students' performance.	2.14	1.99	1.20	.172
35. I think teachers compete with slick packages and high tech machines.	3.76	3.81	1.02	.880
36. When utilizing computers, the teacher becomes guide/facilitator.	2.24	2.10	1.37	*.018
37. When utilizing computers, the teacher's role becomes more complex.	2.68	2.71	1.20	.170
38. When utilizing computers, the teacher is able to further individualize instruction.	2.20	2.10	1.04	.745
39. When utilizing computers, the teacher's role is diminished.	4.06	4.16	1.27	.066

*p<.05 scale: 1 strongly agree, 2 agree, 3 neutral, 4 disagree, 5 strongly disagree

Question 3: What are the implications of involving parents in the planning of school curriculum and activities?

Teacher Group. Not surprisingly, the computer experience of teachers increased substantially over the one-year period. The faculty were unanimous in believing that the computer was of value to students and there were no significant differences among the 1991 and 1992 comparisons. Most faculty valued teaching with computers, and, by 1992, 42% of them believed that computers would decrease their planning time. Interestingly, software ratings decreased dramatically by the faculty, which is similar to the findings reported by Savenye, Davidson, and Orr (1992). However, teachers' attitudes toward computers were in general very positive in 1991 and remained positive at the end of the study. Conversely, teachers' anxieties toward using computers were relatively minor and remained unchanged at the culmination of the study. The lack of change may be due, in part, to a ceiling effect. Teacher attitudes were very high and anxieties were very low in 1991. Except for a few individual items, no significant changes occurred in 1992. The changes that were noted indicated even more positive attitudes and lower anxieties.

Student Group. The majority of the students reported some computer experience with more than half reported having a computer at home. Attitudes about computers among the total student population of the school were generally positive. For the most part, students showed low anxiety toward computers in 1991. Even so, students showed a significant decrease in their anxiety toward computers at the culmination of the study in 1992. Accompanying this change was a significant increase in students' general attitudes towards computers. As students' computer anxiety lessened, their interest in using and learning with computer apparently increased.

Parent Group. Two thirds of the parents had computers in the home and most consider themselves experienced with computers. Attitudes towards computers were generally very positive and changed little between 1991 and 1992. A majority of the parents believed that the emphasis on computer use at the school was at the appropriate level and also believed that computes have a positive impact on children's self esteem.

Summary of Results

Each of the three groups reported successful experiences with the computer and that their attitudes were positive about computers in both 1991 and 1992. Whether it was because attitudes were high that the changes in experience increased with each group or because the groups tended to be experienced with computers that attitudes remained positive or increased remains the question. With this study, we seemed to have run into a chicken-and-egg type of dilemma, that is, which came first (attitudes or successful experience) and had influence over the other. We speculate that it may have been a little bit of both. Soliciting and sustaining the involvement of students, teachers, and parents in the implementation of computer technologies may have resulted in a synergistic effect which augmented the already positive attitudes of the Highland Park Elementary School community towards technology. Therefore, one strong implication of this study may be that serious consideration of the notion of school community involvement must be given when planning for the integration of computers (or any innovation) in schools.

When a total school community is being surveyed about attitudes and perceptions toward computers, the complexity of variables is increased and thus leads to a richness in information about integrating computers into a school environment. By considering parental attitudes in addition to teacher and student, perhaps a better understanding of community support will be established. This understanding could help build widespread support for implementation and infusion of computer technologies within the school.

However, the success at Highland Park Elementary indicated by this study is also due, in part, to measures taken by school leaders during the planning and implementation of computer technology. Teachers were allowed, and encouraged, to take school computers home for self-paced training during the summer of 1991. Over 60% of the teachers availed themselves to this opportunity. Strong collegial relationships helped support general on-going in-house training; teachers continually trained other teachers informally. Faculty were offered over 20 inservice computer training opportunities conducted by teacher leaders, corporate, and university personnel. In addition, parents were offered the opportunity to participate in school-sponsored computer training sessions. Parents were very involved in raising moneys for the computer and actively volunteered for after school computer clubs with students. Thus, results tend to confirm the belief that integration of technology requires a supportive environment from administrators, fellow colleagues, and the community.

While the results of the study are extremely encouraging, one must be cautious about drawing generalizations and inferences about the reported findings to other school populations or environments. This caution is due in part to the nature of the design of the study and the nonrandomization of the participant selection. For the most part, the three groups surveyed may not be typical or representative of the population at large. For instance, the faculty were very experienced in teaching, a large percent of the children (at all grade levels) had experience with computers with half having a computer in the home, and a significant number of the parents had college degrees or higher.

The outcomes of the survey show promise that computers can be effectively implemented into the classroom with student, teacher, and parent attitudes remaining positive and their experiences, successful. It is recommended that additional longitudinal studies be designed and conducted to further substantiate these findings.

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Title:

Design and Formative Evaluation of PLANalyst: A Lesson Design Tool

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Introduction

While most graduate programs in educational technology focus on the design of instructional materials in a wide range of media, the most common delivery mode of education and training is still the instructor-led course. Regardless of how much CBT or multimedia experience a designer may have, he or she is often called upon to put together a workshop or presentation quickly. To enable teachers and trainers to draft and edit lesson plans efficiently and to share them with others in a consistent forma a tool called PLANalyst was developed.

This paper describes the process used to design and evaluate a computer-based tool that guides the development of lesson plans. The tool, PLANalyst, contains a small expert system with a human face which analyzes lessons and gives specific feedback for improvement. The process used to create PLANalyst can be generalized to the development of tools to support any complex intellectual task.

PLANalyst runs on Macintosh computers and was constructed with HyperCard. No knowledge of HyperCard is required other than familiarity with the graphical user interface conventions of mouse and menu use.

The Problem

What makes planning a class or workshop or presentation a challenge? What gets in the way of good instruction? Novice instructors tend to try to pack too much information into the time allotted, don't provide enough opportunities for distributed practice and feedback, forget that many learners need to be systematically motivated by having the relevance of the content made clear, neglect to orient the learners to the material and activate their prior knowledge, and stick to a limited number of tried and true teaching strategies. Seasoned instructors do all of these things, too, though less often.

These mistakes can be avoided by devoting enough effort to the planning of a lesson. As with anything else, this kind of planning effort will happen more in the real world if the task can be made easy, efficient, and (dare we hope) enjoyable.

PLANalyst was developed to support the lesson design process. It...

- allows easy creation and editing of lessons: changing times, adding and deleting activities, rearranging the sequence, etc.

- provides clearly printed out lesson plans which show minute by minute how the lesson is to be presented.

- encourages users to base their lessons on sound instructional principles and to realistically estimate their time requirements.

- contains a built-in expert system that can evaluate lesson plan and suggest changes.

- provides a common language and tool for team teaching and instructional development. The work of designing a lesson can be spread out over multiple authors. PLANalyst allows events from separate lesson plans to be merged into one.

- can be used to promote consistency across classes with multiple sections and instructors.

- can be used to observe, record, document and evaluate teaching by principals, teacher educators and training managers.

Steps in Creating an Electronic Performance Support Tool.
The process of designing a tool like PLANalyst follows a path similar to that performance technologists use to develop other problem solutions.

1. Define the problem.
2. Develop solution specifications.
3. Develop the interface
4. Develop the knowledge base.

Across all of these steps is a constant process of user testing and refinement as needed.

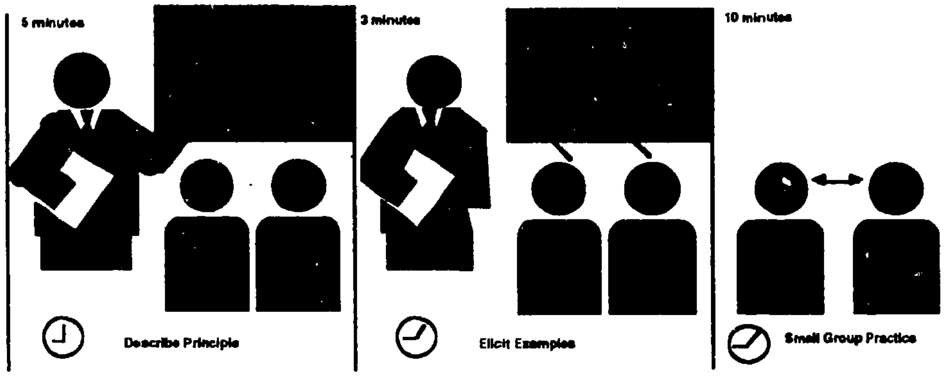
The problem definition in this case included the assumptions that the target users of the tool...

- are sometimes unsure of the necessary ingredients of a successful lesson
- often forget tc include those elements they know to constitute good instruction
- often err in the amount of time allocated to instructional activities
- need to be able to communicate their instructional intentions clearly to others on paper
- see lesson planning as an onerous chore to be done with minimal detail and all in one draft
- would benefit by exposure to teaching strategies they might not normally use

The solution specification included the following characteristics of the tool. The user should be able to...

- generate lesson ideas quickly and refine them later
- rearrange the order of lesson activities easily
- consider time requirements at every point while drafting the lesson.
- create attractive printouts in various forms
- justify the instructional purpose served by every instructor act.
- access specific suggestions for teaching strategies with pointers to published articles and other documents

Design
PLANalyst is built on the assumption that a presentation or lesson can be divided into distinct chunks of one minute or more in duration, and that each chunk should serve some instructional or practical purpose. PLANalyst is intended to be equally useful to experienced and novice presenters or teachers, though meeting this design goal has proven to be a challenge.



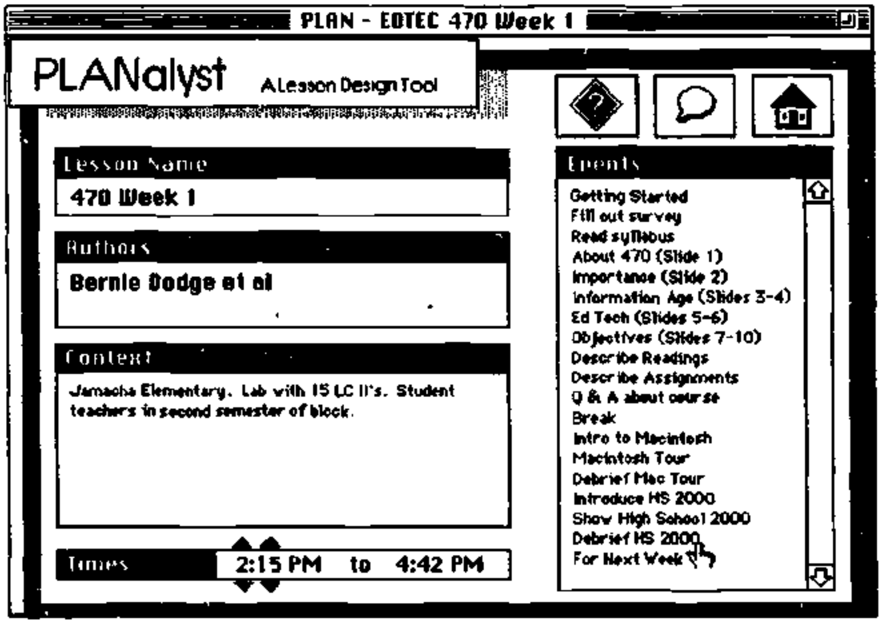
The instructional design model that PLANalyst is based on most closely is that of Gagné's nine events of instruction (Gagné, Briggs & Wager, 1992). That model is most appropriately used for direct instruction ...the teacher-centered, objective-driven approach used most often in the training of adults. Additionally, suggestions summarized from the adult training literature and professional practice by Powers (1992) were incorporated. To widen the applicability of the tool to teachers of children, models of indirect instruction and cooperative learning were added to the rule base. These models were derived from work by Johnson & Johnson (1991), Joyce, Weil & Showers (1992), and Slavin (1983).

In one fundamental way, however, PLANalyst runs contrary to the standard instructional systems design approach: it allows one to begin the process of lesson design by listing possible activities rather than proceeding deductively from objectives. This activities-first approach is in keeping with how teachers conceptualize the lesson planning process (Sherman, Driscoll & Klein, 1994). There is nothing to prevent an instructional designer from using PLANalyst by specifying objectives first and going on to draft learning activities.

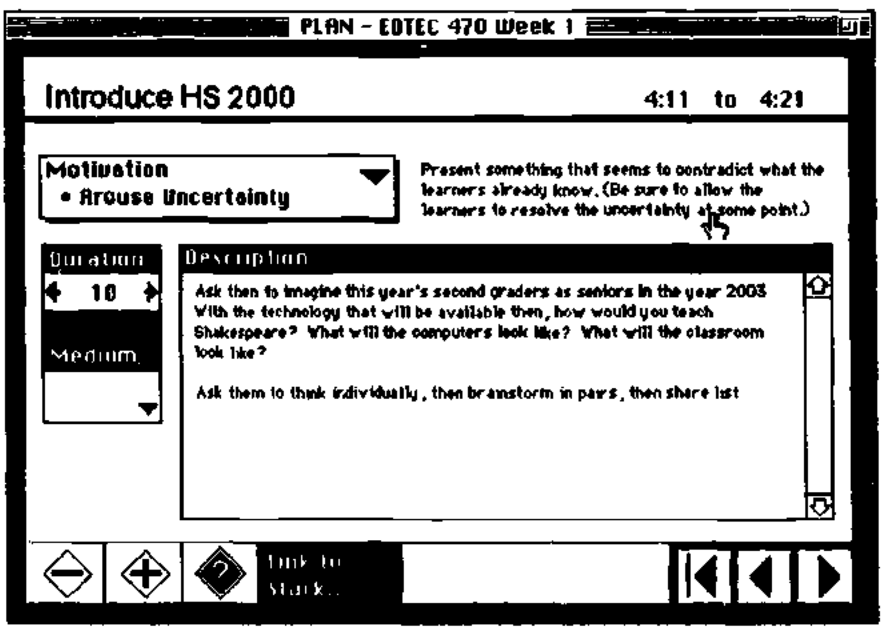
There are three major parts to the PLANalyst tool:

- preparation screens,
- event screens, and
- an expert system.

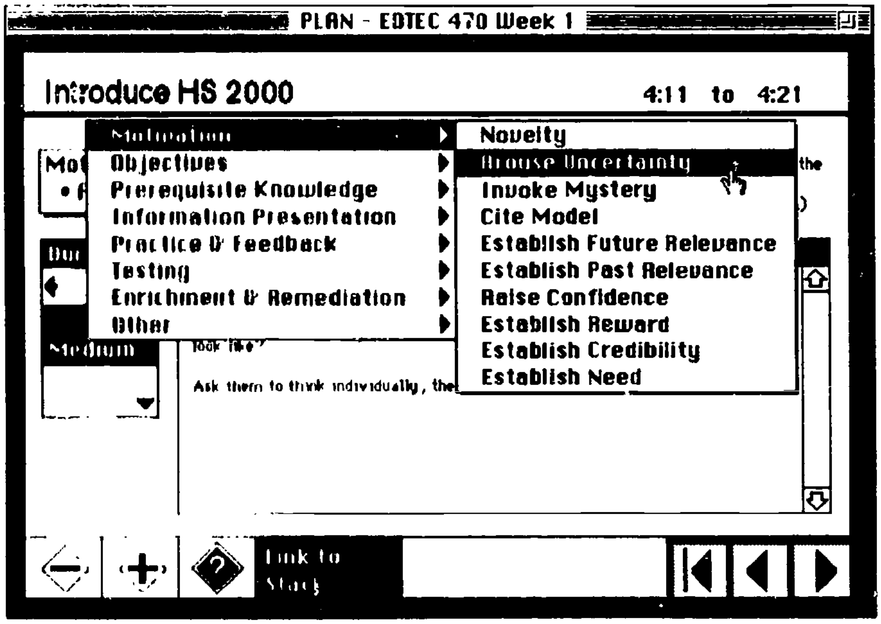
On *Preparation Screens*, the lesson designer describes the learners, the content, the instructional context, and practical considerations such as room arrangements and materials needed. This description can be printed out when the plan is finalized to serve as a reminder before the lesson is delivered. There are three such screens in the present version of PLANalyst. The presence of fields and checkboxes requiring input reminds the user to analyze the learners and subject matter before rushing headlong into design.



To describe each event, the user completes an *Event Screen* like the one below.



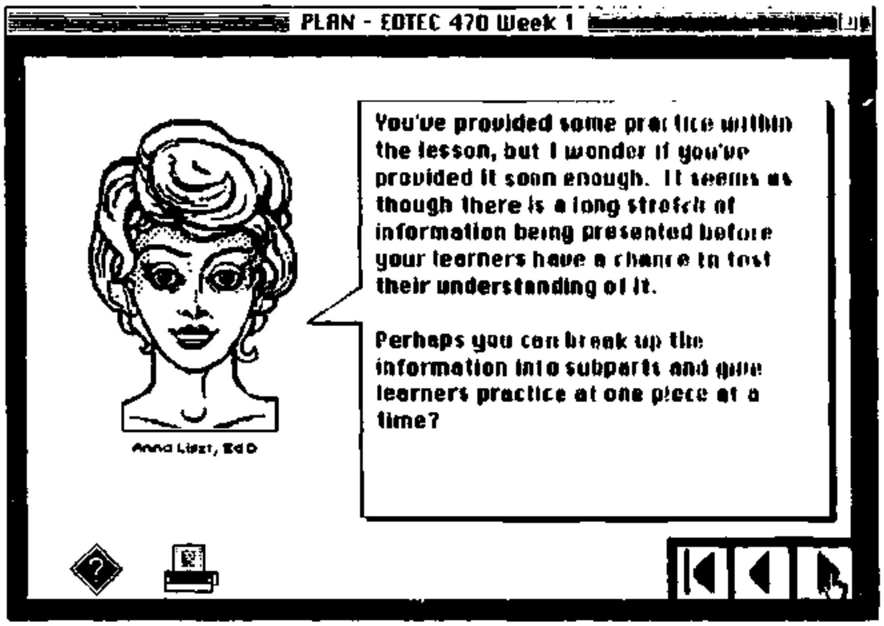
Each event is labeled with a short name (Introduce HS 2000, in this example). A hierarchical pop-up menu allows the user to tag the event with one of close to 70 identifiers which describe the instructional purpose of the event (in this example "Arouse Uncertainty", one of 10 items under the "Motivation" category was chosen.



The user specifies how long the event will take by clicking on arrow buttons and the time span during the which the event will take place is immediately recalculated and displayed at the upper right part of the screen. The largest item on the screen is a scrolling field in which notes on what to do at this point in the lesson can be written. Users can navigate through the lesson by clicking on the arrow buttons in the lower right part of the screen, or by clicking on the "Return to Main Menu" button.

On the Main Menu, the list of all events in the lesson can be seen. One can travel to the screen describing the event by clicking on its name. Events can be re-sequenced by dragging them up or down through the list.

With the *Expert System*, the user can at any point request advice from a modest knowledge base built into PLANalyst. The system scans through the draft lesson plan and looks at the amounts of time spent on specific types of events, the sequencing of those events, and descriptions of the learner gr' up and content. A rule base of twenty principles is consulted which triggers positive comments or corrective feedback as appropriate. The advice is given through the persona of Anna Liszt, who is described as an experienced teacher and instructional designer. This feedback can be viewed on screen or printed out.



Field Testing

PLANalyst has been used by close to two hundred students at San Diego State University during the last two years. About half of those using the tool are pre-service teachers taking a course in educational computing; the others are graduate students in instructional design. At the end of each semester, students rate each element of PLANalyst and suggest improvements.

Routines in the software (Williams & Dodge, 1993) were used to unobtrusively track data on how PLANalyst was used by students. These data include the amount of time spent in each part of the program, the amount and type of editing done, and patterns of use of the expert system.

A typical sample of the tracking data looks like this:

2841218642 SO with PLANalyst version .99c3
2841218648 MBR
2841218813 AS 8:00 AM
2841218819 AE
2841218831 ED Take Roll to 3
2841218878 EW Take Roll . # Words = 9
2841218892 AE
2841218911 ED Importance of Chinese Society to 8

Which translates into this:

Wednesday, January 12, 1994 11:24:02 AM
11:24 Opened stack with PLANalyst version .99c3
11:24 Menu choice: Brainstorm Events
11:26 Adjusted starting time to: 8:00 AM

11:26 Clicked on Events list
11:27 Adjusted duration of Event *Take Roll* to 3 minutes
11:27 Edited Description of Event *Take Roll* . Total # Words = 9
11:28 Clicked on Events list
11:28 Adjust duration of Event *Importance of Chinese Society* to 8 minutes

In the next round of examination of these data now under way, cluster analysis will be used to identify categories of usage patterns, and the completed lesson plans of all participants will be rated qualitatively and related to these clusters.

In the earliest trials of the software, user feedback was collected in the form of open-ended paragraphs summarizing their opinions, as well as informal interviews with users. In the most recent field tests of PLANalyst, a questionnaire was used to get specific feedback on the program (Appendix B). The results of testing the most recent version were as follows: (N=11). To simplify the data for a coarse-grained analysis, Agree and Strongly Agree responses were lumped together, as were Disagree and Strongly Disagree; Neutral responses were left out of the table.

Statement	**% Agree**	**% Disagree**
The printouts were legible and attractive	91%	0%
The Rearrange Events feature is useful	91%	9%
The Brainstorming Events feature is useful	91%	9%
PLANalyst was easy to use	91%	0%
PLANalyst will be useful primarily for planning special or unusual events	90%	0%
The time spent putting a lesson into PLANalyst form would be well spent	**54%**	**36%**
The program seemed to run slowly	50%	27%
It was difficult to find an appropriate category to describe an event I wanted to include	**45%**	**36%**
There were enough different print out formats provided	45%	9%
The advice from Anna was useful and appropriate	**36%**	**45%**
I'd use "Lite" mode more often than the Full mode	36%	0%
PLANalyst is too time-consuming to be practical	36%	45%
In general, a lesson should fit on one page	36%	36%
PLANalyst will be useful for everyday planning	**36%**	**36%**
The program was cumbersome	20%	70%
The type on the printouts was too small	9%	81%
The printouts took up too much paper	9%	63%

The results in the table above break down cleanly into three categories: at the top, desirable statements that most users agreed with; at the bottom, undesirable statements that users tended to disagree with, and the middle ground where targets of improvement can be identified. The statements shown in bold seem the most important to work on, and the next round of software refinement will focus on raising the ratings here. In practice, this means adding more categories for describing instructional events and adding rules to Anna's rulebase to smarten her advice.

One major step in this regard is the addition of a database of teaching strategies. Over 600 ERIC citations have been identified as containing information on useful teaching techniques. In the final release version of PLANalyst, users will be able to access this database and print out strategies and citations appropriate to their present lesson. It is hoped that the database will be rich enough that even experienced teachers and trainers will be shown strategies that they would not have thought of, thus raising the perceived usefulness of Anna's advice and the global value of the tool.

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Software Availability

PLANalyst will be published in late March, 1994 by SuperSchool Software, 1857 Josie Avenue, Long Beach CA 90815. Telephone: 800/594-8580.

Appendix A: Instructional Event Categories

Prior Knowledge Activation
Review Previous Learning
Use Analogy
Ask Review Questions
Pre-Test

Information Preview
State Objectives Formally
State Objectives Informally
Show Final Goal
Provide Overview
Provide Background
Teacher Pre-Questions
Learner Pre-Questions
Advance Organizer

Motivation
Novelty
Arouse Uncertainty
Evoke Mystery
Cite Model
Establish Future Relevance
Establish Relevance to Past
Raise Confidence
Establish Reward
Establish Credibility
Establish Need

Information Acquisition
Give Definition
Examples/Non-examples
Definitions & Examples
Procedure Description
Procedure Demonstration
Fact Presentation
Problem Definition
Discussion
Socratic Dialog
Analogies
Anecdotes
Inquiry - Individual
Inquiry - Group
Peer Tutoring
Teacher Mnemonic
Learner Mnemonics

Practice & Feedback
Individual Practice (Guided)
Group Practice (Guided)
Individual Practice (Independent)
Group Practice (Independent)
Group Feedback
Peer Feedback
Delayed Feedback
Simulation
Drill
Brainstorming
Role Play
Q & A
Debriefing

Closure
Reflection
Student Self-Test
Post-Test
Teacher Summary
Learner Summary

Other
Administration
Assign Roles or Tasks
Ice Breaker
Social
Break
Rearrange Classroom
Planning Time
Session Evaluation
Other (Instructional)
Other (Non-Instructional)

Appendix B: PLANalyst Evaluation Form

Your Name (optional) ______________________________

Years of teaching experience ? _______ Subject/Grade level? ____________________

Thanks for giving PLANalyst a try. Your opinions about PLANalyst are very valuable to me as I refine its features in preparation for publication. Please give your thoughtful, frank and honest responses to the questions on this page. --- Bernie Dodge

For each statement, please circle the response that corresponds most closely with your opinion.

SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

PLANalyst will be useful for everyday lesson planning.	SD	D	N	A	SA
PLANalyst will be useful primarily for planning special or unusual lessons.	SD	D	N	A	SA
The Rearrange Events feature is useful	SD	D	N	A	SA
The Brainstorming feature is useful.	SD	D	N	A	SA
The program seemed to run slowly.	SD	D	N	A	SA
PLANalyst was easy to use.	SD	D	N	A	SA
The program was cumbersome.	SD	D	N	A	SA
It was difficult to find an appropriate category to describe an event I wanted to include.	SD	D	N	A	SA
The advice from Anna was useful and appropriate.	SD	D	N	A	SA
I'd use the "Lite" mode more often than the "Full" mode.	SD	D	N	A	SA
PLANalyst is too time-consuming to be practical.	SD	D	N	A	SA
There were enough different print out formats provided.	SD	D	N	A	SA
The printouts were legible and attractive.	SD	D	N	A	SA
The printouts took up too much paper.	SD	D	N	A	SA
In general, a lesson plan should fit on one page.	SD	D	N	A	SA
The type on the printouts was too small.	SD	D	N	A	SA
The time spent putting a lesson into PLANalyst form would be well spent.	SD	D	N	A	SA

Can you think of any categories of event types that should be added to the pop-up list? If so, please describe them.

Can you think of other features you'd like to see added?

Did you experience any 'bugs' or flaky program behavior? If so, please describe.

If you had to summarize your opinion of PLANalyst in just a few sentences, what would you say?

Title:

The Odyssey Project: A Quest for School Design

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Homer's epic poem, " The Odyssey", recounts the wanderings of the Ithacan king, Odysseus in his quest for the purpose of life. The Odyssey Project is so named because it is based on the philosophy that a new generation of American schools must be viewed as a dynamic lifelong quest for ever changing standards of excellence.

This project is one of eleven designs for new American schools funded by the New American Schools Development Corporation, a private organization which was conceived in the national "America 2000" education strategy. It is located in the Gaston County School District in North Carolina. This presentation provides an overview of the elements and special features of the proposed design. It focuses on the project's quest to rebuild the culture in which schooling exists. Attention is given to the barriers and challenges which result from the uncertainty of change. Public relations materials included in this paper were developed by the Gaston County Design Team.

Events Leading to Odyssey

October, 1989 - President Bush and the nations 50 Governors met in a historic summit at the University of Virginia to discuss how America could improve education and, in turn, its economic competitiveness.

February, 1990 - The fifty Governors and the President unanimously established six national education goals for the nation to reach by the year 2000. These goals are:

- All children in America will start school ready to learn.
- The high school graduation rate will increase to at least 90 percent.
- American students will leave grades four, eight, and twelve having demonstrated competency in English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.
- U.S. students will be the first in the world in science and mathematics achievement.
- Every adult American will be literate and will possess the knowledge and skills necessary to compete in a world economy and exercise the rights and responsibilities of citizenship.
- Every school in America will be free of drugs and violence and will offer a disciplined environment conducive to learning.

Another component of the America 2000 program established national models for public education in school systems throughout the nation. President Bush encouraged leaders from the private sector to donate funds to be used for this purpose. All of the programs to be developed were to move the nation closer to meeting the six national goals.

July, 1991 - A non-profit corporation was formed to accept contributions and a Board of Directors composed of some of America's most outstanding corporate leaders was appointed. The Board of Directors include: John Clendenin, Bell South; Ray Whitman, Eastman Kodak; James Jones, American Stock Exchange; Gerald Bailes, former Governor of Virginia; Louis Grestner, Jr., Nabisco; Frank Shrantz, the Boeing Corporation; Ann McLaughlin, former Secretary of Labor. These individuals, and others helped secure contributions from such corporations and organizations as Martin Marietta, IBM, Ford, AT&T, Chrysler, Exxon and the NFL.

September - November, 1991 - Meetings were held across America to explain how schools would be selected to develop these models of excellence. A team of Gaston County educators prepared one of the hundreds of grant applications that were submitted. Those team members were:

Joseph Miller, Director
Edwin L. West, Jr., Superintendent
Jane Buckner, Instructional Specialist in Early Childhood Education, Gaston County Schools
Leon Moretz, Director of Elementary Education, Gaston County Schools
Brenda Ratchford, Director of Middle School Education, Gaston County Schools
Don Ratchford, Director of Secondary School Education, Gaston County Schools
Melinda Ratchford, Director of Media and Technology, Gaston County Schools
Tim Rickman, Principal of Stanley Junior High School
Vivian Taylor, Director of Student Services, Gaston County Schools
Robert Tyndall, Dean of the School of Education, University of North Carolina at Wilmington
Elizabeth Willis, Instructional Specialist for Student Services, Gaston County Schools

These individuals began writing the project proposal in November, 1991 and completed the application in January, 1992.

February, 1992 - The Board of Education in workshop session received and discussed the project and officially voted to submit the project at the regular February meeting.

June, 1992 - Gaston County officials were invited to meet with representatives of the New American Schools Development Corporation to discuss the project proposal.

July 7, 1992 - Gaston County was named a finalist for the award.

July 9, 1992 - The award was made public. (Gaston County School District was one of approximately 700 proposals submitted, and one of 11 selected.)

July - September, 1992 - Negotiations were conducted regarding budget.

November, 1992 - The Gaston County Board of Education approved the contract.

Project Overview

The Odyssey Project describes a formal system of basic schooling for students ages 3 to 18 with a developmental prenatal to age 3 component. The project will use an outcome-based education model that focuses on the knowledge, skills, and attitudes that students should possess when they graduate from Odyssey learning centers. Five basic exit outcomes will provide the focus for the instructional program proposed by the project: (1) Communicator; (2) Collaborator; (3) Creative Producer; (4) Critical Thinker; (5) Concerned and Confident Citizen. Odyssey schools will subscribe to the theory of multiple intelligences and will seek to develop each student's unique talents. At each level of schooling diagnostic criteria and specific performance outcomes will be designed to address each of at least seven distinct intelligences.

Performance outcomes set for each level of Odyssey schooling will include substantive assessment of each student's mastery of English, social studies (including geography), science, and mathematics objectives. The curriculum in these areas will reflect an appropriate balance between learning concepts, acquiring information, and applying essential processes. Each Odyssey student will study a second language, music, art, drama, and kinesthetics at each level of schooling. The computer will be used as a basic tool for instruction and management in all the disciplines. The curriculum will emphasize critical thinking and problem solving, and students will examine relevant ethical issues and learn how to make sound choices. In all curriculum areas an emphasis will be placed on understanding global issues.

In addition to formulating and refining the exit outcomes set for Odyssey schools, a set of world class standards will be designed against which Odyssey graduates will be judged. The set of world class standards will include recommendations made by various learning societies that impact national and international curriculum standards. Also included in the standards will be recommendations from the U.S. Department of Education and information gleaned from top developmental programs in the U.S. and in non-U.S. countries.

In the five levels of schooling proposed by The Odyssey Project, traditional designations of grade levels will not be used, rather a Greek letter will designate an age range for learners who attend a particular center. "Alpha" will designate the pre-formal component of schooling for children ages 0 - 3; "Beta" will be the center for learners ages 3 - 6; "Gamma" for learners ages 7 - 10; "Delta" for learners ages 11 - 14; and "Odyssey" for learners ages 15 - 18. At all levels movement in and out of learning cadres will be determined by accomplishment of performance outcomes not by age, grade levels, or time frames.

All learning centers will have common characteristics. All will operate on a year round schedule. Four terms of ten-weeks each will comprise the learning year. Learners will attend each of the four terms for a total of 200 days each year. At the end of each term, a three-week mini-term will be provided. Learners who accomplish all performance outcomes during the regular ten-week term may attend enrichment or extension sessions or may take leave time from their schooling. Learners who do not accomplish all performance outcomes will attend a five to seven day mini-term that extends their learning time.

All centers will provide learners with high technology environments. Learners will leave Odyssey schooling technologically literate. A wide range of technologies will be used to enhance learning and manage instruction.

Centers will contract with many different agencies to provide health care, social services, wellness and other essential support programs. Many of the agencies will be housed at the centers. This interagency arrangement will provide holistic support services to learners and their families. Also, these agencies will work closely with each center's staff to establish and maintain a non-violent, drug-free learning environment.

All centers will use Paideia concepts as the primary instructional delivery system. The appropriateness of the three levels of instruction--didactic, coaching, and seminars--will be understood, properly balanced, and consistently used during basic schooling. At the four formal Odyssey levels--Beta, Gamma, Delta, and Odyssey--learners will stay with the same cadre of learners and facilitators for CORE learnings during their years at each center. During CORE-PLUS time learners from different cadres will work together.

At all centers virtually all non-instructional support services will be contracted. The major responsibility of center professional staff will be learning and other services will be managed and provided by outside agencies. For all students at all levels a Learning Support Center will be provided. Located in proximity to the information center, the LSC will play a key role in learners' accomplishment of performance outcomes.

At the three upper levels of Odyssey schooling, learners will be required to attend weekly learning seminars that address national and world citizenship ideals and values. These seminars will focus on multi-cultural issues that prepare learners for living in the global society of the twenty-first century.

At all levels of formal learning, community service will be an integral part of each learner's experience. By the time learners graduate from Odyssey Center, they will have performed at least 220 hours of quality community service time. Family involvement with their child's schooling will be a primary goal of The Odyssey Project. Family members will provide service hours at each Odyssey center and will attend a minimum number of progress conferences with center professionals each year their child attends the center.

Business and community partnerships will be an integral part of Odyssey schooling. A business-education consortium will be formed to determine the best approach to involving businesses in the basic schooling of Odyssey learners. Each center will have an instructional manager and a non-instructional manager. The instructional manager will be responsible for the instructional leadership of the center. The non-instructional manager's responsibilities will be similar to that of an operations manager.

The Odyssey Project not only breaks the mold of traditional schooling, but it also breaks the mold of traditional thinking about school governance. Constraints to implementing the project will be addressed within the host school system by helping local board of education members understand the nature of the project and to adjust or waive constraining policies and regulations. At state-level, existing and pending legislation will be sought to enable the project's successful implementation. The project can be fully implemented without violating federal program regulations.

The Odyssey Project requires teacher training programs that are solution centered, with theory and practice integrated through classroom application. The training will be a joint effort of university instructors, school unit specialists, and consultants from public and private sectors. The most promising educational research and programs were incorporated into the Odyssey Project design. A synergistic adaptation of the best components of the research resulted from the design team's work.

The Uncertainty of Change: Barriers and Challenges

In summary, then, Odyssey is best teaching practices, training for teachers, year round school, voluntary early childhood programs, voluntary family services, limited multi-age grouping, extended time for learning, community service, family involvement, and expanded use of technology.

Despite the excellence and effectiveness of these educational practices, the lessons to be learned from the Odyssey Project are derived from the multifaceted, complex nature of change. The simultaneous implementation of an array of innovations in practices, policies, and procedures raises questions and concerns among the consumers of the reform. Change is a process fraught with uncertainty. It is a search for solutions, new meanings, new structures, and new systems. It is, in fact, a journey, an odyssey in the true sense.

The barriers faced by the Odyssey Project included:

- Legal aspects of state regulations, legislative mandates, and the demands of professional associations.
- Lack of a common language among the various publics.
- School and community awareness and support.
- Opposition from extremist and special interest groups.
- Lack of clarity in defining "world class" standards.

These challenges were approached and met with varying levels of success. For example, special legislation suspended state regulations for schools involved in the project. Efforts were also in progress for defining measurable standards and for building community awareness through a broad public relations program (see Appendix A: Facts About Odyssey Schools).

However, the key issues were primarily ownership and understanding. Opposition from very vocal, militant special interest groups undermined the well-designed public relations effort by focusing on distorted definitions of innovative practices in the design. For example, critical thinking was interpreted as learning to criticize parents and question family values; decision-making skills were considered inappropriate because right and wrong are absolute; and global education was perceived as an attempt to eliminate patriotism. These are fighting words in the Bible Belt! So, as understanding became clouded, ownership wavered and weakened considerably --- even to the point of loss of continued NASDC funding. Reform is truly a political as well as educational process.

Will the quest continue? Probably --- but most likely as pockets of change instead of systemic reform. Dedicated teachers, parents, and administrators at individual schools remain committed to the Odyssey principles and plan to implement them at their sites. The district has also taken a supportive and nurturing stance. The university partner is moving ahead with the design of alternative teacher preparation programs.

Solutions for educational reform are not easy. The system is complex and hence its reform will also be complex.

Appendix A: Facts About Odyssey Schools

Q. Why were school sites identified before the planning phase was completed?

A. Because teachers, parents and students are required to be involved in helping make decisions about the direction of the project.

Q. What is the curriculum that will be used in the Odyssey schools?

A. It is the same curriculum now being taught in the Gaston County Schools--the North Carolina Standard Course of Study and the current Gaston County Curriculum.

Q. Who will teach in the Odyssey schools?

A. Teachers in the Odyssey schools will be experienced Gaston County teachers. Those currently teaching in the selected sites will be the Odyssey staff unless the~l ~h~P otherwise.

Q. Who developed the Odyssey proposal?

A. The people who wrote the entire proposal are educators from Gaston County who have long careers as teachers and administrators in this school system.

Q. Who is funding the project?

A. Odyssey is funded by the new American Schools Development Corporation (NASDC), whose board of directors includes the CEOs of Exxon, AT&T, B.F. Goodrich, BellSouth and Martin Marietta, to name a few. NASDC is part of President Bush's America 2000 program. It is a private non-profit, tax-exempt organization formed by American business leaders to support the design and establishment of new high performance learning environments that communities can use to transform their schools.

Q. Is the project connected with any other organization?

A. Odyssey is not affiliated with any other program or organization, educational or otherwise.

Q. Where will Odyssey be located?

A. North Gaston, W.C. Friday and Carr are the designated sites for Odyssey. Other Gaston County schools, however, will benefit through staff training and new equipment.

Q. What is Outcomes-Based Education?

A. Outcomes-Based Education identifies the basic skills and knowledge that students should learn. It is based on the belief that all students can learn and be successful. It is a proven educational strategy that has been in practice for more than 20 years. Six North Carolina school systems, funded by the Legislature, are officially using the concept with success and many others are just beginning.

Q. What are some of the teaching strategies that will be used in the three selected schools?

A. The techniques and practices to be used in Odyssey are based on strategies that have proven successful in helping all students learn. Team teaching, a 200 day school year, and multi-age grouping are examples of proven strategies that Odyssey will use to enhance learning for all students.

Q. What about technology in the Odyssey classrooms?

A. The students will learn in high technology classrooms which will prepare them for 21st Century jobs and for life-long learning.

Q. Will students have the traditional grades, class rank, transcripts, and test scores required for college entrance?

A. Yes, In addition, students will have a portfolio containing examples of their academic work.

Q. What kind of learning materials will be used?

A. In addition to textbooks, students will have unprecedented access to computers and software programs. Hookups with state and national libraries are anticipated.

Q. What is the length of the school day?

A. The required school day for students will be 9:00 a.m. to 3:00 p.m. However, the schools will be open from 6.30 a.m. to 6:30 p.m. This schedule will make it possible to extend time for learning opportunities and may even include before and after school care should parents want this service provided at their school.

Q. What about graduation?

A. There will be graduation ceremonies in June for seniors. There will also be opportunities for some students to graduate early if they choose.

Q. What will the school calendar be?

A. Students will attend school for 4 ten-week terms and will have the option to attend a 5-7 day mini-term or take 3 weeks vacation at the end of each term. The optional mini-term will help students catch up or move ahead with their studies. Traditional holidays will be built into the calendar.

Q. Will students still take achievement tests required by the state?

A. Yes.

Q. Will Vocational Education/Tech Prep be offered?

A. Yes. All students will have access to a range of opportunities including internships and on-the-job work experience.

Q. Will students continue to be eligible for Governor's School?

A. Yes.

Q. Will students who come into the Odyssey program from other schools after the program is in operation be at a disadvantage?

A. No. These students will be placed in appropriate levels of instruction.

Q. What about sports?

A. Odyssey schools will retain their athletic programs and coaches will retain their jobs. Odyssey schools will continue to have the same sports in the same conferences in the same manner. Some of the burdens of managing the sports programs such as collecting gate receipts, providing security for games, and providing field maintenance could possibly be performed by booster clubs or other civic organizations through contractual agreements.

Q. What about band programs?

A. Odyssey schools will retain their band programs and band staff will retain their jobs. Music will continue to be an integral part of both academic and extra-curricular activities.

Q. What about clubs, student government, and senior prom?

A. All of these school activities will continue.

Q. How will student-teacher ratios be changed?

A. The ratios will be improved as compared with current ratios required by the state.

Q. Will there be services for exceptional children?

A. Public Law 94-142 requires that needs of exceptional children be met in an appropriate manner.

Title:

Effects of Knowledge Representation during Computer-Based Training of Console Operation Skill

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ABSTRACT

Console-operation skill is procedural knowledge of control panel actions. The console operator must select appropriate sequences of steps (e.g. setting dials, pressing buttons, etc.) as mandated by desired goals and subgoals. In the training of console-operation skill, a Computer-Based Training (CBT) environment can simulate control-panel responses and device actions while providing instructional support. The instructional support delivered during practice consists of a set of intervention strategies. This paper discusses an ongoing investigation of CBT approaches in the acquisition of console-operation skill. Two variables of intervention described in this paper include the content of feedback and the timing of feedback. Preliminary results from a laboratory experiment suggest that feedback which elaborates on the goal structure of the console-operation skill is more effective than feedback that simply corrects errors.

INTRODUCTION

Computer-Based Training (CBT) seeks to provide an environment where knowledge acquisition is efficiently and effectively achieved. In the training of console-operation skill, the CBT environment can simulate control-panel responses and device actions while providing instructional support. This paper describes an ongoing investigation of CBT approaches in the acquisition of console-operation skill.

At a basic level, console-operation skill is the execution of control-panel actions such as the pressing of a button or the rotation of a dial. At a higher level, the skill is a complex hierarchy of goals, subgoals and discrete steps. The console operator must select appropriate sequences of steps as mandated by the desired goals and subgoals. During practice of this procedural skill, the instructional support provided by the CBT environment can be described as a set of intervention strategies. These strategies must resolve two important questions: When is intervention most appropriate, and with what message does one intervene?

Studies of human-tutoring suggest that tutors intervene at strategic points within the execution of a learning task (Merrill, Reiser, Ranney, and Trafton, 1992). Tutors often "overlook" minor errors during practice, reserving immediate feedback for errors deemed more important. In contrast, traditional CBT methods typically provide immediate feedback for all errors. Alternative intervention strategies require sophisticated decision-making processes.

The message delivered at an intervention can include an array of information types. Beyond the simple verification of incorrectness, the message can provide an explanation for the error, hints or guidance toward the correct response, and even the correct response itself. Guidance delivered at an intervention can direct the learner's attention to the goal structure of the procedure. This is often the approach of Intelligent Tutoring Systems (ITS) where the content of an intervention message goes beyond simple verification of incorrectness. The study described in this paper attempts to determine the value of these intervention approaches in terms of the efficiency of skill acquisition, quality of achievement and learner preferences.

The platform of the investigation is a computer-based, console-operations simulation called LOADER (Farquhar, 1993). Analogous to many military and industrial tasks that call for knowledge of various procedures, LOADER is a laboratory research tool developed to assess instructional strategies in the acquisition of console-operation skill. The task simulated by the LOADER environment is the operation of a remote crane control arm to load various canisters from a set of storage bins to one or more railroad cars (see, Figure 1 for the simulation interface).

In order to provide instructional guidance capable of determining when to intervene and what to say, an expert system was embedded into the delivery system of LOADER. The expert system evaluates error criticality in order to determine points of intervention. In addition, the expert system analyzes solution methods to best select the goal structure message. Essentially, LOADER behaves as an Intelligent Tutoring System (ITS) when features of the expert system are employed.

BACKGROUND

The evaluation of ITS programs and methods has only recently become a topic of discussion in the ITS literature (Mark & Greer, 1993; Murray, 1993; Shute & Regian, 1993; Winne, 1993). Reported evaluations cover a broad spectrum of analyses from investigations of the internal components of a program to its external effectiveness (Legree, Gillis, & Orey, 1993; Littman & Soloway, 1988). *Internal evaluations* focus on the effects of specific components or processes of a program, such as diagnostic accuracy and pedagogical decisions, while *external evaluations* address the overall educational impact.

In a review of ITS external evaluations conducted by Legree and Gillis (1991), ITSs deemed extensive in nature (i.e. covering a third of a college course or more than 30 hours of instruction) showed an improvement on knowledge-based tests of approximately 1.0 standard deviation. This analysis tends to support the overall effectiveness of ITSs. However, the number of extensive external evaluations conducted remains very small (four in the Legree and Gillis report). The 1.0 standard deviation improvement is also far short of the 2.0 standard deviation improvement that appears to be possible with human-tutoring interactions (Bloom, 1984).

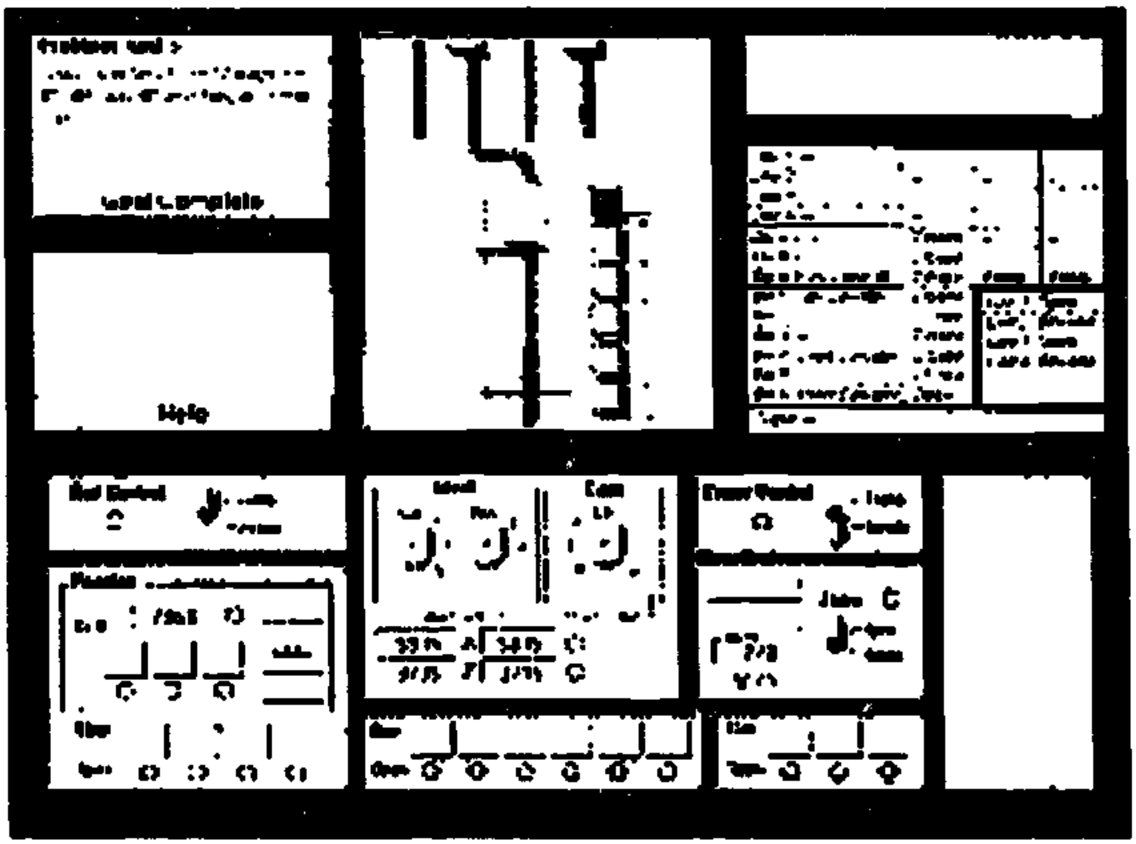

Figure 1: *LOADER interface.*

In addition to conducting more external evaluations, ITS researchers maintain that internal evaluations must also continue in order to determine the efficacy of ITS methods. One effective ITS methodology supported by the literature is *model tracing* (Anderson, 1988; Merrill, Reiser, Ranney, & Trafton, 1992). A tutor employing the model-tracing method matches each step of the student's problem-solving behavior to the possible solution paths. When the student's action deviates from a known solution path, the tutor intervenes with informative and corrective advice.

The theory driving the model-tracing methodology is Anderson's ACT* Theory (Anderson, 1983). A central assumption of the ACT* theory of cognition is that the content of error-corrective feedback is processed by learners facilitating their acquisition of knowledge. In other words, learners will gain from information-rich feedback, such as error explanations and goal descriptions. Unfortunately, some of Anderson's own studies fail to support this assumption (Corbett & Anderson, 1991; Corbett, Anderson, & Patterson, 1990).

The model-tracing methodology also relies heavily on the use of immediate feedback. While the ACT* theory does not mandate the use of immediate feedback (Corbett & Anderson, 1991; Corbett, Anderson, & Patterson, 1990), both practical and theoretical reasons exist for its implementation. Included in the theoretical reasons is the reduction of non-productive floundering. On the other hand, Schooler and Anderson (1990) have found a number of disadvantages of using immediate feedback: 1) the student grows dependent upon feedback and hesitates to act without it; 2) the student does not develop error correction and detection abilities; and, 3) the feedback competes for the student's limited short-term memory resources.

. In a study designed to investigate the effects of immediate, information-rich feedback (Corbett & Anderson, 1991), forty undergraduates completed a series of Lisp programming exercises with the CMU Lisp Tutor. The treatments under investigation delivered four different types of feedback: immediate feedback, error flagging, feedback on demand, and no feedback. Of the three treatments that delivered feedback, all presented similar forms of information-rich feedback. The three feedback types differed primarily in their method of error notification.

Immediate feedback, in the Corbett and Anderson study, provided information-rich feedback upon the execution of every error. The error flagging condition notified students of an error, but did not deliver informative feedback unless requested by the student. The feedback-on-demand condition performed no error notification, delivering informative feedback only when requested. Finally, the no-feedback condition delivered neither error-notification feedback nor informative feedback.

The results of the Corbett and Anderson study found no performance differences between groups that received feedback. The no-feedback condition performed consistently worse on a number of performance measures. Essentially, these results indicate that any feedback that serves to identify errors is superior to no feedback. The benefits of providing *information-rich* feedback (as accomplished with model-tracing) was not demonstrated. The lack of significant differences between feedback conditions in this study can be explained by the small sample size. Even if the feedback manipulation was expected to produce a "large" effect, a sample size of 68 would be required for an acceptable level of power (.80) (Keppel, 1991).

A comparison analysis of human tutoring and tutoring with model-tracing found a few notable differences (Merrill et al., 1992). Among these differences is the use of immediate feedback. Human tutors, it appears, are more flexible in determining when to provide immediate and intervening feedback (Littman, 1991; Littman, Pinto, & Soloway, 1990). Often, the human tutor will allow student's to perform low-level errors without immediate feedback. Instead the feedback for such errors is delivered at a later time, often at the completion of the problem. Therefore, human tutors make strategic decisions in the timing of feedback, reserving advice for the appropriate moment.

Although a number of ITSs employing the model-tracing methodology have been demonstrated as effective through external evaluations, the efficacy of their use of feedback is far from determined. And, since the content and timing of feedback is a central component within these tutors, it is prudent to investigate these attributes.

Content of Feedback

The use of feedback is widely accepted within educational theory and practice as a critical element of the learning process (Anderson, 1983; Bangert, Kulik, & Kulik, 1983; Grinder & Nelson, 1985; Gagné, 1984). Extensive research in feedback has been conducted on psychomotor and cognitive skill (Lee & Carnahan, 1990; Salmoni, Schmidt & Walter, 1984; Wulf & Schmidt, 1989), testing and instructional environments (Heald, 1970; Roper, 1977), tutor, text, and technology-based programs (Kulik & Stock, 1989; Schimmel, 1983), as well as laboratory and field settings. This review is limited to the use of feedback in the acquisition of cognitive skill from instructional situations. While there are a number of theoretical models that describe mechanisms of feedback, simply defined, instructional feedback is a response to students' actions.

Actions and responses to these actions creates a cycle of interactivity. A common feature of current theoretical models of instructional feedback is the cyclic changes that occur with the learner's cognitive state (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Kulhavy & Stock, 1989). These changes are influenced by a number of factors. Perhaps the most important is the type of feedback provided (Dempsey, Driscoll, & Swindell, 1993).

Type of feedback can be classified into the following five categories (Roper, 1977; Bangert-Drowns, et al., 1991; Dempsey et al., 1993):

1. *No Feedback* is often a control condition used in comparison to other forms of feedback.

2. *Verification Feedback* or *Knowledge of Results (KR) Feedback* simply informs the learner of a correct or incorrect response.

3. *Correct Response* or *Knowledge of Correct Response (KCR) Feedback goes* beyond Verification Feedback to inform the learner of the correct answer.

4. *Try-again Feedback* directs the learner to make one or more additional attempts at the answer.

5. *Elaborative Feedback*, may be a number of different forms of additional information that either provides an explanation for the error or reviews relevant material.

A review by Kulhavy and Stock (1989) found more than 50 studies completed since 1970 where elaborative feedback was one of the variables under investigation. Elaborative feedback, as defined by Kulhavy and Stock, consists of any information delivered to the student beyond simple verification. Thus KCR or Knowledge of Correct Response feedback would be included as a form of elaboration. Unfortunately, the manipulations of the content of elaborative feedback have been inconsistent, making simple generalizations of results difficult if not impossible. In addition, or perhaps due to this inconsistency, the results have been varied. Kulhavy and Stock cite that about half of the studies they reviewed where the manipulation of elaborative feedback consisted of increasing amounts of information produced improved performance. The remaining half showed no significant improvement.

An example, cited by Kulhavy and Stock, where "elaborative" feedback was shown to be beneficial is a study by Roper (1977). In that study, subjects who received KCR feedback within a computer-assisted instructional program demonstrated superior performance than those subjects receiving KR feedback. And KR feedback, in turn, led to improved performance over a no feedback condition. Note, however, that the manipulation in this study was simply KCR over KR and not elaborative feedback as defined as additional explanatory information.

The Kulhavy and Stock analysis points to one of the major problems with research into elaborative feedback: a consensual definition. Studies have included numerous types of elaborations from simple explanations of errors to re-presentations of the instruction (Kulhavy, 1985). Often, as with the Kulhavy and Stock report, mere presentations of the correct response is considered "elaborative".

Even though Kulhavy and Stock claim limited evidence for the benefits of elaborative feedback (Roper, 1977), they conclude: "Based on our assessment of the literature, we are unable to reach any useful conclusion regarding how the elaborative component of feedback operates" on post performance (p. 289).

In a more recent meta-analysis, Bangert-Drowns, et al. (1991) also failed to conclude that the amount of information given in feedback effects post performance despite their presumptions that "elaborate feedback would have encouraged the construction of a richer network of pathways to the desired information" (p. 234). Instead, the major conclusion of the Bangert-Drowns et al. analysis is that the primary role of instructional feedback is in the correction of errors. In their report, studies that investigated the use of *corrective* feedback (elaborative *or* KCR feedback), while controlling for major sources of feedback-related variation (such as presearch availability), demonstrated an average effect size of 0.77. While supportive of corrective feedback over verification feedback, the Bangert-Drowns et al. analysis found little support for the use of information-rich feedback.

Only one study in the Bangert-Drowns report compared the use of elaborative or explanatory feedback to correct-answer or KCR feedback (Sassenrath & Gaverick, 1965). In this study, simple KCR feedback was found to be superior to feedback that provided an explanation. A result inconsistent with an information-processing theory of learning.

The resulting picture of the use of elaborative feedback for instruction is, at best, inconsistent. There is much support for the use of corrective feedback, but beyond providing corrective information the role of information-rich feedback is far from understood.

Timing of Feedback

A second major variable of interest in the literature on instructional feedback is in timing. An operant theory approach to behavior modification insists upon the delivery of immediate reinforcement (Skinner, 1968). This approach to feedback was quickly challenged by what became known as the Delay Retention Effect (Brackbill, Bravos, & Starr, 1962; Brackbill & Kappy, 1962; Brackbill, Wagner, & Wilson, 1964). Using multiple-choice testing, researchers consistently found that a delay in feedback of one or more days increased performance. These findings were generally left unexplained until Kulhavy and Anderson (1972) proposed the *interference-perserveration* hypothesis.

The interference-perserveration hypothesis suggests that subjects' initial errors interfered with their ability to immediately acquire the correct response from feedback. A delay in the delivery of feedback reduced this interference because subjects essentially "forgot" their initial (erroneous) response. This hypothesis gathered further support through a meta-analysis by Kulik and Kulik (1987).

The Kulik and Kulik analysis reviewed 53 studies that compared some form of immediate to delayed feedback. The studies covered a broad range of experiments from applied studies with classroom quizzes and programmed materials to controlled experiments in list learning and learning from test materials. Such differences between studies warranted a separate analysis for type of study. Indeed, Kulik and Kulik found that immediate feedback was more effective than delayed in typical classroom settings with an average effect size of 0.28.

Experiments involving delayed feedback and list learning have demonstrated highly equivocal results. Strong support for immediate feedback as well as strong support for delayed feedback have been reported. Kulik and Kulik provide a detailed explanation for these findings. Essentially, studies reporting positive effects for the use of delayed feedback presented feedback in such a way that the feedback constituted a separate and additional practice trial. Experiments that controlled for this event (by fusing the feedback to the instruction through a reduction in the time interval or an elimination in cues) resulted in a greater effect for immediate feedback.

Consistent with this conclusion, experiments involving the delay of feedback during testing conditions showed gains over the use of immediate feedback. Again, the delay of feedback in these studies allowed subjects to essentially perform additional practice trials. Since most of the studies showing support for delayed feedback failed to control for additional instructional trials, the use of immediate feedback for most educational situations, is strongly recommended by Kulik and Kulik.

Unfortunately, the Kulik and Kulik analysis has not laid to rest the issue of immediate versus delayed instructional feedback. A number of supporters remain loyal to the use of delayed feedback for some situations (Dempsey, Driscoll, & Swindell, 1993; Cohen, 1985). Roper (1977) suggests that the delay of corrective feedback (while providing immediate verification feedback) may promote learners to actively rethink the problem, thus giving the question more attention than situations where all the feedback is given at once. Cohen (1985) lists a number conditions under which delay of feedback may be beneficial. Immediate feedback may impede the pace of learning for high-mastery students, becoming more of a distraction than an aid. Cohen also claims that delayed feedback, or end-of-session feedback, facilitates long-term retention and "has also been shown to be helpful if a student is working at the comprehension and application level of Bloom's Taxonomy" (p. 35). These claims, however, have little, if any, experimental support.

A study cited by Cohen in support of these claims (Gaynor, 1981), investigated the effect of delay of feedback in a computer-based mathematics program. Comparing immediate, 30-second, end-of-session, and no feedback treatments, the study analyzed the acquisition of matrix algebra at three levels of performance: knowledge, comprehension, and application. While noting some differences of feedback-delay for the knowledge and application levels of the taxonomy, all differences were statistically insignificant. The only significant difference reported by Gaynor were the post-test scores between high- and low-mastery students -- categories presumably determined by the subjects' overall performance on the task. The Gaynor study, therefore, indicates that delay of feedback, or even no feedback, had little effect on performance. A conclusion also reached by Mory (1992).

Surprisingly, most of the research comparing immediate and delayed feedback has not been conducted in the area of Computer-Assisted Instruction (Kulik & Kulik, 1988). Instead, applied situations tended to study the timing effects of feedback from classroom quizzes. The few CAI studies reviewed by Kulik and Kulik showed small to moderate gains for the use of immediate feedback.

While there is very little experimental support for the delay of feedback in instructional situations, there is some consensus that delay *could* be beneficial in *some* circumstances. One revealing line of research in the use of instructional feedback is in the analysis of interactions between students and human tutors (Fox, 1991; McArthur, 1990). As suggested by Bloom (1984), the effectiveness of human tutoring is very high and is often cited by ITS researchers as the ultimate process to model (Carbonell, 1970).

Merrill, Reiser, Ranney, and Trafton (19[illegible]) describe a number of common features of human tutoring that bring new insight into the use of immediate feedback for instruction. Human tutors maintain a delicate balance of responsibility, giving students great amounts of control while providing just enough guidance to keep them productive. In doing so, human tutors frequently give immediate feedback in very subtle forms. A slight hesitation in responding with confirmatory information often serves as a clue to the student to double-check for errors.

In maintaining the role of a guide, the tutor is ofttimes presented with a problem of intervention. Human tutors do not tend to intervene at every sign of error. Instead, the intervention strategy is determined by the context of the problem. Episodes of floundering or critical missteps are quickly corrected, but feedback on other types of errors may be withheld until a more appropriate moment. Therefore, human tutors modulate their responses based upon how serious the error is perceived to be. These attributes of selecting intervention strategies based upon the seriousness of errors has not been investigated by researchers of ITS.

METHOD

Independent variables of the study consist of the type of feedback and the timing of feedback for non-critical errors. Each variable has two levels, forming a 2 by 2 matrix (see, Figure 2). The types of feedback are instantiated with elaborative and corrective feedback, whereas the timing of feedback is either immediate or delayed for non-critical errors.

Elaborative feedback includes one or all of the following items: 1) a notification of an error; 2) a reason why the response was incorrect; 3) a brief description of the appropriate subgoal; 4) a detailed list of steps to complete the subgoal; 5) an indication of progress toward completion of the subgoal; and, 6) a direct identification of the very next step. Corrective feedback, on the other hand, simply gave notification of an error while identifying the correct answer.

The immediate feedback condition delivered feedback (either elaborative or corrective) upon the execution of any type of error. Conversely, the delayed feedback condition makes a decision on when to provide feedback. If the error was critical, immediate feedback was given, if the error was non-critical (identified as either inefficient or inappropriate) then the error was recorded, but not immediately reported to the student. Under this condition, all errors were reported in an end-of-problem information screen.

Dependent variables of the study include time to complete each of the Session 1 trials, number of completed problems during Session 2, and, speed and accuracy of Achievement Tests 1 and 2. In addition, subjects' ratings of the treatments, from an on-line questionnaire, were collected. This paper includes an analysis of the Session 1 trials and the speed and accuracy of the first Achievement Test. Data from the remaining two sessions has been collected, but not completely analyzed at this time.

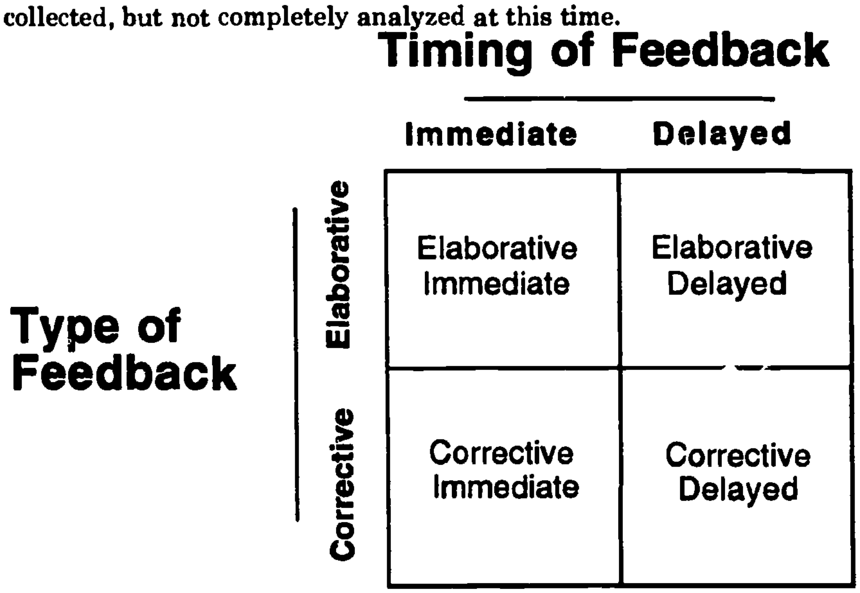

Figure 2: *Levels and variables under study.*

Subjects

This study was carried out at the USAF Armstrong Laboratory under the auspices of the Cooperative Laboratory (CoLab). A total of 119 subjects participated in the study. The Air Force selects, recruits, and hires subjects through temporary employment agencies to fulfill experimental laboratory needs. Selection criteria limited subjects to high-school graduates with no college degree.

	Activity	Data
Session 1	Tutorial & 21 Trials Achievement Test #1	Completion Time Speed & Accuracy
Session 2	Practice Trials Achievement Test #2	Completed Problems Speed & Accuracy
Session 3	Summative Evaluation	Questionnaires

Figure 3: *Schedule of Events.*

Procedure

Groups of twelve to thirty subjects entered the laboratory seating themselves at individual computer workstations. One of four treatment groups was then randomly assigned to each subject. After a brief verbal introduction to the experiment, subjects began Session 1.

Session 1 consisted of a computer-based tutorial followed by a set of 21 complex LOADER problems. The tutorial presents a series of text and graphics screens which describe the loading task. Subjects proceeded through this activity at their own pace. Immediately following the tutorial, subjects began practicing the loading task through the control-panel interface presented in Figure 1. Each treatment was presented with an identical set of practice problems. The presentation of practice problems began with each of the six basic subgoals of a larger LOADER procedure. The number of necessary control-panel actions for each subgoal ranges from five to seven steps. Three problems of each subgoal were presented. The subgoal problems were followed by a set of three problems which required performance of the complete procedure. Execution of the complete procedure is a 32-step process. During practice, feedback was presented according to the treatment types. Session 1 activities ended after subjects completed an immediate acquisition test. The acquisition test was a 32-step LOADER problem. Feedback type during the acquisition test was held constant across treatments. Representative of the "real" console panel, the feedback strategy during the test was of the corrective-delayed type with no on-line help available.

Session 2 consisted of subjects practicing additional LOADER problems with the tutor for a period of 2 hours. This practice session was again followed by an immediate acquisition test. Session 3 included a review and an evaluation of all four treatment conditions. During Session 3, subjects gave each treatment condition a rating.

LOADER: The Console-Operations Task

LOADER is a complex problem-solving task requiring the operation of a simulated control-panel console. The task simulated by the LOADER environment is the operation of a remote crane control arm to load various canisters from a set of storage bins to one or more railroad cars. Simple tasks include the loading of a single canister whereas complex tasks require the operator to analyze the availability and capacity of railroad cars in order to appropriately position and load a number of different-sized canisters. Complexity of the task depends upon variables such as the number and size of canisters to load and the position and capacity of rail cars. Simple tasks may be performed with as few as 30 steps while complex tasks may require as many as 150 steps.

Each problem can be solved through a set of six subgoals (or procedures). These procedures are: 1) Position Rail Car to Appropriate Dock; 2) Position Crane to Appropriate Storage Bin; 3) Lift Canister from Storage Bin; 4) Position Crane to Appropriate Rail Car Receptacle; 5) Load Canister into the Rail Car; and, 6) Dispatch Rail Car to Appropriate Rail Line. Each subgoal has 5 to 6 individual steps or control panel actuations. The rail yard "situation" determines the appropriate settings for various knobs and buttons as well as the correct order of sub-procedures. Complex tasks require one or more iterations through certain subgoals.

The Control-Panel Console

The control-panel console appears as set of knobs, switches, buttons, and indicators appropriately labeled and organized by function on the lower half of the LOADER interface. All interactions with the console are performed through a mouse. While most interactions occur with a simple click of the mouse, some interactions require that the mouse button be held down for several seconds until the action is complete. The panel responds with visual feedback in the form of indicator lights, knob and switch settings with each selection. For certain actions, an audible "click" indicates the completion of the action.

The console is organized into eight panels associating their related functions. The rail control, line and dock panels allow the operator to position rail cars to appropriate loading docks and dispatch cars to available rail lines. Operations requiring positioning the crane, use the centrally located panels including the crane control, crane coordinate system, and the jaws panels. Along the bottom of the screen are panels that allow storage bin doors and rail car doors to be opened.

The Dynamic Model

Located on the upper half of the LOADER interface is the dynamic graphical model. This model provides a representation of the loading task from a birds-eye-view perspective. Positions of the rail cars, storage bins, canisters, doors, the overhead crane, and the line and dock selections are indicated with a number of graphical elements. Colors aid the identification of canister sizes and rail car capacities.

The dynamic model responds to control panel interactions with animated sequences representing their outcomes. For example, engaging a selected rail car south with the button labeled "South," results in the animated motion of the rail car moving down toward the rail docks. In addition to the motion of rail cars, car doors and bin doors open and close, the crane moves above the rail cars and storage bins, and the crane lowers, grasps and lifts canisters. All of the information displayed by the dynamic graphical model (minus the motion and graphical relationship qualities) is also represented on the upper half of the screen in table form.

The Expert Help Feature

Embedded within the interactions of the problem-solving task is an expert help system. The expert help provides intelligent advice to assist in the solving of the loading task. Under the *corrective* intelligence mode, expert advice consists solely of error notification while giving the correct answer. The *elaborative* intelligence mode provides levels of advice often beginning with a reason why the attempted action was incorrect (see, **Error**

Notification in Figure 4). Secondly, with **Level 1 Help**, this mode will give a description of the subgoal that the user should be attempting. By requesting additional help, the expert advice will provide **Level 2 Help** which is a list of the steps required to perform the subgoal with an indication of the steps already accomplished. Finally, if the user requests still more help, the system will give the correct answer (**Level 3 Help**). The levels of expert help (with the exception of describing the reason for an incorrect answer) are also available to the user by selecting the on-screen **Help** option.

Other Display Features

In addition to the dynamic graphical model and its accompanied table, the *LOADER* interface includes a number of other helpful display features. Starting in the upper-left corner of the screen, the name of the problem file is displayed. Below this, a verbal description of the goal for the selected problem appears. Within the same area, a **Goal Complete** button is available for the user to select to indicate that they believe they have completed the problem.

Error Notification:	Critical Error -- Crane cannot be lowered through the door of a closed storage bin.
Level 1 Help:	You should be attempting to: Load Canister to Receptacle 2 of Car at Dock 3.
Level 2 Help:	To Load Canister to Receptacle 2 of Car at Dock 3: * 1. Set West Car to 3 * 2. Set West Receptable to 2 * 3. Enter West Side Crane Coordinates 4. Set Crane Control to Enable 5. Execute Coordinates 6. Set Crane Control to Disable * Denotes Action Complete
Level 3 Help:	To Set Crane Control to Enable: Click at the button indicated with the red arrow.

Figure 4: *Levels of Expert Help*

Software and Hardware Specifics

LOADER is programmed entirely in OpenScript® using the ToolBook® software development environment from Asymetrix Corporation. Software requirements include MicroSoft Windows as well as ToolBook® run-time files. The program is specifically designed for '486 compatible computers with monitors of 800 X 600 screen resolution.

Results

Three dependent measures are under investigation: Session 1 completion time, Achievement Test 1 completion time, and Achievement Test error count. Analysis of variance with repeated measures on trial completion times during Session 1 revealed no significant differences between treatments [F(2,113) = .690, p = .56]. Figure 5 shows mean completion times across the 21 practice trials.

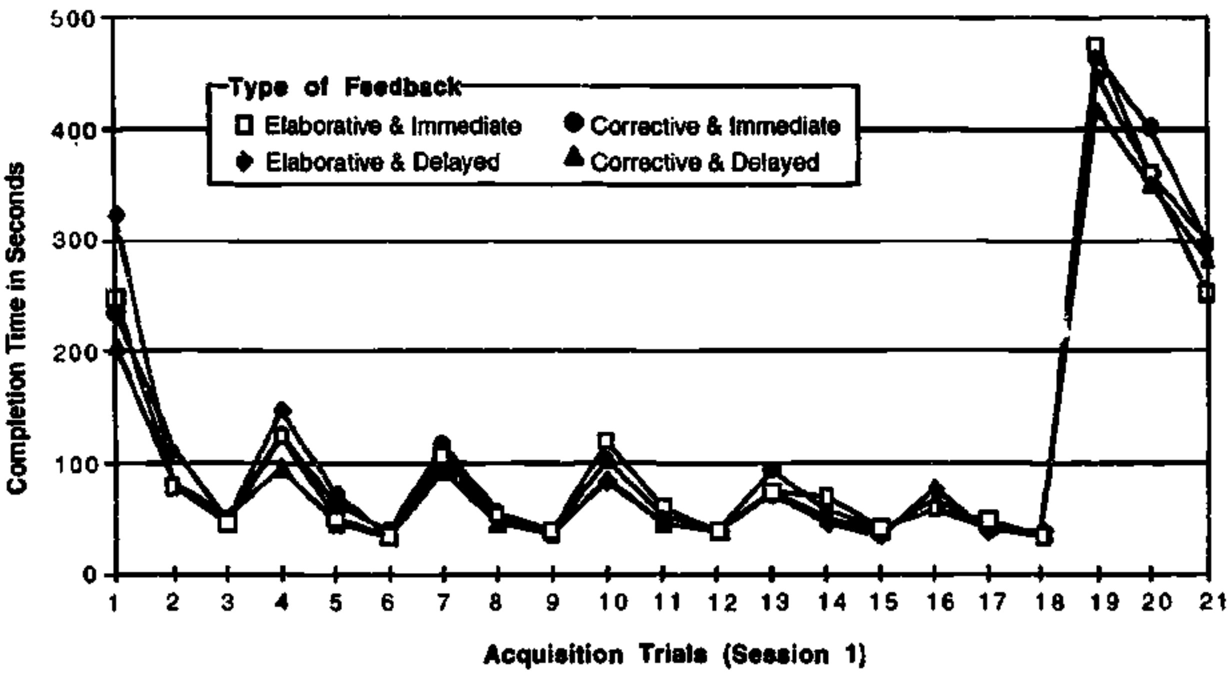

Figure 5: *Mean completion times of acquisition trials.*

Table 1 presents mean scores for the achievement test completion times. Mean error counts for the achievement test are presented in Table 2. These scores reflect an adjustment whereby outliers where removed from the analysis. Due to the nature of the laboratory setting, where subjects are paid for their time, not their performance, extremely poor outlying scores were removed. The analysis did not include six scores for completion time, and seven scores for errors . ANOVAs conducted on these means for overall effects reveal a significant difference for errors [F(3,108) = 2.978, p = .0347], and completion time [F(3,109) = 2.709, p = .0487)]. Fisher's PLSD test was used to determine which differences were significant. Of interest was the significant difference between error count means of the elaborative-immediate feedback and corrective-immediate feedback groups (p = .0229). All other differences between groups were either non-significant or of little interest (such as differences between elaborative-immediate and corrective-delayed groups).

Feedback Type	Count	Mean	Std. Dev.	Std. Err.
Elab/Immed	30	294.600	158.164	28.877
Elab/Delayed	27	350.741	206.678	39.775
Correct/Immed	28	402.429	196.869	37.205
Correct/Delayed	28	448.893	289.225	54.658

Table 1: *Mean completion time for Acquisition Test 1.*

Feedback Type	Count	Mean	Std. Dev.	Std. Err.
Elab/Immed	30	23.933	25.748	4.701
Elab/Delayed	26	26.269	26.784	5.253
Correct/Immed	29	42.828	33.739	6.265
Correct/Delayed	27	42.556	38.071	7.327

Table 2: *Mean errors for Acquisition Test 1.*

DISCUSSION

This study investigated the value of CBT intervention approaches in terms of the efficiency of skill acquisition, quality of achievement and learner preferences. Three general hypotheses predicted that the use of elaborative feedback and the delay of feedback for non-critical errors would result in gains over corrective feedback and immediate feedback for all errors. A discussion for each of these hypotheses is now presented.

Hypothesis 1: *Elaborative feedback and the delay of feedback for non-critical errors will result in greater efficiency of skill acquisition.* It was suggested that feedback of a more elaborative nature as well as a reduction of intervention by delaying feedback for non-critical errors would result in greater efficiency of acquisition. No differences, however, were found during the first session of training for any of the treatment groups. Differences in acquisition time may become evident with an analysis of Session 2 trial times. Nevertheless, with the data presented here, we can conclude that while elaborative or delayed feedback may not be more efficient, it is at least equivalent to other strategies.

Hypothesis 2: *Elaborative feedback and the delay of feedback for non-critical errors will result in greater performance of skill achievement.* Another measure of the benefits of an intervention approach is the post-training performance. We conjectured that the intervention strategies of elaborative feedback and the delay of feedback for non-critical errors would result in greater post-training performance. In support of that hypothesis, significant differences were found between the means of the elaborative-immediate and the corrective-immediate treatments. All other differences were not statistically significant. Therefor, support is found for the use of elaborative feedback when immediate feedback is implemented. The delay of feedback seemed to affect performance in a negative manner, although this difference was insignificant. Other differences may not become evident until the second session achievement test results are analyzed.

Hypothesis 3: *Elaborative feedback and the delay of feedback for non-critical errors will be preferred by learners.* This data was gathered following the second session of data collection. The results have not been analyzed.

In summary, we hope to reveal additional effects of CBT intervention strategies through a continued analysis of the data collected. The use of feedback which elaborates on the goal structure of the procedure is effective for console-operation training as it reduces achievement errors rates after only a brief training session. The effects of using immediate or delayed feedback for errors which are critical is less cle.r. These findings tend to support methods used in many Intelligent Tutoring Systems which offer elaborative feedback during practice in a variety of training programs.

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Title:

"Tooling Up to Go the Distance" Video interaction analysis

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221

Abstract

The purpose of this presentation is to demonstrate a new video evaluation instrument designed specifically for distance education. It was designed to be used for instructional design consultation, distance education teacher training, or research. Categories include students interacting with the teacher, other students, and content.

Instructional designers in distance education are not always developing instruction, they are facilitating the transfer of teachers from a traditional to a high tech setting. In a two-way television setting, teachers accustomed to the rich environment of subtle communication through body language may find themselves stymied by the cavernous feeling of a television classroom. Beyond the worries of the technology and "being on TV," one may experience a disconnectedness that makes the meaning of "distance" even more pronounced. One obstacle facing teachers is facilitating interaction, an essential component to success in traditional <u>and</u> distance classrooms (Fulford & Zhang, 1993b; Garrison, 1990). Traditional methods of interaction may not transfer well to television (Garrison, 1990; Moore, 1989). Having an on-site group of students may increase the comfort level, but could this greater the risk of forgetting the receive-site students? Unfortunately, if the distance learners do not perceive acceptable levels of overall interaction, they are less satisfied with the instruction (Fulford & Zhang, 1993a).

The linguistic study of discourse has a rich past (Searle, 1969; Flanders, 1970). For the distance educator, a linguistic approach may not be the most expedient. Moore (1989) says that interaction "carries so many meanings as to be almost useless unless specific sub meanings can be defined and generally agreed upon" (p. 1). He provides a framework for studying interaction in distance education suggesting three distinct, but closely related types: learner-to-instructor, learner-to-learner, and learner-to-content. The purpose of this research was to create an instrument to quantify and classify interaction in distance education using Moore's (1989) three categories. The instrument was designed to be used for instructional design consultation, distance education teacher training, and research.

Johnson (1987) found that teachers could be trained to improve their ability to facilitate interaction using video and audio tapes to analyze and categorize their behavior. He used Flanders' (1970) model of interaction analysis to develop the instrument. Flanders' system of interaction analysis was defined by Verduin (1970) as "the systematic quantification of behavioral acts or qualities of behavior [sic] acts as they occur in some sort of spontaneous interaction" (p. 32). "Teacher talk" is divided into seven sub-categories, four that are indirect, three direct. The indirect categories are: accepting feelings, praising or encouraging, accepting or using ideas of the student, and asking questions. The direct categories are: lecturing, giving directions, and criticizing or justifying authority. There are only two "student talk" sub-categories: response and initiation. "Silence" is a category falling outside the teacher and student domain. Johnson updated the names of some categories, but the meaning was essentially the same.

Changing philosophies of classroom organization are altering the way teachers facilitate interaction in the traditional classroom. Hertz-Lazarowitz and Shachar (1990) discuss the differences between the traditional "whole ass" method versus a "group investigation" method. They said that "Flanders and l s colleagues assessed teachers' verbal behavior mostly in traditional direct-instruction classrooms" (p. 79) and therefore, additional categories of behavior needed to be derived from observing cooperative classrooms. Altogether, twenty categories were defined from transcripts of cooperative classes: instructing, lecture, short questions to elicit short answers, translation, interruption, disciplining one student, disciplining the whole class, disciplining by proxy, pluralizing, prompting, mediating, mechanical reinforcement, competitive reinforcement, spontaneous reference to children's initiatives, helping the child in the course of learning, encouraging interaction among children, referring matter-of-factly to problems of procedure and organization, reference to students' performance, individual personal reinforcement, and revealing emotions.

Moore (1989) has a student-centered perspective. The three types he has specified all originate from the learner, not the teacher. Johnson's (1987) and Hertz-Lazarowitz and Shachar's (1990) instruments are mainly teacher-centered. Both interaction analysis instruments to evaluate classroom dialogue are detailed and differentiate between micro-levels of teacher behavior. This suggests a major theoretical division in interaction analysis. Conventional instruments (Johnson's 1987, Hertz-Lazarowitz, & Shachar, 1990) may have been successful in traditional settings for research and training, but, applying them to the distance education TV classroom is problematic. The purpose of interaction analysis may be different. Johnson (1985) and Hertz-Lazarowitz and Shachar (1990) focus on "functional" analysis, while Moore's framework focuses on the "parties involved". Interaction analysis in the traditional classroom is often for the purpose of training new teachers (Johnson, 1987). In many distance education TV settings, veterans already have teaching skills, so the emphasis is on adjusting to the two-way capabilities of the television classroom. The dilemma is not so much compelling teachers to interact locally, but to interact with <u>all</u> students across the distance. Since both parties are essential to the interaction process, this research attempts to give equal care to students and teachers.

The idea of analyzing interaction in two-way television is valid, but the instrument must be suitable for the setting. Hiring trained classroom observers is costly. A workable tool has to be simple to use, and require minimal training. Videotaping may be one tool for evaluating interaction. However, videotaping alone is not enough, because no analysis can be conducted without a systematic, objective-based approach. Simply watching videos of themselves in the classroom may alienate "technophobic" teachers.

<u>The Conceptual Framework</u>

Some may assume that interaction requires overt speaking behavior. However, interaction has also been defined as covert behavior, that is carrying on an internal conversation (Kruh & Murphy, 1990). Therefore, it seems important to examine all facets of classroom communication in the study of interaction. Fulford (1993), in a model of cognitive speed, explains that one-way communications such as television and lectures are half the speed of the mind's cognitive capacity. The pace of one-way communication may be too slow and distract the learner. Two-way communication requires interaction, keeping the learner's mind occupied. Normal speech is usually 125-150 words per minute (wpm), but the theoretical cognitive capacity is 250-300 wpm. The model illustrates that this provides enough capacity for the speakers to simultaneously to speak and to monitor their delivery, and listeners to listen and to prepare responses. Since listening requires only 125-150 (wpm), "if they aren't engaged in a situation in which they must interact, their renegade thought patterns may dominate their cognitive activity" (Fulford & Zhang, 1993a). This may explain why anticipated interaction has been linked to positive learner attitudes (Yarkin-Levin 1983).

Flanders' (1970) direct and indirect categories also seem to reflect the idea of one-way and two-way communication. "Direct influence ... tends to minimize the freedom of the student, because the teacher directs the learning activity. The second factor, indirect influence, would have the opposite effect, or that of maximizing the freedom of the student to respond" (Verduin, p. 32).

For this study, Moore's (1989) framework of learner-to-instructor, learner-to-learner, and learner-to-content categories were sub-divided into "one-way" communication and "two-way" communication using Fulford's model (1993). Since interaction may imply a need for overt responses, the word "communication" was used to include both types of classroom behavior. One-way communication was considered a uni-directional information flow with a passive receiver. It was defined in this study as communication directed at the entire class with no expectation of a response, such as, the teacher lecturing or giving directions, a student making a presentation, or a pre-recorded video-tape being shown. Two-way communication was considered as a multi-directional information flow requiring overt interaction and active participation from at least two people. It was defined in this study as directed communication with expectation of a response. Similar to Flanders' (1970) indirect categories, this included: asking and answering questions, responding with praise, or encouraging.

In a traditional classroom, sub-categories of teacher to student and student to student may be sufficient, but in a distance setting it seemed important to analyze interaction across all sites. Although, Fulford & Zhang (1993a) indicate that every student does not have to participate publicly to enjoy satisfaction from interaction, there could be a group identity that says "if my site is not called on, I'm being ignored." For this reason, two-way communication was sub-divided into two teacher categories and five student categories. The categories differentiated between the person initializing the communication and the person responding. Teacher-to-student and student-to-teacher were standard categories. The student-to-group category was provided in consideration of collaborative learning techniques and to examine how much freedom students have to converse without teacher intervention. Teacher-to-specific location and student-to-specific location were designed to examine whether distance interaction is occurring that takes into account group identity. A student-to-all category was used to find out if students were encouraged to address everyone across the distance, rather than just the teacher. The student-to-content category was to examine how much active involvement students have with the instructional materials. Since a large part of classroom time could be taken up by management issues, non-instructional categories were provided for both one-way and two-way communications.

Flanders (1970) and Johnson (1987) both required the coding of categories every three seconds. Skill training, that lasted several hours, was supposed to acclimate the rater to three second intervals. There was no actual timing device used. Analysis was often carried out through real-time observation. In this study, video analysis had the advantage of allowing the rater to record the exact time a category occurred and to replay the instruction to be sure all coding was accurate. This method allowed coding of "events" or discrete topics instead of chopping the instruction into three second bits. Each occurrence of a category was defined as an event. An event started with the initiation of a new topic. For example, a student asked "How do you keep the mouse cage clean?" The teacher responded "Does anyone have suggestions?" Another student offered "I use soil instead of wood chips..." The teacher praises "Good idea..." When a third student asked "What do you say to the children if the mouse dies?" this begins a new topic, therefore a new event.

Analyzing interaction by category per event provides a wealth of information about the direction and participants of interaction. However, additional information can be obtained by examining single transactions. To examine the richness of an event, it is important to know how many exchanges occurred between communicators. A single exchange, although lasting several minutes is very different from numerous exchanges over the same period. Coding discrete transactions may help determine how many people were involved in the instructional event. Exchanges that involve only one teacher and one student seem limited, when the goal is to create lively group discussion. This study defined transaction as the contribution of a single individual. A series of exchanges or transactions between individuals constituted an event.

Context of the Study

The two-semester, two-credit university course used in the study provided in-service training for the Developmental Approaches in Science and Health (DASH) program. There were ten sessions from October 1991 to May 1992. DASH is a sequential kindergarten through sixth grade (K-6) program that integrates the content of science, health, and technology. The course was offered through the Hawaiian Interactive Television System (HITS) which is a 4-channel interactive inter-island closed-circuit television network that uses both Instructional Television Fixed Service (ITFS) and point-to-point microwave signals to connect six classrooms across the state. Instruction was delivered to five receive-site classrooms; there were no participants at the origination site. This was the first time this course was offered over HITS and the first time these teachers taught via two-way television.

Each session had a similar format. Participants met locally for an hour with a DASH facilitator, before the broadcast portion that lasted one hour and fifteen minutes. After a brief check-in, a pre-recorded videotape was shown for about twenty minutes. Collaborative activities took up approximately fifteen minutes, ending with each location presenting their work for three minutes. The panel answered faxed questions at the end of the session.

This course provided the occasion to examine a large number of participants over a long period of time. The researchers were not involved in the development or teaching of the course. The videos were analyzed independently by four research assistants to prevent potential bias.

Procedures and Methodology

The participants were K-6 teachers who were already using DASH in their classrooms. For most this was their first interactive TV experience. The 233 participants were in 5 locations: 98 in 2 two-way audio/one-way video locations, and 135 in 3 two-way video/two-way audio locations. The 10 sessions used in the study were recorded at the origination site. The videotapes included only the broadcast portions of the course. Due to lack of recording equipment, it was not possible to record every site at all times. Each site was shown on the screen as they participated. During discussion with one-way video sites, a still photograph of the participants was shown while the audio was heard. Collaborative activities were the greatest challenge to videotaping. The two-way video sites were scanned in sequence while open microphones collected the overall audio activity. Although this provided a sampling of what occurred during these activities, these activities were rated as a single event and transactions were not recorded.

Four graduate students in educational technology were recruited as evaluators. All of them had completed instructional design coursework. They were given a description of the categories and then shown video-taped examples. They were shown how to code information onto the instrument. The training lasted about a half hour. The evaluators were asked not to compare their evaluation forms. They commented that the form was straightforward and easy to use. The four evaluators each analyzed the video tapes of the 10 sessions.

The Evaluation Instrument

The instrument was designed using Moore's (1989) framework for studying interaction in distance education. Three categories of interaction were examined: learner-instructor, learner-learner, and learner-content. The evaluation instrument was a half page form used to record each "event" of the lesson (see Figure 1). An "event" was defined as a single topic. For example, the teacher asked a specific question, a student answered, the teacher clarified, and another student expanded. This was one event. If the teacher asked a new question, or a student changed the focus, a new event began. The coding of the event is based on the person who initializes the topic, although other people become involved in the communication. A VCR with a time-based counter was used identify the "beginning" and "ending" time of each "event". Both were recorded on the form and a "total" time was calculated. Since ten tapes were used in the study, the tape number and event number were recorded for tracking.

The type of interaction was then recorded. "One-way" interaction was defined as communication directed at the entire class with no expectation of response. There were four "one-way" categories. "Non-instructional" events pertained to the management of the class, not the content of the lesson, these included directions about turning in homework, purchasing materials, operating equipment, and so forth. "Teacher only" events were lecture type events. "Student only" events were presentations made by students. "Content only" was for presentations using media such as pre-recorded video tapes.

Figure 1. Video evaluation instrument.

Beg. Time _____ End Time _____ Total _____ Tape/Event # ____

Type of Interaction

One-Way	**Two-Way**	
_____ Non-Instructional	_____ Non-Instructional	_____ Student-Teacher
_____ Teacher Only	_____ Teacher-Student	_____ Student-Group
_____ Student Only	_____ Teacher-Spec.Loc.	_____ Student-Spec.Loc.
_____ Content Only	_____ Student-Content	_____ Student-All

Transactions

____ Total _______

____ Total _______

____ Total _______

UHM LCC KCC Hilo Maui Molokai Kauai Kailua # of people ___ Final _______

Notes

____

____

____

"Two-way" interaction was defined a directed communication with the expectation of a response. There were eight categories of "two-way" interaction. "Non-instructional" two-way differed from "non-instructional" one-way in that responses were given. Site sign-ons are an example of a "two-way non-instructional" event. "Teacher-student" was a teacher asking a question directed to all students. "Teacher-specific location" was a teacher directing a question to a specific location or site. "Student-teacher" was the student asking a question directed to a teacher. "Student-specific location" was a student directing a question to a specific location or individual. "Student-group" was a student conversing within their own site, including the entire group or groups formed for collaborative activities. "Student-content" was a student interacting with course materials that required active participation. This category was intended for written activities, reading, or using computer assisted instruction, although in this study, none of these events occurred. "Student-all" was when a student asked a question for anyone to respond to.

Next, individual transactions were recorded. This portion of the instrument was designed to provide an indication of the richness of the communication. For example, if the teacher asked a question, a student provided a short answer, and then the teacher expounded for several minutes, the event would be very teacher focused. However, if the teacher asked a question, a student provided a short answer, then the teacher asked for elaboration, another student responded, and another teacher provided another example, the event would be richer and more student focused. These events may take the same amount of time, but by recording transactions, an instructional designer could examine patterns of interaction.

For this study, transactions were recorded by using T for teacher and S for student. If more than one teacher or student was involved in an event, numbers were added. The recording of the first example above would be T S T, the second example would be T S T S_2

T_2. To insure the accuracy of the ratings, evaluators were asked to rewind the tape and record lengthy events three times (see the three lines in Figure 1). The number of transactions was counted. A final count was determined using the evaluators' best judgement which of the three attempts was most accurate. The evaluators then counted and recorded the number of people involved in each event and circled the involved sites.

<u>Reliability</u>

The video interaction analysis instrument was tried out during the DASH program. The raters viewed the video tapes of the ten DASH sessions independently and recorded:

1. The total number of occurrences for each type of interaction in each session.

2. The total time spent for each type of interaction in each session.

3. The total number of events in each session.

4. The total number of transactions in each session.

5. The total number of people involved in all the events in each session.

The information above was used to generate a quantitative summary of the overt interaction in the TV classroom. From Item 1, one could see how frequently each type of interaction occurred in any session and determine whether the interaction pattern over TV was balanced or appropriate. Item 2 showed the proportion of time actually spent on each type of interaction, which revealed the time reserved for the particular type of interaction. Item 3 showed how many topical segments or events of teacher-student interaction occurred (Figure 2). Item 4 showed how many exchanges or transactions occurred (Figure 3).

Figure 2

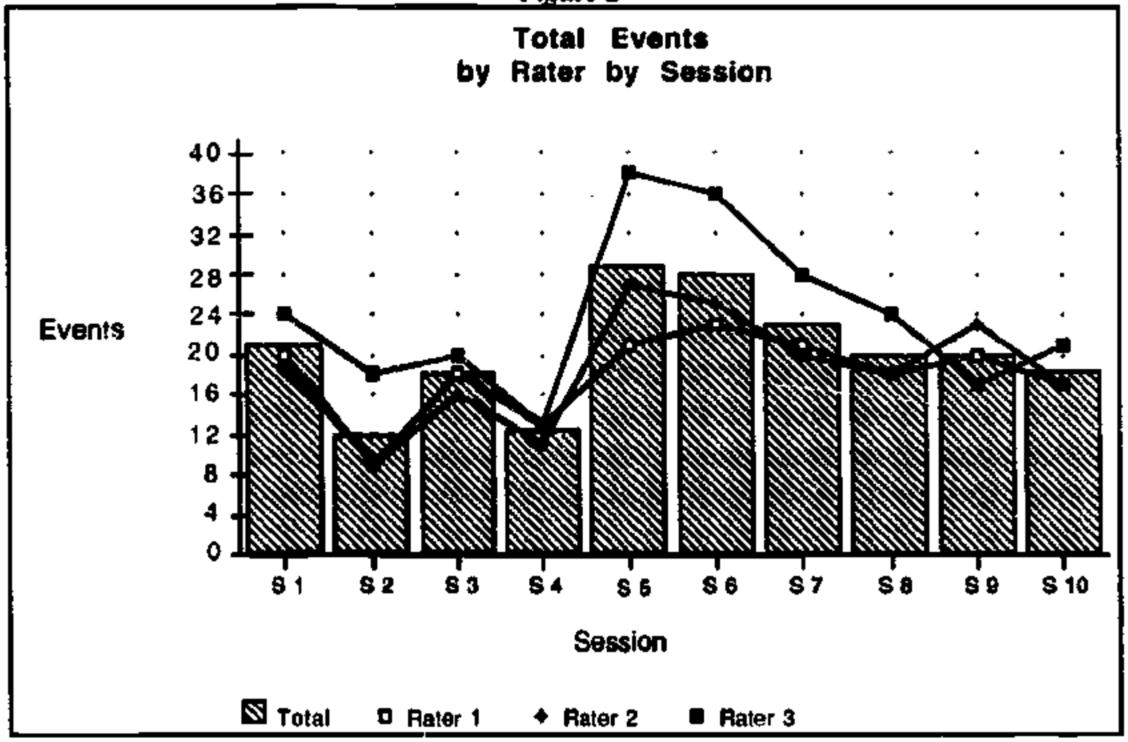


Figure 3

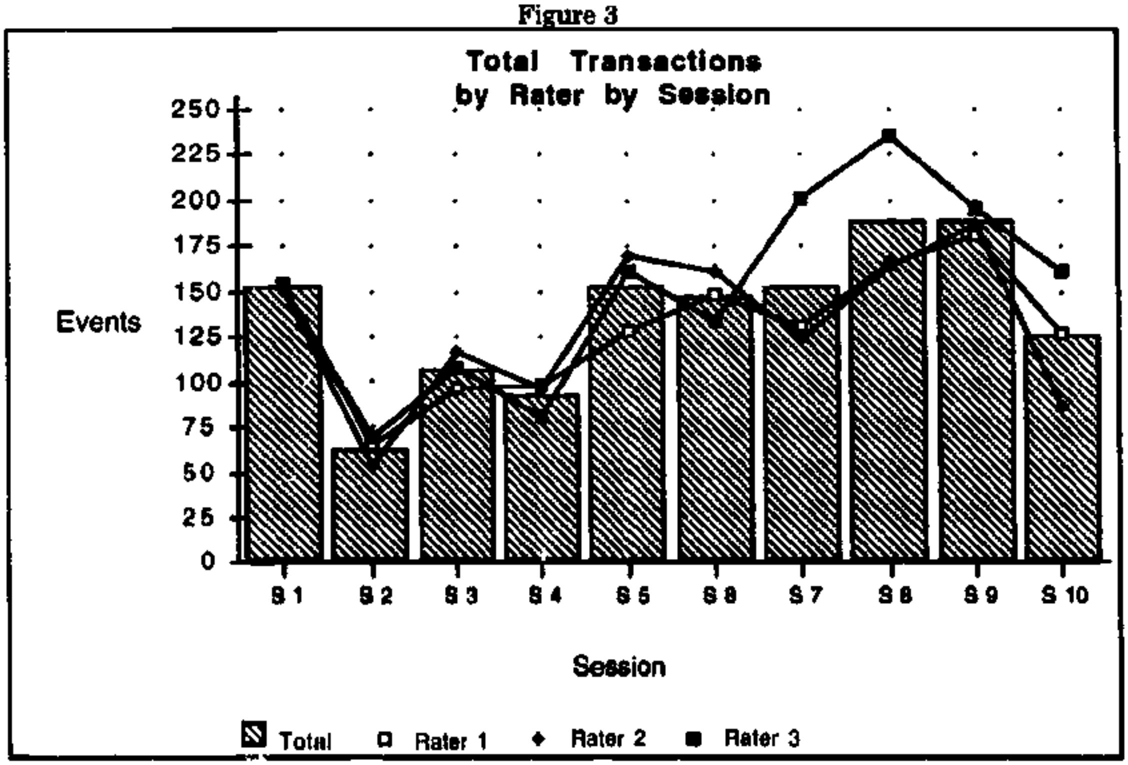


Figure 4

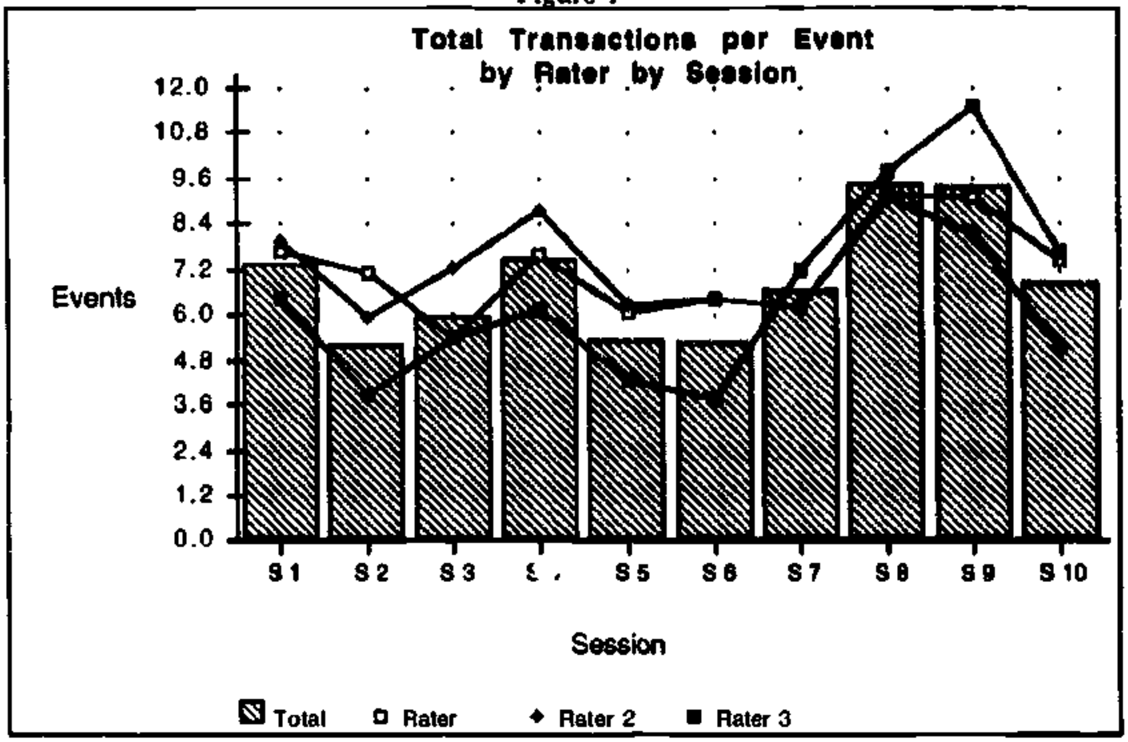


Figure 5

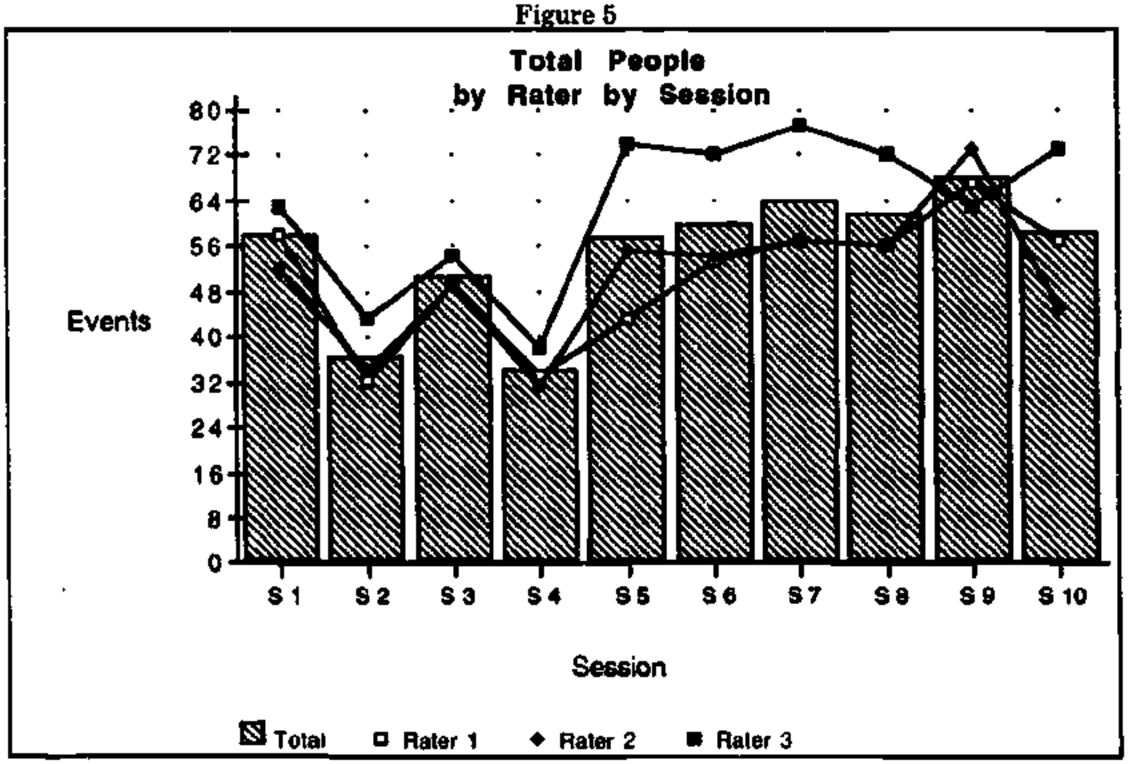
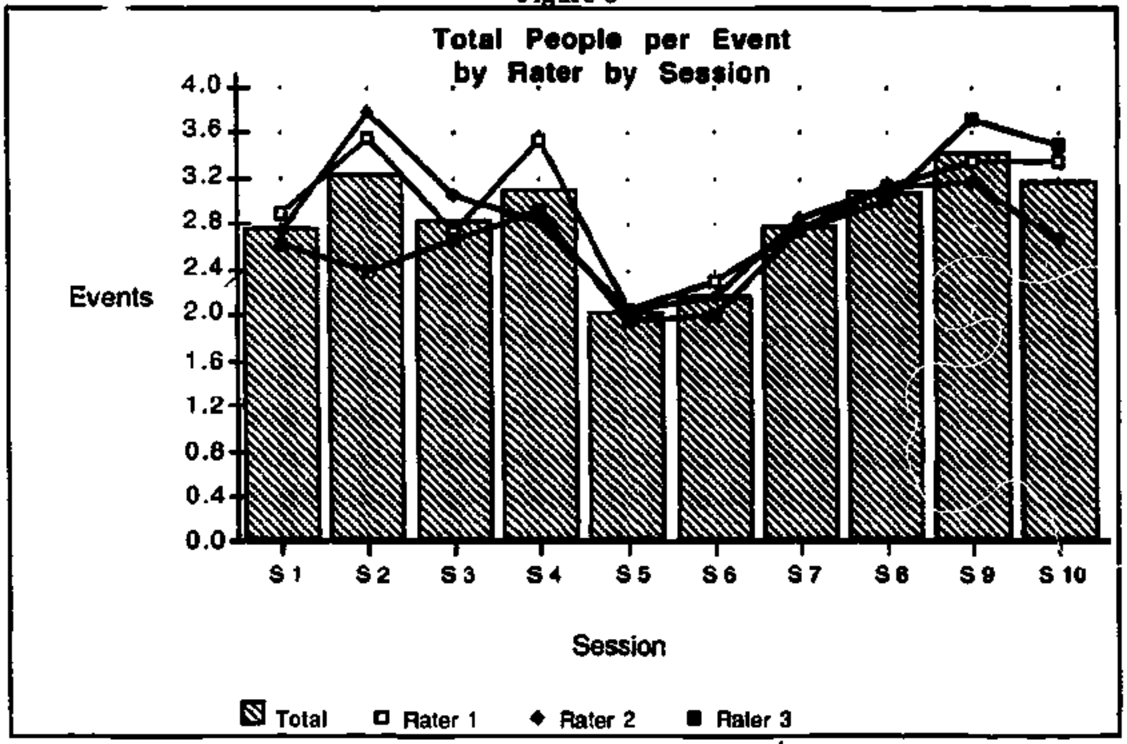


Figure 6



Items 3 and 4 produced the average number of transactions per event, which was a convenient index of the extent to which an instructor allows a topical segment to elapse (Figure 4). Item 5 showed the total involvement during the session (Figure 5). This total was derived from adding the number of people in each event, therefore, the same individuals may be counted a number of times to create this figure. Item 3 and 5, on the other hand, showed the average number of participants the instructor allowed in an event (Figure 6). A highly interactive class would be expected to generate more exchanges and engage more students per event than a lecture-type, non-interactive class.

Aggregate reliability is considered invalid if the pairwise inter-rater reliabilities vary a great deal, for instance, between - 0.6 and + 0.6 Aggregate reliability is valid only when the pairwise inter-rater reliabilities are similar (Overall, 1965). All the four raters provided the total number of occurrences for each type of interaction and the total time actually spent on each type of interaction in each session. Their mean pairwise inter-rater reliabilities and the aggregate reliabilities on the two variables are reported in Table 1. The reliabilities are generally acceptable, except in those categories where few occurrences were observed. Not all the categories of interaction are in Table 1, because some types of interaction did not take place in the DASH program. The "content only" category had only one occurrence, thereby creating a misleading perfect reliability so it was not reported.

Three raters completed analyzing the events and transactions in the video tapes of the 10 DASH sessions. Therefore, the reliabilities reported below in Table 2 were based upon three not four raters. The reliabilities reported show that using the mean of three or four raters will result in high reliabilities.

Table 1
Reliabilities for total number of occurrences and total time spent for each type of interaction

		Mean inter-rater reliability		Aggregate reliability	
Type	Sub-category	Number	Time	Number	Time
One-way	Non-instructional	0.38	0.53	0.71	0.82
	Teacher only	0.89	0.93	0.97	0.98
	One-way Total	0.60	0.85	0.86	0.96
Two-way	Non-instructional	0.72	0.62	0.91	0.88
	Teacher to student	0.39	0.33	0.72	0.68
	Student to teacher	0.81	0.66	0.94	0.89
	Student to student	0.31	0.91	0.64	0.98
	Two-way Total	0.27	0.97	0.61	0.99

Table 2
Reliabilities for total number of events, transactions, and people involved, and average number of transactions per event and people per event

	Mean Pairwise Inter-rater Reliability	Aggregate Reliability
Number of Events	0.80	0.93
Number of Transactions	0.79	0.92
Number of People Involved	0.66	0.85
Average Number of Transaction per Event	0.61	0.82
Average Number of People per Event	0.62	0.83

After the four raters had analyzed the video tapes of the 10 DASH sessions, pairwise inter-rater reliabilities and aggregate reliabilities were calculated. The pairwise inter-rater reliability is simply the correlation between the counts or recorded times of any two judges (Sax, 1989). The aggregate of effective reliability is the reliability of the mean of the counts or times independently given by the four raters (Guilford, 1954; Rosenthal, 1987; Rosenthal & Rosnow, 1991). The aggregate reliability estimates the proportion of the variance in the mean of the four scores that is due to true scores, and its formula follows the same logic as the Spearman-Brown prophecy formula (Sax, 1989, pp. 265-266; Rosenthal & Rosnow, 1991, pp. 51-54). The aggregate reliability is higher than the mean of pairwise inter-rater reliabilities for the simple reason that employing multiple judges and adopting their mean is a more reliable scoring procedure than relying on any two potentially idiosyncratic individuals serving as raters.

Discussion

Episodes that may be categorized into more than one category were sometimes a problem. For example, the difference between "non-inctructional" and "teacher to student" was not always easy to discern. An example from the tape was a conversation that began with asking about materials being mailed which is a "non-instructional" event; ended with a discussion of how the materials should be used when they arrive, a "teacher to student" event. One judge may decide to categorize the event at the beginning of the transaction, another at the end, and still another may break the event into two separate events. These episodes that do not seem to have precise beginnings and endings may cover more or less time allotment units. Such ambiguity is more evident in some categories, such as "two-way teacher-to-student" and "two-way student-to-student". It is not clear whether these categories are superfluous, or, due to the way this course was taught. Categories such as this could be grouped together, or eliminated, however, it is possible in some classes the only interaction occurring is "non-instructional." In this case, removing the category eliminates important information. The findings suggest when training judges, those categories should be emphasized.

Some sub-categories produced little or no data. For this study, "student to specific location"; "student to group"; and "student to all" were collapsed into an overall student to student sub-category to create more meaningful analysis. "Student to content" had to be eliminated for the lack of data. Does it mean these categories are superfluous? Or, is it only because of the way this particular course was taught? In the former case, they may be eliminated from the instrument or grouped in order not to distract judges. Although the rating process is simplified, removing categories reduces detailed information.

The "content" categories also caused some problems. The episode of watching a video-tape was too obvious to really test the extent of the concurrence among the raters. In the "two-way, student-to-content" sub-category, no episodes occurred. "Content" events may be both difficult to measure and difficult to include in an interactive TV setting. It may be considered a waste of costly air time to show video-tapes, have the students read, or complete written or computer assisted instruction alone. These activities can be done "off-air" while collaborative activities and a discussion of the results "on-air" may increase the amount of interaction time available. More research is needed regarding the concept of "interacting with content" as proposed by Moore (1989).

The overall reliability of this instrument is sufficiently high to warrant its use analyzing interaction in distance education. Care should be taken not to just consider the amount of time spent interacting, but also the richness and patterns of interaction. By using this instrument as a consulting tool, instructional designers may be able to help instructors improve the quality of interaction across the distance.

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Title:

A Socio-Technical Perspective of Instructional Development: A Change in Paradigms

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Traditional ID models lead to an engineering-style linear planning process (see Figure 1) led by technocrats and relying almost solely on expert analysis. The implications of the traditional model are: training and performance requirements occur late in the process; training solutions are often fixes to other broken parts of the system; and human performance personnel are out of the primary decision loop. Increasingly, people find this approach severely lacking in the face of problems that call for customer/user focus, adaptable technical and social designs, and solutions where training is impractical or unaffordable. This brief paper is intended to outline an alternative model based on the *socio-technical* paradigm, which in our view suggests a better match to a growing list of problems in ID.

(INSERT FIGURE 1)

From a socio-technical perspective, the purpose of design and development is to support human behavior, not to create an innovation (Eason, 1988). Innovations are, therefore, situated in settings of complex, unpredictable, multi-form relationships among the various elements that make up a working organization. Successful technology is only one critical component among many that are highly interactive and interdependent with each other. Technology is only one component of what Moran and Anderson (1990) refer to as the "Workaday World" amd Harbour (1992) refers to as the PETT (People-Environment-Task-Technology) model of organizational processes.

From a socio-technical perspective, organizations are comprised of *people* using *technology* to perform specific *work practices* in a particular *environment* (see Figure 2) (Goodrum, Dorsey, & Schwen, 1993).

These four components can be briefly defined as (adapted from Moran and Anderson (1990)): <u>People</u>: The work and learning roles people play, patterns of formal and informal communication, social relationships, and so on. <u>Environment</u>: The physical and cultural aspects of the organization such as open or closed floor plans, virtual environments, organizational values, traditions, and so on. <u>Work Practice</u>: The knowledge, skills, and routines for accomplishing specific tasks associated with the work and learning roles. <u>Technology</u>: The technical computation, communication, and multimedia systems which support the other components.

Each component of the organization is seen as being integrally tied to the other. A change in one necessarily affects a change in the others. Therefore, organizational solutions must be planned taking all into account (Eason, 1988). Instructional developers, therefore, need to deal with creating and investigating *whole* environments, not just the technological, pedagogical, or training innovations of specific interest.

(INSERT FIGURE 2)

(INSERT FIGURE 3)

The planning process (see Figure 3) is a concurrent one that brings human performance people, as well as others who are often out of the decision loop, fully into the process. In the traditional model, by the time the decision comes down to the training and performance people, the design my already be flawed with no chance for redesign, requiring the fitting of the people and organization to the innovation, versus the innovation fitting the people and organization.

Similarly, the socio-technical design team (see Figure 4) includes *all* of those people who have an invested interest in the success of the innovation. The key people included here are the direct and indirect users of the innovation. These are the people who must live with the consequences of the innovation long after the designers, implementers, and project managers have disappeared. Teachers and students in school and supervisors and workers in the workplace should, from a socio-technical perspective, be included from the very beginning of the decision process as well as the innovation design process.

(INSERT FIGURE 4)

Within the large scale development project there are many small scale design processes which go through a full problem solving process of iterative design (see Figure 5), for purposes of exploring options and developing a fuller understanding of the requirements.

The creation of prototype versions of proposed socio-technical solutions are for the purpose of evaluation and refinement of specifications. This allows users and others to have a realistic experience for basing assessments and revisions. Conceptual prototypes allow for early user reaction, feedback, and projection of consequences. 'Working' prototypes allow for hands-on use in the context of the task. Alternative prototypes in the early stages of development assist the team in keeping an open mind and not locking into a particular, potentially flawed, design too early.

(INSERT FIGURE 5)

In summary to this point: Development occurs iteratively, allowing for concurrent problem definition (i.e., analysis), innovation prototype creation, and evaluation. Development is conducted by a cross-functional team comprised of people who have a stake in the product's success. Development does not focus solely on the creation of technology. To the contrary, the focus is on the work practice, the relationships between people, the social and cultural environment; the technology should support the changes in the other three areas.

This process is not a one-time occurrence. Rather, it goes through successive phases (see Figure 6), each of which allows for a certain level of evaluation as well as a projection of additional levels.

(INSERT FIGURE 6)

Each phase can be described with a primary *activity*, *product*, and *evaluation output*. During the initial phase, a team *brainstorms* a *vision* and can gather data on people's *projections* concerning how stakeholders will react to the innovation, how usable the innovation might be, what performance improvements or behavior changes might result, and what impact that might have on the core business of the organization (e.g., profitability of a business, teaching and learning in schools and universities).

During the second phase, a team *shows* alternative *idea sketches* of the innovation and can gather *reactions* as well as projections of the usability, performance improvements and bottom line results.

In the third phase, the team creates opportunities for *hands-on* use of one or more partially functioning *mock-ups*, observing the innovation's *usability*, and also gathers reactions as well as projections of foreseen performance improvements and bottom line results.

In the fourth phase, the team *pilot tests* one or more alternative *working prototypes*, observing performance improvements or changes in behavior, gathering additional and more refined information on the innovation's usability as well as users' reactions, and projects bottom line results.

In the fifth phase, the team *fully implements* the completed design of the innovation, understanding that this may be only the first implementation of an *evolving vision*. One can now gather data on *bottom line results* on the core business of the organization, while gathering additional information on performance improvements, usability, and users' reactions.

The scope of a project will more likely increase than narrow as the relationships among the four components of the socio-technical system are better understood and the solutions/innovations are capable of being more substantively evaluated. Alternative prototypes, tested against one another during the early phases, will combine into a single design for full implementation.

There is also an emphasis on developing for organizational change, understanding that solutions must evolve over time. For people can only deal with so much change at one time, whether on the job or in the classroom. Furthermore, one can implement revolutionary change, but the impact cannot be predicted. Evolutionary change is required in order to have a chance at understand the resulting effects.

The successive phases of development -- each with concurrent problem analysis, development and evaluation -- become increasingly concrete. The team may progress through phases quickly, depending on a) the scope of the change, b) how informative the evaluation outputs are, c) how closely prototypes fit the needs of the individuals and organization, d) how much development from scratch is required versus use of existing or off-the-shelf materials, e) the commitment of the client and client organization, and f) how well consensus is negotiated.

Currently, in our view the socio-technical approach to instructional development is based on seven fundamental principles:

1) Socio-Technical Systems Comprised of People. Environment, Work Practice, and Technology

2) A Focus on Organizational Change, not Technology

3) A Design Team Consisting of All (or representatives of all) Stakeholders throughout the Process

4) Iterative Cycles of Design

5) Creation of Alternative Prototypes

6) Concurrent Analysis, Creation, and Evaluation Becoming *Concrete* Over Time

7) Evolutionary not Revolutionary Phases of Development

To date, our own work in developing, applying, and learning from a socio-technical approach has included a number of projects, ranging from individual instructors creating lecture presentation materials to large companies in the process of changing the way thousands of employees work and learn. In every case, the more we worked from a socio-technical paradigm, the better we were able to foresee and resolve many barriers as well as make more efficient and effective progress in the design, creation, and implementation of innovations. The socio-technical paradigm provides for ourselves an approach to development where we can still apply the skills and knowledge from areas such as instructional strategies, learning theory, etc., which in and of themselves do not provide a framework that leads to successful use. We also attempt to continuously reflect on our mistakes and failures (as well as our successes) in adjusting and refining the approach.

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Note: For a background and description of some of the projects from which this work evolved, see the November, 1993 issue of *Educational Technology*, Special issue: Articles on enriched learning and information environments.

FOR FIGURES SEE APPENDIX B

Title:

The Effects of Varied Visual Organizational Strategies within Computer-Based Instruction on Factual, Conceptual and Problem Solving Learning

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Abstract

The purpose of this exploratory study was to examine the effectiveness of learner manipulation of visuals with and without organizing cues in computer-based instruction on adult's factual, conceptual and problem solving learning. An instructional unit involving the physiology and anatomy of heart was used. A posttest-only control group design was applied with 74 undergraduate subjects from a large eastern University. Subjects were randomly assigned to one of three treatment groups -- Learner Generated with Cued Visual Organization, Learner Generated with Uncued Visual Organization and Control (System-Provided Organization). The dependent variables measured the subject's ability to identify individual parts of the heart using visual cues, retain facts and definitions, reproduce key information and utilize the information for problem solving. No differences were found between the Control and the Learner-Generated Groups. For the problem solving measures, the Learner-Generated with Cued Visual Organization group scored significantly higher than the Uncued Visual Organization group. Subjects in the control group also scored significantly higher than the Uncued Visual Organizational group for problem solving. In post hoc comparisons, trends were found with the Cued Visual Organizational group scoring significantly higher than the Uncued Visual Organizational group for the identification, problem solving and drawing measures.

INTRODUCTION

Technological advances have evolved computer-based instruction into an increasingly visual and engaging learning system. With these advances, new strategies of presenting information within computer-based media have emerged. The graphical user interface of current computer technology and development software allow for the manipulation and movement of visual elements. Providing opportunities for active learner manipulation of visual elements on the screen may demonstrate and encourage generative processing of information. But, is the mere manipulation of visuals sufficient to increase cognitive processing or should some type of cueing strategy be provided so that the learner can actively construct visuals into a meaningful arrangement? Theoretically, generative learning strategies support this notion. Generative learning strategies have shown that interaction with and selective attention to sensory information may establish links to memory in constructing meaning (Wittrock, 1974a, 1974b, 1990).

Manipulation of individual visual elements may be more effective when learners create their own visual organization versus an organization or cued visual structure provided by the system. Activities to encourage learner's organization or ordering of the information can activate the encoding process which builds connections between thoughts, develops a cognitive organization for ther and integrates relevant information in working memory with a learner's prior knowledge (Weinstein & Mayer, 1984).

Empirical evidence to support the use of a learning strategy for manipulating individual visual elements onto an organizational framework in CBI is lacking in the literature. Numerous studies exist involving the use of visuals within instruction (e.g., Dwyer, 1978; Guttman, Levin & Pressley, 1977; Levin, 1986). However, the manipulation of visual elements with and without organizational cues in computer-based instruction is an instructional strategy only recently possible through current technology, and was investigated in this study.

Visuals

The use of visuals within instruction has been the subject of a large body of research over several decades. Many studies conducted with children have dealt with the recall of information from illustrations that support aural or print instruction (e.g., Guttman, Levin, & Pressley 1977; Levin, 1986). Levin (1989) has concluded from this accumulated literature that pictures presented in conjunction with text improve comprehension and memory over information presented by text alone.

Related to this body of research, Guttman, Levin & Pressley (1977) conducted a study involving oral prose and visuals. After reading a story, they presented visuals with missing pertinent information (or partial pictures) to kindergartners. Contrasting this treatment with the presentation of the complete visuals, the experimenters found that the incomplete pictures did not have an effect on learning. The presentation of incomplete visuals devoid of critical content may be more powerful through the construction of a visual organization.

The manipulation and organization of visuals has been examined through the illustration of stories with cutout characters. Lesgold, Levin, Shimron, and Guttman (1975) conducted a series of experiments to examine the potential benefits of pictorial elaboration with young children. Interestingly, the researchers found that experimenter-constructed illustrations provided significantly improved acquisition of information in comparison with learner-constructed illustrations. The construction of the cutout figures by the experimenters may have provided a type of organization not present when the children constructed their own representations. These results suggest a possible connection between experimenter-provided organization of visuals and increased cognitive processing.

Levin, Anglin and Carney (1987) conducted a meta-analysis of these studies involving prose learning and visuals. Based on this review, recommendations were formulated concerning the use of visuals within prose instruction. One principle presented includes that the function of visuals or pictures should be based on the needs of the learner, the instructional objectives and materials used. Reiber (1994) interprets this principle suggesting that the ".... the function of any visual must be consistent with its intent" (p.141). Recommendations such as these point toward the essential role of visuals within instruction and that caution must be taken that they not detract from the content and serve a functional purpose for learning.

Visuals and Computer-Based Instruction

In contrast to studies conducted with visuals and text, recent investigations involving visuals within computer-based instruction is a fairly unexplored area. In response, Park (1991) has called for an increased research effort concerning the appropriate selection of information-representation forms for instructional computing. Existing research has included comparisons involving visual presentation modes (Calvert, Watson, Brinkley & Penny, 1990), static vs. dynamic display of graphical information (King, 1975) and the use of animation within instruction (Reiber, 1990). The results of these studies were mixed and involved various conditions of presentation mode, levels of learning and findings. McCuiston (1991) found that the use of dynamic visuals within a college-level computer-assisted lesson on descriptive geometry concepts facilitated spatial ability skills, but did not increase content acquisition. The college students scoring in the lower 25% of the content acquisition test who viewed static visuals achieved higher scores than those who viewed a dynamic presentation. These conclusions, however, are based on computer manipulation of visuals and cannot be extended to the learner manipulation of visuals.

Visuals and Cueing Strategies

Dwyer (1978) has also substantially added to the literature by investigating the use of visuals and expository text within instruction. He maintains that for optimal learning to occur with visualized instruction, the learner must be able to "...locate, attend to, and interact with the relevant instructional stimuli while ignoring or minimizing the effect of the competing irrelevant stimuli" (Dwyer, 1978, p. 156). Cautioning against the use of complex or realistic of visuals within instruction, Dwyer advocates the use of cueing to highlight the essential information from other types of stimuli. Reviews of these studies conclude that visual presentation of information should attract and sustain the learners attention without adding unnecessary attention-gaining devices that may impede learning. These conclusions suggest that involving the learner with the visual (i.e., by selecting and moving it) may optimize learning.

The use of visual cueing strategies has also been shown to be effective within computer-based instruction. Canelos, Dwyer, Taylor, Belland, and Baker (1989) found the use of imagery cues and attention directing strategies to be effective with adult learners. Presentation modes and cueing, as well as the use of partial pictures and system provided organization of visuals have been shown to be important instructional strategy variables to be considered in the design of visual instruction.

Generative Learning Theory

The generative process of learning holds that it is necessary for the learner to have an active, participatory role within the instruction in order to construct and interpret individual meaning of information. Wittrock's (1974a, b) construct of generative learning defines the purpose of learning as the generation of abstract and distinctive, concrete associations between prior experience and incoming stimuli. Research in this area has primarily been carried out with textual information such as word lists, word pairs, sentences, headings, word problems (e.g., Wittrock, 1990; Wittrock & Carter, 1975), but has also included some studies involving visual elements.

Linden and Wittrock (1981) taught children to generate interpretations of paragraphs and create images relating sentences to one another. In addition, children were taught to generate relations between stories they read and their own experience. With time held constant, the results indicated about a 50% increase in comprehension attributed to the generative activities (Linden & Wittrock, 1981). In a related study with 5th grade students, Bull and Wittrock (1973) found that drawing pictures of vocabulary words enhanced recall of definitions among the subjects one week later. Mode of generation did not seem to be the primary factor in these studies. The important variable, however, was the encouragement and facilitation of processing by the learner. The learning environment should facilitate some type of generation within the learner. Generating relationships between the parts of the information may build stronger connections in the learner's mind compared to simply reading the material.

Direct Manipulation and Organizational Strategies

Generative activities can include various types of interaction with instructional content including paper and pencil activities, and manipulating concrete objects (Bull & Wittrock, 1973; Bennett, 1991). Current computer technologies are also well-suited to providing generative experiences through the direct manipulation of on-screen visuals. Direct manipulation refers to a type of computer interface in which learners use a mouse to manipulate spatially organized objects on the screen (i.e. click and drag) (Whiteside, Wixon, & Jones). This type of interface may potentially contribute to learning. Schneiderman (1992) contends that physical, spatial, or visual representations of information appear to be easier to retain and manipulate than textual or numeric representations. Carrol, Thomas and Malhotra (1980) found that students who manipulated spatial representations were faster and more successful in problem solving than subjects given similar problems without spatial representation.

The direct manipulation of computer visuals by the learner must incorporate an instructional purpose in order to constitute a viable learning strategy. The movement of visual elements toward an intentional goal is a strategy to involve the learner for the purpose of increasing cognitive processing. Learning strategies assist the learner in selecting, acquiring, constructing and integrating new information (Weinstein & Mayer, 1986). Organizational learning strategies include ordering or grouping items which activate two parts of the encoding process --construction and integration. Construction involves a process that builds connections between thoughts and develops a cognitive organization for them, while integration includes connecting new information with prior knowledge (Weinstein & Mayer, 1984; 1986). Learner manipulation of on-screen elements into a target visual organization may support the learner in the process of connecting information about the individual visual items to other items in long term memory. Jonassen (1988) states that organizational learning strategies can assist in the structuring and restructuring of the learner's knowledge base by clarifying how the concepts relate to one another.

PROBLEM STATEMENT

The purpose of this study was to explore how the active, spatial manipulation of visual elements by the learner and the placement of them into an organizational framework can assist in increased cognitive processing and achievement. Specifically, this research drew upon generative processing theory to investigate the effects of two forms of visual organizational strategies (cued and uncued) on four types of learning objectives. It was hypothesized that those who participated in the cued and uncued organizational treatments would become more engaged in the content and would achieve significantly higher scores on the posttests than the control group. It was also hypothesized that those students in the uncued organizational treatment group would require a higher level of attention and cognitive processing and thereby recall more facts and concepts and solve more problems than those who were provided a cued organization.

METHOD

Subjects

This study involved 74 volunteer college students enrolled in an undergraduate statistics course at a large eastern university. Individuals were randomly assigned to one of the three treatment groups. No attempt was made to group the subjects by ability or reading level, however, previous knowledge of human physiology was assessed prior to instruction.

Materials

The content of the lesson used in this study was adapted from paper-based text materials (2000 words) developed by Dwyer and Lamberski (1977) concerning the physiology and function of the human heart. The lesson includes factual, conceptual and problem solving information covering the parts of the heart, circulation of blood, cycle of blood flow and blood pressure. The basic lesson was re-created in a computer-based instruction format programmed using Authorware Professional for the Macintosh. A pretest consisting of 36 questions on the basic physiology of the human body was initially given to the students to assess the effect of prior knowledge on posttest scores.

Instructional Treatments

Three treatments were developed for this study which contained identical instructional content while varying the levels of manipulation and visual organizational cueing.

Learner-Generated Cued Visual Organization. Subjects in the Cued Visual Organization group were required to move (click and drag) a visual graphic of a part of the heart from the left side of the screen onto a frame of the whole heart containing tan outline of the primary parts. This outline served as an organizational guide for the correct placement of the visuals (see Figure 1). Subjects received instructions to place the part in its correct location on the outline of the heart. A pre-lesson exercise was provided to familiarize subjects with mouse control and to allow for practice with the manipulation and placement of visuals.

No text was presented prior to the movement, forcing the learner to first locate the correct position on the heart. After successful placement of the part, textual information describing the part, its location, function and/or relationship to other parts of the heart appeared next to the visual. If the part was not placed correctly, it would automatically return to its original position in the left hand corner of the screen, providing animated negative visual feedback. The subject was required to place the visual again until correct.

Insert Figure 1 about here

Learner-Generated Uncued Visual Organization. The Learner-Generated Uncued Visual Organization treatment group utilized a similar strategy. After an identical pre-lesson exercise, the Uncued Organizational treatment group was required to move the parts of the heart onto a frame of the whole heart containing no outlined visual organizational guide concerning the parts' location. As the lesson progressed, the visual of the heart was constructed part by part encouraging the learner to actively build the visual connections from the parts, their location and their function within the heart to the textual information (see Figure 2). As in the Cued Visual Organization group, when not placed correctly, the part would automatically return to its original position on the screen and the lesson would not advance. As with the Cued Organization, after successful placement of the part, textual information describing the part, its location, function and/or relationship to other parts of the heart appeared next to the visual.

Insert Figure 2 about here

Control (System-Provided Entire Visual). The control group presented the lesson content via text and graphics in a page-turning format with no learner manipulation of visuals. Subjects viewed graphics with specific parts of the heart highlighted and their corresponding textual information. The only action required by the learner was proceeding to the next frame.

Dependent Measures

The posttest was a pencil and paper test consisting of a total of 90 questions measuring different types of educational objectives. The identification test consisted of twenty multiple-choice items requiring students to identify numbered parts on drawings of the heart. The terminology test consisted of twenty multiple-choice questions designed to measure knowledge of facts, terms and definitions. The comprehension test consisted of twenty items and tested the ability of the student to use the information to explain another phenomenon occurring simultaneously. The drawing test required students to reproduce a diagram of the heart and place numbers of the twenty parts in their correct positions measuring the student's ability to construct, and/or reproduce items in their appropriate context. Finally, a problem solving test of ten multiple choice questions tested the students' ability to transfer understanding of the information and to solve problems related to the content. The following reliability coefficients (KR-20) were recorded for each of the tests: .93 total test, .82 Identification, .79 terminology, .80 comprehension, .83 Drawing, and .583 problem solving. A paper and pencil pretest was also conducted prior to the instruction. The pretest consisted of 36 questions on human physiology.

Procedures

The study was conducted in one of the University computer labs. As the students arrived they were randomly assigned to one of three treatment groups. After a brief presentation, the students individually took the pretest followed by the instruction. Upon completion of the instruction, the posttests were immediately administered in the following succession: drawing, identification, terminology, comprehension and problem-solving tests. Individualized instruction was conducted via computer while the pretest and final testing were delivered in traditional, paper and pencil format.

Research Design and Data Analysis

This study encompassed a post-test only control group design controlling for prior knowledge. The variables manipulated were learner-generated manipulation of visuals with cued organization and learner-generated manipulation of visuals with uncued organization and control (system-provided organization).

Separate one way analysis of covariance (ANCOVA) was used to test for significant differences among the three groups for each criterion measure: drawing, terminology, identification, comprehension, problem solving and total test. A .05 alpha level was selected to determine significance among the three treatments. Due to the exploratory nature of this study, post hoc comparisons were conducted to analyze the differences between groups for all measures.

RESULTS

Descriptive results for achievement showing the means adjusted for prior knowledge are reported in Table 1. Total score approached overall significance $p>.05$ ($F(70,2)=3.10$, MS=288.74, MSE=93.15). Examining the subscores revealed a significant effect for problem solving $p<.05$ ($F(70,2)=3.58$, MS=12.49, MSE=3.49).

Since the means for the cued visual group were higher for each dependent measure, exploratory post-hoc comparisons were run between groups for each. Based on this data, an interesting trend was discovered. For the identification, problem solving and drawing tests, the cued visual treatment scored significantly higher than the uncued visual treatment, but not significantly higher than the control group. For problem solving, the control group also scored significantly higher than the uncued group. The remaining two tests, comprehension and terminology were not significantly different at p=.068, 063, respectively.

DISCUSSION

This exploratory study investigated the relationship of the direct manipulation of visual elements toward an organizational framework, providing varying levels of cued information and achievement on four types of learning objectives. The results suggested some interesting conclusions. Of primary importance was that fact that in no case were the scores on either treatment group involving manipulation of visuals significantly greater than the control group which provided the visuals. These results, although theoretically somewhat unfounded, support the findings of Lesgold, Levin, Shimron and Guttman (1975).

Although it was expected that the manipulation of visual elements would be more effective, especially when learners created their own organization, this hypothesis was not supported. Learner-generated uncued visual organization was perhaps too cognitively demanding thus exerting a detrimental effect on achievement. Given no visual structure, the students expressed difficulty inferring the locations of the parts of the heart. The majority of their cognitive processing, therefore, may have been utilized by unstructured guessing, leaving very little attention available to associate textual information with the visual.

The second interesting and important finding of this study, supports the inclusion of visual cues when incorporating a generative learning strategy. In post hoc comparisons for three of the dependent measures (Identification, Problem Solving and Drawing), the cued visual organization group scored significantly higher than the uncued visual organizational group. These results lead to some interesting speculation. When little or no information is provided in a generative strategy, learners may become frustrated and inattentive (reverting to trial and error guessing) when required to make a specific right or wrong response. The learner cannot construct his or her own organization since a specified one is already expected. The generative nature rests solely in the movement, but not the placement of the visual. With the system cues present, locating the visual may have reduced frustration and enabled the learner to concentrate on the part's label and location.

Another speculation regarding these findings is related to the three types of dependent measures which were significant. The generative activity required the learner to move visuals which were labeled onto a framework, closely representing the cognitive processing required on the tests. The most interesting finding was the impact of this activity on problem solving. Upon closer examination of the problem solving questions, it became quite evident that without being able to identify the parts mentioned (i.e., right atrium, tricuspid valve, vena cava, etc.), the learner would not be able to understand the question. While not directly supporting the notion that generative learning or cueing enhances problem solving, it does support the learning of prerequisite knowledge necessary for problem solving.

While the generative nature of manipulating the visuals showed no significant main effect, the combination of this type of activity and a cued organizational framework displayed an interesting trend. This strategy supports strengthening the organizational cues when combined with the manipulation of visuals. In each case, means were higher for the cued organization, although not significantly, than the control. The combined strategy points toward a potentially integrated generative strategy through which the learner interacts with sensory information. Manipulating the part in addition to targeting a visual structure may provide a cueing strategy and assist the learner in cognitively organizing the information.

This study, while exploratory in nature, provided valuable information in regard to the generative manipulation of visual elements into an organizational framework. Distinct from traditional system-provided animation, this strategy capitalized on the direct manipulation interface capability of authoring software. Yet researchers and designers must consider the effects of this strategy on learning and further research questions remain. How much visual organizational cueing is necessary in combination with manipulation to encourage optimal cognitive processing by the learner? Should textual information be given prior to the movement of the visual so that learners are provided with more information with which to organize the visuals? Should the learner create his or her own organization without a framework or outline, based on previously presented textual information? What other factor may be potentially masking the generative effect? The results and positive trends found in this study warrant further research in the area of learner-generated manipulation of visuals and cued organizational frameworks.

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Table and Figure Captions

Table 1
Adjusted Means and Standard Deviations

	System-Generated Organization	Learner-Generated Organization	
		Cued	Uncued
Identification	12.98	14.11	12.49
Terminology	11.99	12.79	10.87
Comprehension	10.78	12.34	10.44
Problem-Solving	4.77	4.72	3.53
Drawing	13.54	14.56	12.07
Total Score	40.53	43.95	37.32

Covariate is pretest score

Table 2
Analysis of Covariance

	DF	Sum of Squares	Mean Square	F Value	Significance of F
Identification	2	35.86	17.93	2.69	.075
Terminology	2	48.63	24.31	1.73	.185
Comprehension	2	52.42	26.21	1.96	.148
Problem-Solving	2	24.98	12.49	3.58	.033**
Drawing	2	80.93	40.47	2.58	.083
Total Score	2	577.48	288.74	3.10	.051

Covariate is pretest score

** Significant at the .05 level

Table 3
Significance Levels
Post-Hoc Comparisons

	Control vs. Cued Organization	Cued Organization vs. Uncued Organization	Control vs. UncuedOrganization
Identification	.151	.026**	.518
Terminology	.480	.068	.318
Comprehension	.159	.063	.754
Problem-Solving	.921	.024**	.028**
Drawing	.395	.027**	.218
Total Score	.240	.015**	.267

Notes

1. Legend

   Control = System-Provided Organization

   Cued Organization= Learner-Generated Cued Visual Organization

   Uncued Organization = Learner-Generated Uncued Visual Organization

2. Covariate is pretest score

3. ** Significant at the .05 level

4. Not all analyses of variance are significant at the .05 level.

Title:

Information Landscapes and Exploratory User Interfaces: Redesigning to Improve Learning Outcomes

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Abstract

The concept of information landscapes has been a constant theme in the development of interactive multimedia packages. For the user interface to this information to be effective and efficient consideration must be given to the cognitive load placed on the user. Improvement in learning outcomes can be supported by allowing students to focus on metacognitive processes as a component of performance support. The renewed interest in student-centred learning environments and recent constructivist approaches to learning place responsibility for learning firmly on the shoulders of the student, but this responsibility can only be taken on when appropriate support is available and the necessary skills can be developed with students. This paper examines these issues in the context of the development of a CD-ROM based interactive multimedia package, 'Investigating Lake Iluka', and reviews evaluation of the learning outcomes from initial use of the package.

Over the last decade there has been a significant shift in emphasis in curricula generally. Learning basic facts and definitions from textbooks has become less important than the application of knowledge in daily life and the development of higher order thinking skills such as problem-solving, critical thinking and decision making. In many countries this shift has been developing in parallel with national programs which are emphasising a move toward a more literate populus. The quality of the learning outcomes of a nation's education and training systems play a central role in determining the future levels of economic and social development. Many in-house industry training programs have realised that the focus should be on effective performance and problem solving rather the ability to remember facts and repeat theory without real understanding about its applicability

Recent curriculum documents in many western countries emphasise the skills of investigation, reflection and analysis to generate or refine knowledge. The appeal of cognitive process training to support this development is obvious, and it seems far more efficient to provide the student with general-purpose problem solving than instruction on specific solutions to specific problems. Metacognitive support provides a key to efficient higher order learning.

There has been considerable controversy, which will no doubt continue to simmer, over the clarification of constructivism as opposed to subjectivism. The constructivists argue that learning outcomes depend on:

- the learning environment.
- the prior knowledge of the learner.
- the learner's view of the purpose of the task.
- the motivation of the learner.

The process of learning involves the construction of meanings by the learner from what is said or demonstrated or experienced. The role of the teacher is one of facilitating the development of understanding by selecting appropriate experiences and then allowing students to reflect on these experiences.

To the learner, the constructivist learning experience may not look welcoming. It may seem daunting and complex to those who feel ill-prepared for such creative freedom and choice of direction. Often constructivist learning situations suddenly throw students on their own management resources and many fend poorly in the high cognitive complexity of the learning environment. Cognitive support tools and the explicit acknowledgment of the double agenda of metacognitive self-management and learning can help. The scaffolding and coaching of the cognitive apprenticeship model offer another solution.

Multimedia Design in a Contructivist Framework

A number of multimedia design models have been developed which illustrate the combination of complex learning environments and which also give students their own real control over their learning environment. Our model (Figure 1) is based on a more organic and iterative approach than traditional instructional systems design. Phase one takes the basic information derived from a needs assessment and converts it into a description of the Project space—the information which is to be included in the materials, how it is structured, what the target audience understands about the information and how it might be structured for the audience. A possible structuring device might a concept map of the ideas and links that are to be included in the project.

The second phase reviews the basic description and seeks to link the elements through an appropriate instructional or presentation strategy. It also seeks to identify metaphors which help both the design team and the final presentation of the information structure. The outcome of the second phase would be a formal description such as a design brief. The detail would enable the reader to understand the underlying knowledge structures and the ways it is proposed to link them conceptually and intuitively.

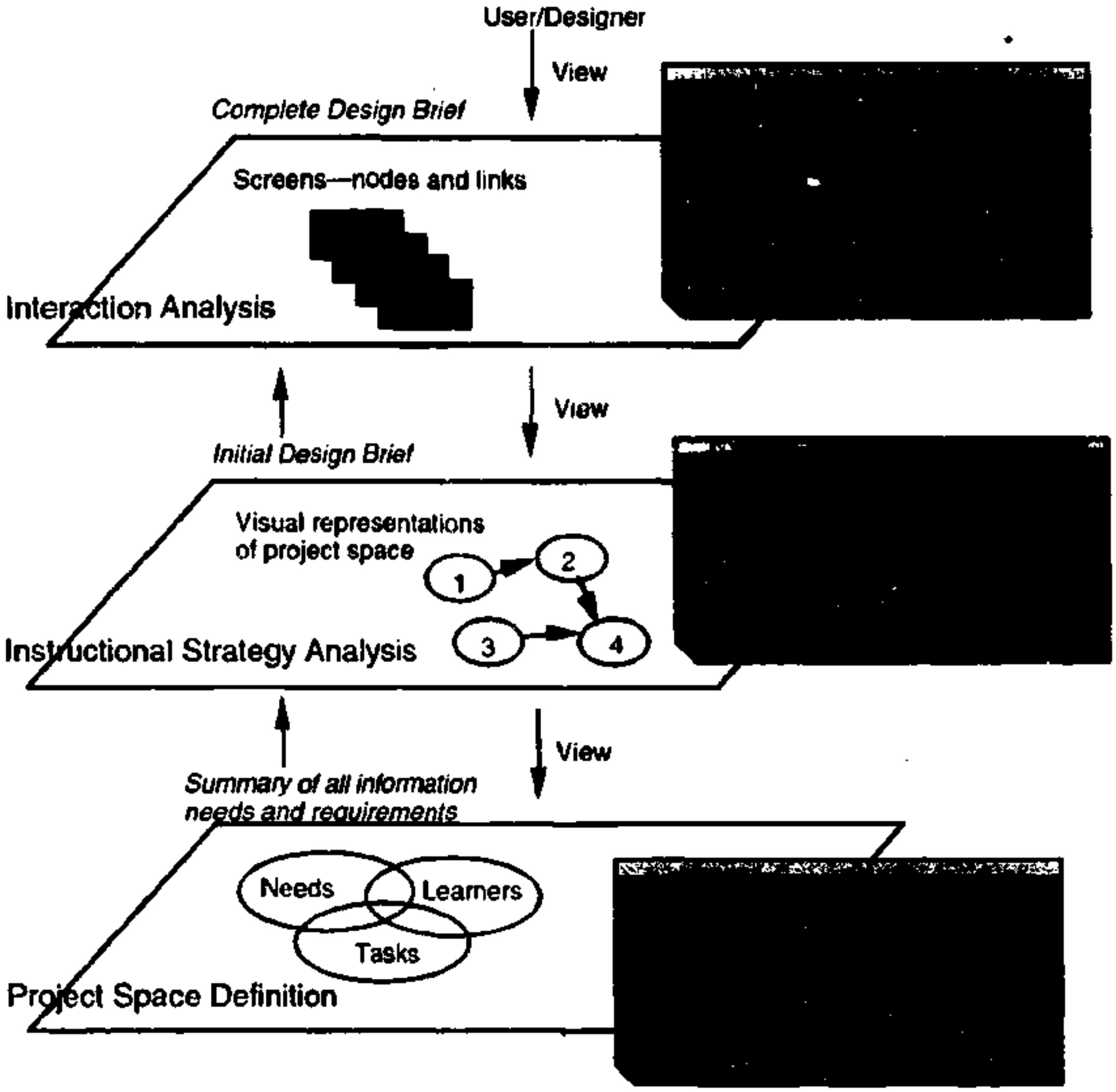

Figure 1: The design process used for this interactive multimedia package.

The third phase is a third pass at the same material, this time with the express goal of linking the design ideas into a potential interaction structure. One output of this phase would be an interactive mock-up of the interactive materials using such tools as HyperCard or Toolbook to illustrate not only static display of information but also the graphical and visual metaphors used to create understandable links. The information included in this prototype may include visual, motion, static graphics, sound and data landscapes as appropriate to the concept under development.

Each interaction consists of a node point which forms the basis of the interaction, a set of options which provide links to other nodes or additional information attached to the current node. One of the links must relate to earlier travelled or preferred paths through the materials, and each choice must inform the user about what is likely to occur as a result of a choice. These can translate into the traditional concept of results (correct or incorrect) or information feedback choice, but should also include simple feedback elements such as confirmation of choice (feedback that a button has been selected) or performance support enhancement such as suggested hints, or revision of the underlying concept/principle which might be employed to make the choice. Depending on the instructional strategy chosen another element might include the concept of duration, either time or the limit of options based upon previous choices or paths taken. What constitutes each of these functions and what they create in terms of cognitive skill development for the user are determined by their physical manifestation in terms of navigation options.

The complex integration now possible with a variety of hardware and software combinations raises problems for the user in ti. ·* multiple paths are possible to the same or different end-points. Learners are faced with the need to understand what learning possibilities might be available from where they are in a multimedia learning environment. When a student can branch down multiple paths and rapidly change the direction and focus of the learning sequence, there is possible interference with effective learning through the inappropriate application of information by the learner to their internal schemas. Other concerns include disorientation with location, cognitive overload when following several trails or trying to remain oriented on their goal, flagging commitment and a poor presentation rhetoric or metaphor.

The potential of both the technology and learning strategies to incorporate the recent initiatives in science education have lead to the development, production and evaluation of a particular interactive multimedia CD-ROM based package called Investigating Lake Iluka. The package has been designed to facilitate access to the information landscape through the learner's choices by:

- supplying accessible and useable tools to allow access to the scope of supporting interactive multimedia resources (eg. video and graphic representations of concepts)
- providing an adaptive navigation system and coherent information metaphor which requires little or no explanation.

Investigating Lake Iluka has been based around an ecology simulation and employs a number of different interface metaphors in presenting the materials to the user. The package is based on the concept of an information landscape that incorporates the biological, chemical and physical components of a range of ecosystems that make up a coastal lake environment. The user is given some problem solving strategies to investigate this information in a variety of ways using the range of physical tools provided. They can collect biological, physical or chemical data as well as media information and 'construct' their own understanding of the basic ecology concepts embedded in the package. This facility has the potential to increase student understanding and control of their learning through control of their learning environment. Inquiry and problem-solving techniques have been embedded in the package through case studies of ecological scenarios presented to the user via media reports of problems posed directly to the user. Each scenario can be investigated using the package tools. It is expected that users will develop a broad array of scientific investigation skills using this realistic simulation. One of the unique features of this package is the facility for users to generate their own customised report which can be refined and presented independently of the package.

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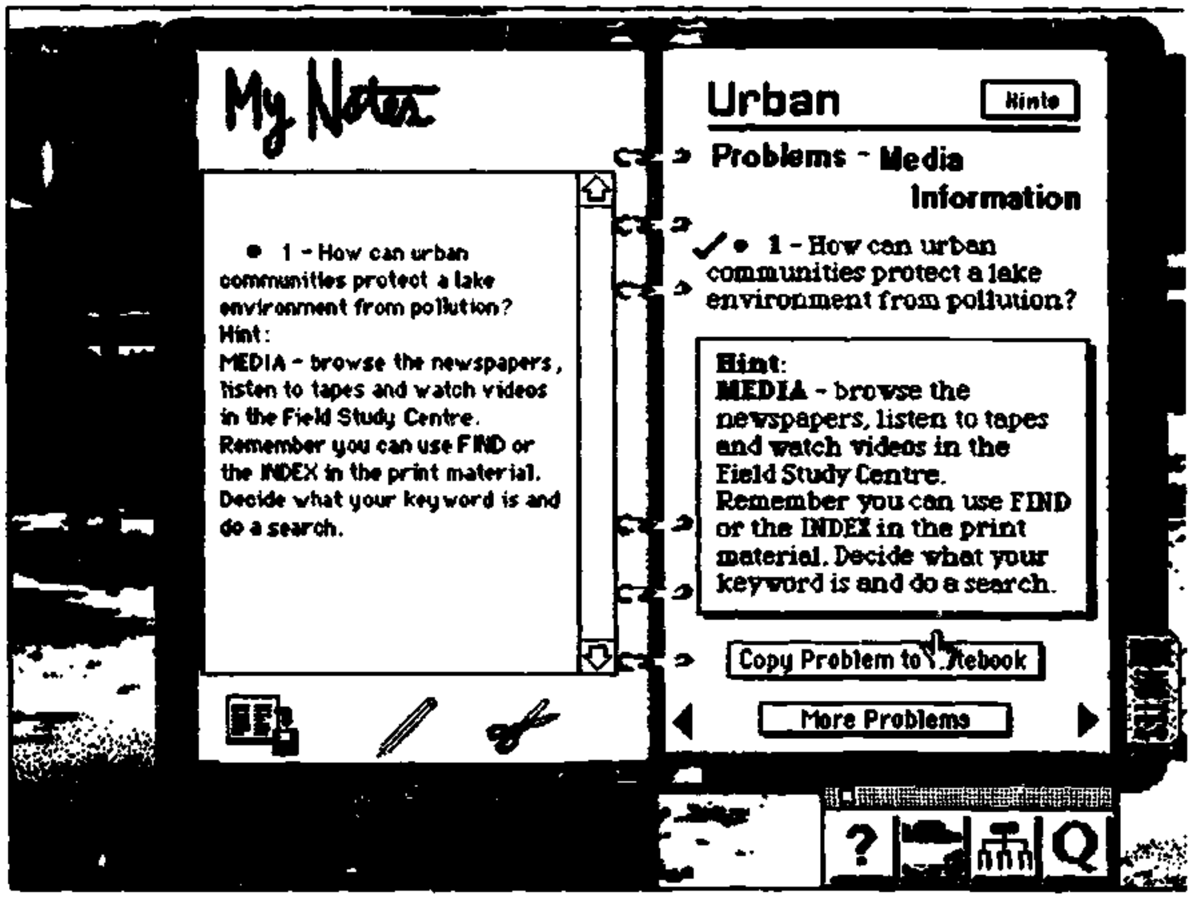

Figure 2: Investigating Lake Iluka where the user is presented with a problem and a set of suggestions to help them solve a problem not simply choose an answer to prepared multiple choice questions. (Program from Interactive Multimedia Pty Ltd, Old Parliament Hourse, Canberra)

Metacognitive Support in Investigating Lake Iluka

Paris & Winograd (1990) have defined metacognition as knowledge about cognitive states and abilities that can be shared among individuals, including the affective and motivational aspects of thinking. Cognitive strategies can be addressed directly in the structure of an information landscape. The affective and motivational aspects of metacognition are embedded in the interface.

The problem solving nature of Investigating Lake Iluka lends itself to metacognitive support through a number of means:

- cognitive self-management: Students should form good plans, use a variety of strategies and monitor and revise ongoing performance. The notebook within Investigating Lake Iluka allows the student to collect and manage information from a variety of sources. Transcripts are not provided for video and audio material as this is not consistent with how students would process material in these media outside the package. They must organise and edit what is potentially an overload of information, within the broad constraints of an open-ended problem.

The role of the teacher is vital to the editing process at this stage. Students need to be encouraged to be critical in appraising the relevance and credibility of material. They also need to be guided through the development of a report on the problem posed.

- provision of prompts: Hints accompany the problems posedwithin each ecosystem. Students choose to access these hints, which guide them to explore various areas of the landscape or measure certain physical, chemical or biological characteristics with the toolkits provided.

  The role of the teacher is to ensure students record data collected in a systematic and scientific way.

- experience of experts: the reference book and a number of media reports give the student the chance to gain from the experience of those who specialise in ecology.

  The role of the teacher is to help students evaluate issues of hidden agenda, conflict among experts, alternate sources of information and timing of information release.

You need specific and accessible knowledge to solve problems. An information landscape such as Investigating Lake Iluka provides the knowledge base and the knowledge schemas of experts in association with a mechanism for the student to collect, analyse, assimilate and synthesise responses to problems. The ability to see a bigger picture is facilitated by rapid information access and retrieval.

Embedded content independent strategies are general learning strategies incoporated within available content. They support local learning but emphasise strategy transfer as well (Osman & Hannafin, 1992) . A well structured information landscape will provide a template for a range of content. The strategies used in Investigating Lake Iluka could well apply to other tools and other problems.

Evaluation Strategy

The evaluation involved three main approaches. Expert review of the package, one–on–one testing of the prototype materials via video observation and interviews and in-depth case studies, including the verification of the methods for data analysis of complex multi–path data This type of data collection varies from subject to subject and requires the development of special techniques for its analysis and interpretation. Examination of the contents of the incorporated notebook provided some indication of the pattern of student use of both physical and metacognitive tools in the package. This formative aspect of the evaluation was be used to guide decisions on debugging and enhancing the package. A further evaluation strategy was employed with classroom groups of students, who were set learning tasks individually in the multi–media environment, and tracking data collected for analysis.

Analysis of the collected data provides the group with an interesting opportunity for the continued development of techniques to extract the maximum amount of information for feedback to developers and those who commission interactive materials. Simple statistics such as how many users have used the system and the lengths of time they used it are relatively simple to extract, but more sophisticated analyses of how a particular interactive package is actually being used (what sections are being used, to what extent, what is not being accessed, where users exit the system, by what method, and so on) were examined and the results used to provide feedback on the future specifications for new versions and added features.

Expert Review

A naive expert tester had an educational background in Mathematics and Computers. He was asked to review the program and to verbalise his actions and thoughts. He had not been introduced to the program before. His commentary was observed and recorded, and comments and observations were added later.

The naive expert's responses were about two main issues: interface conventions and the conceptual structure and functionality of the package.

Interface Conventions

- Text transfer to the Notebook: he wanted to cut and paste. He tried to "Drag" across the text as a method of 'select all', and felt that a click was not a standard method to cut and paste. "If I click on there (the text) I get the whole the lot. I can't just pull a sentence off". He found the process of editing a little confusing, but realised this was necessary otherwise text would be corrupted by the novice user.
- The recording of measurements in the Notebook: he was confused as to what the pencil was used for. He felt once the hand symbol moved into his notes it should automatically turn into an "I" beam so he could write. The naive Expert wanted to use the pencil to activate this. "I was looking for a tool to turn the hand curser to an "I" bar.

Conceptual Structure and Functionality

Early in the testing process, he realised that he needed the help screens to fully understand how to use the program. After the introduction finished he worked through all of the Help screens. "I now feel that I have an understanding of that".

Within an ecosystem, the naive Expert selected a problem and used the Notebook to review the question and hints. He kept losing the question which was not at the top of the notebook (he had other data in there), as the scroll bar jumped back to the top each time the notebook was opened and closed. This was subsequently rectified by putting the heading "PROBLEM" and a blank line before the problem in the notebook, so it was more easily located.

He found measurement from the image of the ecosystem a wonderful idea, and set himself a problem of investigating wind speed in different areas. It took some trial and error getting measurements into the Notebook as the pencil was turned off and also hidden by toolkit. The naive Expert expressed the desire to establish a transect for measurements to make a set of multiple readings.

Within the media room, the naive Expert noted the video titles didn't give an idea of content and expressed a desire to see these indexed. He opened the notebook while a video was playing and began typing. "That is really good, that you can play the video and enter data."

Having used the program once, the naive Expert felt confident about its use and moved through the media room easily on his second visit while solving a different scenario problem. He was still confused about the pencil, but with trial and error was able to record measurements.

The naive Expert was impressed with the full screen presentation of downloaded notebook contents for editing in a word processor. The main outcome of this evaluation can be summarized as a series of guides to faciltators:

- Work through the Help screens early in the introduction of the program to students.

- The Teacher's manual should emphasise that editing capacity is only on the blue pages of the Notebook and is activated by clicking within the notes.
- There should be a demonstration early in the presentation of the program so students know to turn the pencil on to begin recording measurements.

User Evaluation (Teachers and Students)

Evaluation of the package by teachers and students in the early stages of completion resulted in a number of insights into the design features of the application and also helped to focus the package objectives. The package was introduced to two classes of year 11 students studying the topic of ecology. Extensive observations were made of the student use of the package, as well as their response to the percieved outcomes of its use.

The information landscape structure of the program relies heavily on teachers understanding of the processes that can be practised and the nature of the problems posed in the problem section of the the program. The performance support tools, such as the notebook, are an integral part of the investigative design, but they do rely on good direction by teachers. As an example of this issue one of the inbuilt problems in the Mangrove Ecosystem was posed by one of the teachers in these initial trials—"What types of animals are adapted to this environment?"

After setting up small groups, demonstration of the navigation process and a brief practice with the use of the note book, the class was given the opportunity to use the package over a number of class sessions. The expectation from the teacher was that students would read or collate the relevant information from the package. They would analyse the information and present a synthesised statement of the key characteristics of the animals of the mangrove ecosystem. The students had no difficulty collecting the information via the notebook cut and paste facility, but for the majority of groups, the teacher recieved a complete printout of the "Animal and Plants Book" information for every animal that lived in the mangroves. Thus they have not attempted to analyse the pertinent information and remove sections which did not answer the question. Two groups did attempt some synthesis of the information, but again tended to include rather than exclude irrelevant information.

Interviews with the students and teachers revealed that they did have skills to synthesize such data, and had previously demonstrated these skills, but the students admitted that the power of being able to extract, in electronic form, every bit of information on individual animals from the package compared with the usual practice for such tasks of having to type in their response, or write it out by hand proved to be too attractive not to include all that could be collected. Even after a class discussion of the type of report the teacher was expecting the importance of synthesising information to produce a concise answer, the final reports by students were much longer than the teacher would normally received, if written resources were supplied to the students. After using the complete package, the skills required together with the necessity to edit and tighten reports was seen as an important learning point for students. It was seen as a new skill which up to the availablity of this technology had not been an issue.

Observation of the use of the navigation facilities indicated that the students had little difficulty in finding information in the package that they sought. The "help" facilities were only used occasionally. It is important to note that all the help was provided in three ways. Help on how the package worked and how to use the measuring tools was provided by animated movies of the screens with accompaning explanation. Help on how the package was organised conceptually was provided through a stack map which was allways available and also allow navigational "jumping" between sections. the third form of help was provided through the use of hints and suggestions about where to look to solutions and what might be important concepts, this last form was highly context specific and provided specific ideas related to the learning task.

Other Teacher Evaluations

Information was collected on teachers response to the use of the package with their class and also through use of the package in workshops at local conferences. A number of key issues arose from this trialling. Some of the recommendations were incorporated in the release version, and others will be incorporated in future developments of the package. Most of the key issues raised by teachers were not to do with the internal workings of the package, but to do with the teaching process and organisation of their classes.

Many schools do not have large numbers of machines with CD-ROM facilities. Teachers were concerned that, even though they believed that the package would strongly support the teaching process, lack of technology would reduce the impact, and in some schools mean that teachers would not use the package. A strategy to maximise the availability of the program to students was adopted. Two versions of the program were placed on the CD-ROM, one which relied on the video segments on the CD-ROM disc, and one which did not use the video materials and could be copied to hard disc. Each package then represented a licence to use twenty copies of the hard disc version and one copy of the CD-ROM with the video segments.

The other key issue raised by teachers was related to appropriate teaching and learning strategies. Many teachers wanted guidance on how to organise cooperative group learning, independent research and guided inquiry lessons. It was considered that this teacher support could not be incorporated into the package directly, but was added as part of the printed materials distributed with the package. There was also considerable interest expressed for ideas on how to integrate field trips into use of the package. Ideas on use of the package before visiting a field site and on following up the field trip were considered to be important to add to the support materials.

The teachers involved in the initial class testing of the program were particularly excited about their students use of the notebook concept and were surprised at the ease with which their students used this inbuilt tool. However, they did find that students took notes and saved their notes effectively at the end of each session, but had difficulty determining what data they had previously collected when they started a new session. Teachers proposed that previously saved notes should be able to be read back into the package so that students could more easily continue their investigation. This feature has not been incorporated into the current version.

There was also a general consensus amongst the teachers that the package had a much wider application than ecology education. Many teachers envisaged application to geography and especially English, in the form of media studies. One interesting aspect of the evaluation involved discussion of student access to the video and audio scripts. The design team had intended to incorporate this feature, but teachers disagreed. They proposed that it was necessary for students to develop skills in summarise information from such media sources and if the students had access to a textual form, this would negate development of an essential skill for students.

Teachers evaluating the package were particularly supportive of a number of features of the package that they saw stongly supporting the teaching and learning process. The features of the package noted in this context were:-

- the level of interactivity
- the measuring tools
- the notebook facility
- the video and audio resources.

Their main concern was that teaching support ideas should be available with the package so that they could use the package to the maximum advantage.

Future Developments

On the basis of this inital work we have been encouraged that the package does in fact require the user to take control of their learning. The metacognitive supports do work well to provide a structure and support for problem solving. The main drawback has been the reluctance of the students to edit out redundant or unessary text in their reports. As a result it is suggested that future versions of the software incorporate:

- Prompts or advice on report format either though expert opinion or structure.
- Expert scientists, how they would approach the solution to the problem (Guides) (Hints mainly focussed on where to look in the package.)
- Report generation incorporating other media.

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Title:

TEA^{3}M: A System for Infusing Technology into Teacher Education

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TEA^{3}M:
A System for Infusing Technology into Teacher Education

To meet the challenges of the 21st century, teachers must address the highly diverse needs of today's students and prepare them for life in an information-based, technology-driven society. To respond to these challenges, the University of Houston--Clear Lake, in collaboration with Houston area school districts and communities, NASA, and IBM have established the Teacher Education Advancing Academic Achievement Model (TEA^{3}M) to design and implement an innovative program for teacher education. This paper addresses the integration of technology and innovative instructional practices in the pre-service and staff development training of teachers and administrators. More specifically, this paper describe the systems approach taken to restructure and infuse technology into the pre-service and in-service teacher education program at the University of Houston--Clear Lake

Systems Approach to Infusing Computer-Technology

The high-tech transformation of schools predicted by many has yet to materialize. Schools today look very much like they did a hundred years ago. Compared to our counterparts in business and industry, relatively little has changed in practice or structure. In few instances, one may find a class where students' huddle around computer workstations, actively engaged in group problem-solving, working as a team to access, manipulate, and interpret vast amounts of information as an integral part of their schooling. More common is the sight of students, herded through computer-labs to learn isolated computer-skills or to remediate instruction. Effective and innovative applications of computer-technology with classroom instruction remain isolated.

A number of factors contribute to the inadequate use of computer-technology. Insufficient resources, incongruence with teachers' beliefs, incompatible hardware, top down initiation, fear of change, lack of rewards, inadequate software, and insufficient time or training are some of the more well documented causes. Together, these factors suggest one basic underlying problem: failure to view education as a system, a set of interrelated components that must work together to achieve a common purpose.

Applications of the "Systems Approach" to education are not new. Human performance specialists made system concepts popular during the 1960's and 1970's. Many alternative models are now available including those of Senge (1990), Banathy (1987), Kaufman & Thiagarajan (1987), Dick & Carey; (1985), Deming (1982), Branson, Rayner, Cox, Furman, King & Hannum (1976), Churchman (1969), and Gagne (1962). The purposes and contents of each model differ based on context and the authors' interpretation of General Systems Theory (GST). There is, however, one basic concept common to all approaches: A system is a set of interrelated components that work together to achieve a common purpose. The reminder of this paper describes how this principle is being used to create a system for infusing computer-technology with teacher education.

Defining System Goals

Application of the systems approach began with goal definition. By first defining their goal, system designers were able to identify essential system elements and focus their resources without the constraints of existing organizational policies or structures. To help ensure that the goals for technology would be aligned with other system components, a collaborative mission definition process was used with participation from all system stakeholders (more information about the mission definition process is given later in this paper).

The goal for technology was defined as, "to ensure that all prospective and practicing educators are technology proficient. That is, they will be able to facilitate student and their own performance using: (1) personal productivity tools (e.g., word processors, databases, spreadsheets, and graphic programs); telecommunication tools (e.g., E-mail, electronic networks, and on-line services); learning tools (e.g., drill & practice, tutorials, simulations, multimedia programs); learning management tools (e.g., gradebooks, test banks, electronic portfolio's); (5) programming and authoring tools (e.g., HyperCard, Macromind Director, Linkway, Asymetics Toolbook, Basic, LOGO, Pascal), and 6) collaborative tools (e.g., electronic group problem-solving, decision-making, and brainstorming applications)." It was argued that attainment of this goal was essential for the collaborative to achieve its mission.

The second step in designing the system was to define the interrelated components that must work together to achieve its goal. Figure 1 illustrates the essential functional components of the system. This model is based on the operations model for successful schooling developed by Florida's Schoolyear 2000 initiative (Branson & Hirumi, 1994).

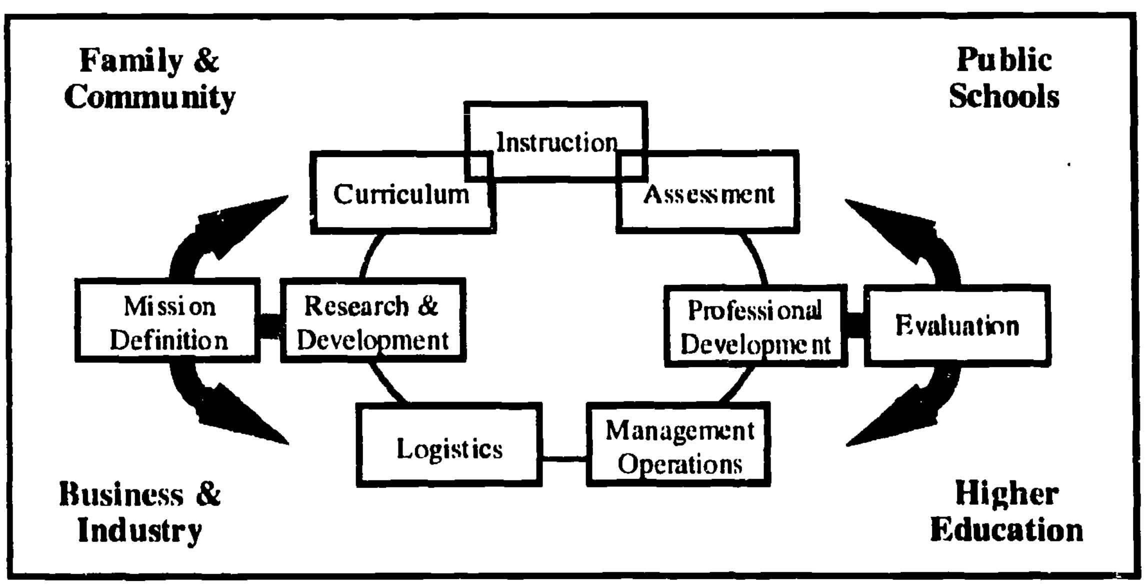

Figure 1. TEA^{3}M's System for Infusing Computer-Technology

System Components

The system for infusing computer-technology under development by the TEA^{3}M collaborative is made up of nine interrelated components. It is believed that these nine components must be designed to work together in order to develop an effective and efficient system for infusing computer technology with teacher education. This system is also viewed as a subsystem of the larger teacher education system and thus, must be designed to work with other components of teacher education. The remainder of this section describes the function and design of each system component.

Mission Definition

The function of mission definition is to: (1) define the vision and mission for the system; (2) define functional goals for system components; (3) help define individual objectives; and (4) ensure that the objectives, goals, mission, and vision are aligned (viz. the achievement of individual objectives will result in the achievement of functional goals that, in turn, results in the achievement of the organizational mission, and achievement of the organizational mission contributes to the realization of the vision for an ideal society).

The mission definition process for the TEA^{3}M collaborative was undertaken during the planning stages of the new program. Representatives from all system stakeholders (i.e., family and community, public schools, business and industry, and higher education) spent an entire day at UHCL to define the vision, mission, and functional goals for the collaborative. The group stated, restated, discussed, and argued until consensus was reached on a vision and mission for the collaborative. Subcommittee were then formed to define functional goals for each component of the TEA^{3}M collaborative. Figure 3 depicts the vision and mission for the collaborative and the functional goal for technology.

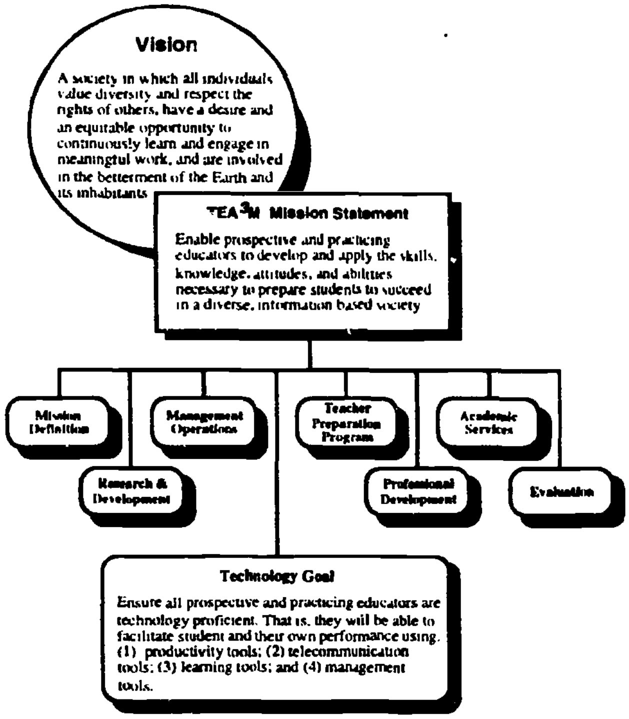

Figure 3. Mission Definition for Computer Technology

Research & Development

At best, education has been slow in translating technological advances and research findings into actual classroom practices. While universities and other research institutions continue to conduct considerable research on education, technology, and learning, the results of such studies are rarely implemented at the school level. Some reasons for the lack of transfer are that research findings are not easily accessible and are not reported in a manner that is readily applicable by classroom teachers.

The function of the Research & Development is to acquire new knowledge related to educational and administrative practices, and to make this knowledge readily accessible and applicable for teachers and administrators. To help achieve these purposes, the technology component of the TEA^3M collaborative is developing an electronic network that will link the public schools directly to UHCL and to the Texas Education Network (TENET) and Internet. As a part of the network, a mail and file server at UHCL will contain specific areas for accessing and discussing research findings and classroom practices related to education. Professors at UHCL will locate and synthesize research related various topics (e.g., technology, early childhood education, multicultural education, interdisciplinary strategies, etc.) and make this information accessible to teachers through the server.

Curriculum

Curriculum provides guidelines for what teachers should know and be able to do with computer-technology. It also recommends curriculum scope and sequence. The words "guidelines" and "recommends" are used especially to denote the flexibility of the program. Past practices have shown that there is no one single set of competencies that are appropriate for all teachers. Nor is it necessary for teachers to learn these many of the competencies in a specific sequence. Relevant computer competencies depend on each teachers role and responsibility and the context they are to be applied. The scope and sequence will depend, to a great extent, on each teachers' interest and prior experience.

Technology related learning outcomes for TEA^{3}M teachers are currently being specified through a collaborative-wide consensus process. The process includes several stages. The first stage was to generate a comprehensive list of computer-technology related competencies based on: (1) the predefined goal for technology; (2) a technology standard for the professional preparation of teachers specified by the collaborative; and (3) a review of national and state standards, journal articles and textbooks.

For the second stage, currently in progress, focus groups, made up of representatives from system stakeholders (e.g., teachers, administrators, district technology coordinators, university faculty) are being brought to UHCL's Group Support Systems (GSS) Lab to reach consensus on essential computer-technology related competencies. The GSS Lab is equipped with state-of-the-art electronic collaborative tools. Here, fourteen networked workstations running the software application, *VisionQuest®*, are being used to facilitate brainstorming, group discussion, and consensus building. During this activity, collaborative members are being asked to determine whether each competency is either: (1) essential to all beginning educators; (2) essential to all experienced educators; (3) essential for only certain educators; or (4) not essential.

After essential skills, knowledge, and attitudes are defined for various stakeholders, they will be grouped into logical clusters based on their content and function. The clusters will then be used to define learning outcomes. It is believed that specifying discrete skills and knowledge may inhibit learners' ability to synthesize and apply the competencies in real world situations. Thus, learning outcomes will be generated that describe how learners are expected to apply the learned competencies. The learning outcomes will then be used as a basis for instructional design and development.

Instruction

The function of instruction is to design, develop, and deliver instructional programs and materials that will enable educators to achieve the specified curricular objectives. To achieve the technology-related competencies defined by curriculum, TEA^{3}M educators will receive information, training, and support from six primary resources: (1) Knowledge Network; (2) Teacher Technology Exploration Center (TTEC); (3) Distance Learning Programs; (4) Undergraduate and Graduate Coursework; (5) Workshops and Seminars; and (6) Site-based Training and Support.

Knowledge Network

The Knowledge Network provides the backbone for transporting information to and among all system stakeholders. The network connects students, interns, public school teachers, university faculty, administrators, and business partners to each other, to the Teacher Technology Exploration Center, and to experts and databases from all over the world. The network allows the collaborative to bring expert knowledge and research on innovative educational practices and technologies directly to the public school sites as well as diffuse the knowledge acquired by the collaborative to other researchers and educators. Connection to state, national, and global networks helps free learning from the confines of the classroom, giving students and teachers virtually limitless access to knowledge and information produced by students, teachers, schools, businesses, community members, and government agencies in Texas, the United States, and beyond. Figure 3 illustrates the design of the knowledge network.

Teacher Technology Exploration Center (TTEC)

The TTEC's primary responsibility is to train and empower students, teachers, and administrators to apply learning and performance technologies. The center will allow educators to explore leading edge technologies at their convenience. Center staff will guide them in areas of interest, expand their awareness of technology, and provide the knowledge and expertise required to utilize technology. Housed on the University campus, the TTEC will be readily accessible to teachers and administrators from over 600 schools in the 22 independent school districts surrounding the center. There will also be an on-line information service so that people can find out what is currently available at the center.

The TTEC contains six components: (1) a high-tech electronic classroom; (2) a showcase arena; (3) a multimedia development lab; (4) a resource library; (5) video production studio; and (6) research and development lab (Figure 4). The following is a brief description of each component.

Electronic Classroom. The Electronic Classroom will model a classroom of the future. It will include multi-platform, electronic workstations that will support 1-6 users that will be networked to both local and wide area networks, automated presentation stations and capabilities for synchronous and asynchronous video and audio conferencing. Graduate and undergraduate classes, workshops, seminars will be provided in the classroom.

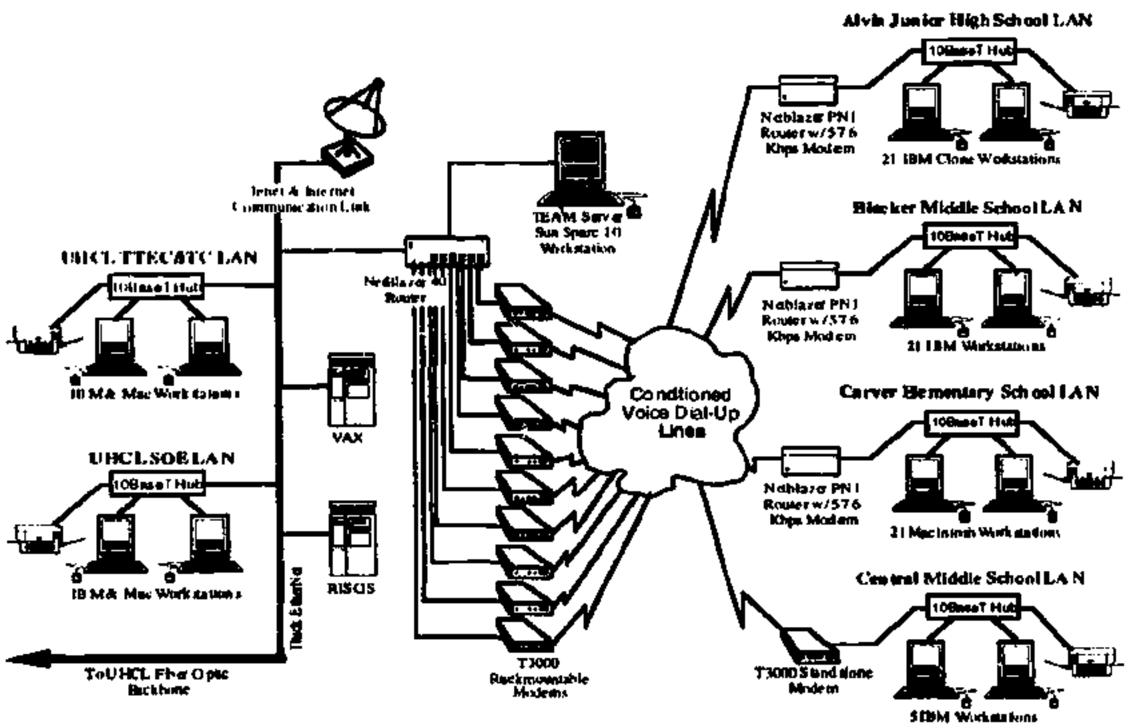

Figure 3. Collaborative-Wide Knowledge Network

Showcase Arena. The Showcase Arena features cutting-edge educational technologies. Here, teachers, students, administrators, and university faculty can explore the latest in educational hardware and software at their own leisure. The arena showcases a wide variety of vendor products and innovative applications developed by research institutions such as electronic performance support systems, telecommunication interfaces, electronic learning environments, instructional management software and administrative, presentation, authoring and multimedia systems.

Multimedia Development Lab. The Multimedia Development Lab will be a state of the art facility for pre-service and in-service teachers and university faculty to receive training and develop their own multi-media programs. The development area would contain multiple platforms for creating and conducting research on multimedia programs, electronic performance support tools, and innovative learning environments. It will facilitate high-level qualitative and quantitative research and the development of innovative instructional programs.

Resource Library. The Technology Resource Library would house instructional materials, educational software, and vendor information for educators. The library will feature an indexed collection of educational software and information on instructional technology. The materials will be made accessible both manually and on-line. Resources will also include informative materials on vendor supported technologies. Educators visiting the center will able to preview the materials as well as receive training on its use. Educators will also be allowed to check out the materials so that the can demonstrate them at the collaborating school sites.

Video Production Studio. The TTEC Video Production Studio provides facilities to edit and produce video tapes. The studio also serves as a receiving point and distribution site for video conferencing, distance learning via satellite or microwave, and closed circuit television. Post-production facilities include the capability for non-linear digital editing or video, voice, text and graphics.

Research & Development Lab. The TTEC Research and Development Lab services as a focal point for research projects currently conducted by UHCL faculty and students. The lab provides a synergistic environment where software engineers, instructional technologists, graphic artists, cognitive psychologists and content area specialists work together to build learning environments of tomorrow. The lab contains the hardware and software necessary to truly impact the way we teach and learn via cutting-edge computer technologies.

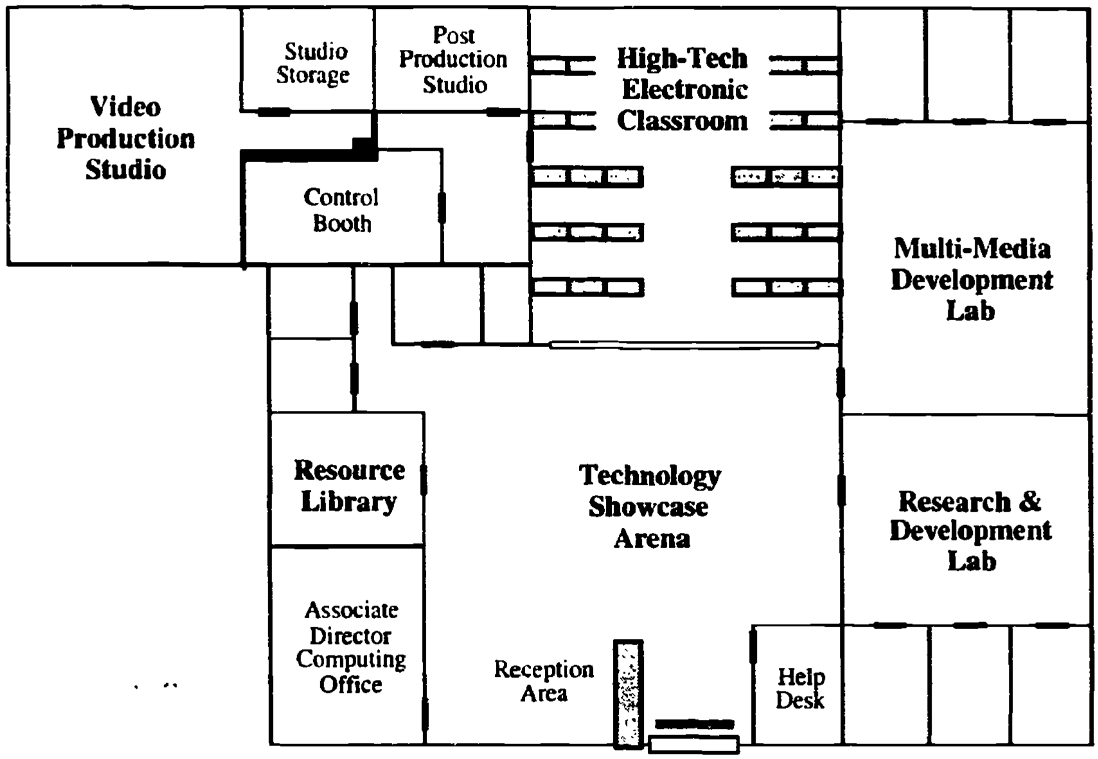

Figure 4. Teacher Technology Exploration Center

Distance Learning Programs

The development and implementation of distance learning programs allow the TEA^{3}M collaborative to optimize its resources. Consistent with the TEA^{3}M's strategy for providing site-based, real-world experiences, distance learning program will permit university faculty to deliver instruction to teachers and students at the collaborating school without the cost of sending instructors to each site. In-service workshops and seminars provided by the Region IV Education Service Center and by the UHCL Teacher Center may also be delivered to each site by this mechanism.

In addition to providing information and training to TEA^{3}M collaborative members, the development of the distance learning program will allow students and teachers to communicate and share experiences with other students, teachers, and other professionals from all over the world. After the initial program and networking infrastructure have been installed, UHCL and the Education Service Center will work with teachers at each collaborating site to develop their own distance learning programs. These programs will help break down classroom walls and allow students at the collaborating sites to share experiences with students from other regions of the Texas, the United States, and around the world.

Development of the distance learning programs will be a collaborative effort between the Region IV Education Service Center, the collaborating schools, the University of Houston--Clear Lake, and public utility companies. During the first year of the initiative, collaborating schools will be linked to the existing Interact system with a TV antennae, TV monitors, VCRs and telephone lines. One-way video and two-way audio transmission will permit UHCL, the Region IV Education Service Center, and the UHCL Teacher Center to deliver interactive workshops and courses to each school site. This system will meet the collaborative's immediate needs as well as provide a foundation for the development of future distance programs. In addition, SouthWestern Bell and Phonoscopes Inc. are now assisting UHCL assess the availability of networking resources at the collaborating schools and at the university in preparation.

The long-term plan is to connect public schools, UHCL, and the Region IV Education Service Center with high speed digital networks. Digital networks reduce attenuation, distortion, and noise accumulation common to current analog systems. Digital transmission is also the universal language of data communications, thus, reducing compatibility problems and the expense of converting analog and digital signals. Digital networks allow two-way video, audio, and data transmission between all sites with greater

Currently, the plan is to keep abreast of legislative, university, district, and school decisions regarding technology, monitor technological advances, and continue to develop our own capacity for delivering distance learning programs. As a clearer picture of this technology emerges, we will make much more informed decisions about the purchase and installation of high-end networking systems. Until then, we will train educators in the design, development, implementation, and evaluation of distance learning programs utilizing the existing Interact system as well as any system made available in the TTEC.

Undergraduate and Graduate Courses at UHCL

Pre-service teachers will acquire much of the basic, technology related skills in undergraduate courses at UHCL. Soon, all pre-service teachers participating in the TEA^{3}M collaborative will be required to take a computer literacy course as a pre-requisite to enrollment in the teacher education program. As a part of their teacher education program, they be required to take INST 3133--Classroom Computer Usage. In this course, students will learn how to use personal performance tools, such as word processors, databases, spreadsheets, and communication applications and learn how to locate, evaluate, and integrate computer-based educational programs. Students in this class will also learn how to access and critically examine research studies on computer use in education. In addition, pre-service teachers will learn technology related skills as a part of their respective teaching methods course. In these courses, students learn how to integrate subject-area related computer-based educational program with course curriculum.

The University of Houston--Clear Lake also offers a series of courses and a masters degree in instructional technology. As a NCATE accredited program, the Instructional Technology program at Clear Lake offers quality classes on the use of leading-edge instructional technologies (e.g., Macromind Director, Authorware, and hypermedia), the systematic design of instruction, and needs assessment and strategic planning. All pre-service and in-service teachers involved with the TEA^{3}M collaborative will be urged to take these courses as well as others provided by UHCL.

Workshops and Seminars

To be responsive to the on-going needs of educators at each of the collaborating school sites, workshops and seminars will be given by UHCL, the UHCL Teacher Center, and the Region IV Education Service Center. A survey of educators will be taken on a regular basis to determine what type of workshops and seminars are to be delivered. For example, during this past spring, a survey was distributed to all educators at each of the four collaborating school sites. It was indicated that a significant number of educators would like some training and information on the use of TENET. These requirements were matched with resources available at UHCL, the UHCL Teacher Center, and the Education Service Center and it was decided that faculty at UHCL will provide a workshop on TENET during the summer. Workshops and seminars will be provided on an as needed basis and will be delivered at the UHCL campus, at the Region IV Education Center, at one of the collaborating school sites, or via the distance learning network.

Site-Based Training and Support

It is anticipated that the integration of technology at each of the collaborating schools will require some site-based training and support. No matter how much instruction is given through courses, workshops, and seminars, there will be some need, particularly during the early stages of this initiative for one-on-one support. The plan is to give pre-service teachers sufficient skills so that they can provide practicing educators with much of the support and training necessary to use technology. However, particularly during the first year of the program, both pre-service and in-service teachers may require training, particularly in the areas of networking and the use of learning management systems. Faculty and staff at UHCL, graduate students in the Instructional Technology program at Clear Lake, and staff at the Region IV Education Service Center will go to each of the collaborating school site and provide training and support on an as needed basis.

Assessment

The function of assessment is to collect data on pre-service and in-service teacher performance. In terms of technology, data will be collected to determine if teachers: (1) acquired the computer technology related skills and knowledge defined by curriculum; and (2) apply these skills and knowledge to facilitate their students and their own performance. Data from assessment will be used as feedback for pre-service and in-service teachers to improve their performance as well as to evaluate the effectiveness and efficiency of the technology system.

For the TEA^{3}M collaborative, pre-service teachers achievement of computer-technology related outcomes will be assessed by a portfolio. For their portfolio, pre-service teachers are expected to provide five different types of products as evidence of their accomplishments. The products include: (1) research, such as a review of literature on the use of particular computer application in education; (2) a video which depicts the teacher implementing computer-technology in an instructional setting; (3) lesson plans which show the inclusion of technology; (4) assessments that demonstrate teachers ability to measure students acquisition and application of computer-technology; and (5) resources, such as a directory of people, software, and hardware products and services. The portfolios are examined by university faculty as well as the TEA^{3}M of teachers who are supervising the pre-service teacher.

Evaluation

The evaluation function monitors both internal programs and external conditions to make necessary revisions to the system. This approach assumes that if teachers and students are not learning, one or more components of the system is not working. Where assessment focused on individuals acquisition and application of specified learning outcomes, evaluation aggregates assessment data and collects additional information to determine the effectiveness and efficiency of the system and system components.

A framework was created to guide the evaluation process. Based on Kaufman's (1983) Organizational Elements Model, the framework outlines 5 different levels of organizational effort and results that are to be evaluated. The framework also helps define evaluation questions and specific components that are to be evaluated. Figure 5 illustrates the evaluation framework used to guide the evaluation of the TEA^{3}M system for infusing computer technology.

Logistics

Logistics are responsible for all business-related aspects schooling. In terms of technology, this refers directly to the purchase and maintenance of hardware and software. Grants are often written to cover the initial cost of buying and installing computer equipment. However, relatively little thought goes to the institutionalization of hardware and software upgrades and maintenance. Educational innovations, particularly those received from grants, are frequently viewed as add-ons to the current system. Thus, support for certain innovations dissolves as political and economic climates change. Without continued funding, hardware and software soon become obsolete and are left to gather dust in an obscure corner of the classroom.

To address these concerns, the TEAM collaborative works directly with each school's district office. Decisions regarding hardware and software purchases, networking, and maintenance are aligned directly with each districts long-term plan for integrating computer technology. In this manner, the collaborative ensures that hardware and software brought in through the grant will be compatible with the technologies to be installed at each site by the district over the next five years.

Based on the premise that schools will continue to acquire classroom computers, the TEAM collaborative decided to allocate its technology resources on computer workstations for each teacher's desk. If teachers are expected to develop innovative strategies for increasing students' performance through the use of computer technology, it is believed that they must first feel confident in their ability to use it through its daily application.

Level	INPUTS	PROCESSES	PRODUCTS	OUTPUTS	OUTCOMES
Evaluation Question	What resources were used for this initiative? Were they cost-effective & sufficient to meet goals?	How efficient was the process? Were the customers satisfied?	To what extent do learners acquire the desired skills and knowledge?	To what extent do learners apply their newly acquired skills and knowledge?	What impact does these learned capabilities have on student achievement?
Evaluation Components	1. **Human** - Number, Position, Skills, Knowledge Time, and Attitudes 2. **Materials** - Type, Cost, and Allocation 3. **Equipment** - Type, Cost, and Allocation 4. **Space** - Amount & Location 5. **Financial** - Total Cost, Cost by Location, Cost by item	1. Knowledge Network 2. Teacher Technology Exploration Center 3. Distance Learning 4. Undergraduate & Graduate Courses 5. Workshops & Seminars 6. Site-based Training & Support	1. Productivity Tools 2. Telecommunication Tools 3. Learning Tools 4. Management Tools 5. Collaborative Tools	1. Productivity Tools 2. Telecommunication Tools 3. Learning Tools 4. Management Tools 5. Collaborative Tools	1. Placement rate of teachers 2. Students' skills, knowledge, & attitudes @ each grade 3. Students' ability to use personal productivity tools 4. Students' ability to use telecommunication tools 5. Graduation/Dropout Rate 6. At-risk probability 7. Success in next grade level
Evaluation Techniques	1. Hardware & Software Inventories 2. Preservice & Inservice Teacher Surveys 3. Cost-Benefit Analysis 4. District Technology Plans 5. University Technology Plans 6. State Technology Plans 7. TEAM Budget Reports	1. Customer Satisfaction Surveys 2. Workshop Evaluations 3. Student Course Evaluations	1. Course Exams 2. ExCet Exams. 3. Preservice Teacher Portfolios 4. Inservice Teacher Class Products 5. Workshop Products	1. Preservice Teacher Portfolios 2. Preservice Teacher Journal 3. Classroom Observations 4. Inservice Teacher Class Products 5. Administrator Questionnaires 6. Piems Data	1. TAAS Scores 2. NAPT - Norm referenced tests 2. Placement Data 3. Classroom Observations 4. Student Grades 5. At risk probability instrument 6. Student Surveys

Figure 5. TEA^{3}M Evaluation Framework

Each public school received twenty teacher workstations (one per teacher working directly with the TEAM collaborative) and a multimedia presentation system. One school choose IBM and another IBM compatibles because the district would support only those platforms. The third school choose Macintoshes because they felt that it would be easier for their students and teachers to learn. The IBM and IBM compatible teacher workstations included a 33Mhz 486DX processor, 4-8MB of RAM, 120-240MB hard drives with DOS and Windows pre-installed, SVGA monitors, mouse, keyboard, and 10baseT transceivers. Centris 610 with CD ROM, 8MB of RAM and 240MB hard drives and Duo Docks with PowerBook Duo 210 with 4MB of RAM and 80MB hard drives were purchased for the Macintosh school. Each multimedia presentation system included a high powered CPU, color scanner, a CD and a laser disc player, a LCD projection panel, and an overhead projector.

By working with each district office, the collaborative was also able to leverage resources to install the local area networks. In most cases, plans were already in place for cabling the entire school within the next two to three years. By pooling the resources, the collaborative was able to get the district to install the cabling required to network the teacher workstations by the end of this school year. The public schools will retain the computer equipment as long as they remain active participants of the collaborative (e.g., provide internships for TEAM pre-service teachers) and the districts assume responsibility for maintenance and upgrades.

Management Operations

Management operations is charged with making decisions regarding organizational policies and procedures, resource allocation, and program design and implementation. In education, researchers and administrators distant from daily classroom practices, initiate and manage numerous grant-related programs. Few top-down strategies, however, have had a significant impact on classroom instruction because they fail to account for the pragmatics of daily school routine. Scorned by teachers who have been asked repeatedly to implement new programs with little time or training, top-down interventions are not owned by the practitioners and thus, are not frequently implemented as planned.

New programs designed by site-based comn ttees have also seen limited success. In contrast to top-down strategies, "bottom-up" initiati. e are constrained by the lack of time and training for program design. As advances in technology continue to increase, even the most avid technologists are hard pressed to keep up with the latest changes. Practitioners responsible for educating 20-40 students on a daily basis can not be expected to continuously acquire the skills necessary to apply leading-edge technologies without additional resources.

To address the limitations inherent to top-down and bottom-up interventions, TEAM employs a collaborative consensus process to guide system design and implementation. In this process, representatives from all system stakeholders participate in programmatic decision-making.

Five committees manage the computer-technology system for the TEAM collaborative, including: (1) three site committees, made up of the principal, the site coordinator, the school computer lab coordinator, and the district technology coordinator for each school; (2) a university committee, consisting of three representatives from the University Computing department and three faculty members from the Instructional Technology program; and (3) a collaborative-wide technology committee, comprised of all members of the public school and university committees. In addition, a Director of Technology for the TEAM collaborative is charged with coordinating the activities of the various committees as well as integrating technology with other aspects of the TEAM's teacher education program.

The site-based committees are responsible for making decisions that affect resource allocations and program implementation at each school. For instance, each public school committee determined the type of computers that were to be provided by the collaborative. The university committee, in comparison, choose the hardware and software used to network the schools to the university and created the Teacher Technology Exploration Center. The collaborative-wide committee set policies for allocating grant-related funds and specify the software to be purchased and supported by the collaborative.

Professional Development

The function of professional development is to train and support staff in implementing the TEAM system for infusing computer technology. The products of professional development are educational experiences and staff support services. Initially, focus is being placed on developing each site's capacity to manage their own local area network and utilize the computer applications provided by the collaborative. The strategy is to develop a core of technology proficient educators who can trouble shoot basic problems and serve as a resource for students, teachers, and administrators at each site.

Educational experiences range from specific training sessions provided by computer vendors on the use of their equipment, to more general types of experiences such as attending computer conferences. The goal is to provide a wide range of opportunities that will enable educators to pursue their own areas of interest. In this manner, educators will gain expertise in different areas of computer use at each collaborating school site and will be able to provide information and support to other educators at their school on a timely basis.

Particular attention is also being placed on establishing a collaborative-wide human performance support system. The support network identifies individuals from the university, public schools, computer vendors and other businesses both within and outside of the collaborative who have expertise in particular areas of computer use such as networking, desktop publishing, distance learning, and multimedia development. A list of experts, including their e-mail address and phone number, is kept up-to-date and disseminated to all members of the collaborative.

Summary

The TEA^{3}M collaborative is currently in its first year of development. The goals for technology during this year are to: (1) analyze the computer-technology requirements at each collaborating site; (2) install computer workstations, local area networks, and the wide area network which links the public schools to the University, TENET, and Internet; (3) purchase and install basic computer applications (e.g., productivity & telecommunication tools); (4) define a computer-technology curriculum for both pre-service and in-service teachers; and (5) begin the design and delivery of instruction. To date, the technology requirements at each collaborating site have been assessed, curriculum and instruction are being designed, and the computer workstations have been purchased and installed. By this summer, the local area networks, the collaborative-wide network, and the Teacher Technology Exploration Center should be fully functional. By year two, we hope to see a significant number of pre-service and in-service teachers who are able to increase student and their own performance through the infusion of computer-technology.

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Title:

Technology in Education: Making a Change in Arkansas,"The Comeback State"

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Arkansas is a rural state with diverse educational needs. For many years Arkansas ranked 50th in the nation by most criteria used in measuring educational comparisons with other states. Governor Bill Clinton recognized that in order for Arkansas to improve economically it must invest in education and measures were implemented during his tenure to improve education. Additional monies were raised to increase teacher salaries, build facilities and expand curricula. Another major change in education was the establishment of standards (1983) for all schools in Arkansas. Course content guides were developed for every subject area and documentation was required for minimum performance in basic skills. Students were tested in the third, sixth and eighth grades. Although most of what happened was positive, there were some negatives. Instead of the curriculum driving the content and instruction, the test determined the curriculum. Teacher expertise and knowledge of student management, group dynamics and flexibility were lost. Teaching to the test occurred in many schools; when test results were published in local newspapers, this put even more emphasis on test results.

In 1991 Arkansas passed Act 236 which required public schools to restructure. Learner outcomes were developed which correlated with the six national education goals. Local schools are currently working to finalize frameworks which will be implemented over the next few years. One component of Act 236 was the establishment of the Arkansas Leadership Academy with four areas of concentration: (1) Leadership Development; (2) District Support; (3) Minority Recruitment; and, (4) Information, Research and Technology. The Arkansas Leadership Academy has many partners across the state: colleges and universities; K-12 schools; Arknasas Public School Computer Network (APSCN); Wal-Mart; Tyson; Arkansas Educational Television Network (AETN); Arkansas Library Association (ALA); Arkansas Department of Education (ADE); Arkansas Association of Instructional Media (AAIM); Instructional Microcomputer Project for Arkansas Classrooms (IMPAC); and private individuals. The Academy has within its structure the mechanism to involve all the players to truly change education in Arkansas.

The decisions concerning technology in Arkansas have been made by people working in isolation. Project IMPAC labs have served a useful purpose and are designed in such a way as to furnish training, technical suport and maintenance. AETN provides videos to education cooperatives and schools. APSCN has the task of networking all 320 school districts across the state for administrative reporting and also for instructional uses. There are pilot schools that have built their local network and are exploring the opportunities of accessing information electronically for instructional use. All of these players are to be complimented on their efforts and support, but Arkansas schools must utilize this collaborative effort to make a lasting change in Arkansas schools. We are currently looking at restructuring not only what we teach, but how we teach it.

With these ends in mind, The Arkansas Academy for Leadership Training and School-Based Management Technology Management Technology Committee made the decision to survey all public school library media specialists (LMS) in Arkansas during the Spring of 1993. The committee felt that library media specialists are the primary information specialists in the schools with expertise in the area of technology.

The purpose of the survey was to determine what technology is presently being used in Arkansas schools, to develop a database of educators with expertise in specific areas of technology, and to compile a list of priorities library media specialists would like to have implemented in their library media centers/schools. Survey questions were developed with the assistance of the state library supervisor, library media specialists in Northwest

Arkansas, the media specialist at the Northwest Arkansas Education Service Cooperative, and the Arkansas Academy for Leadership Training and School-Based Management Technology Committee. The University of Arkansas Sociology Department's newly acquired Scantron survey equipment was used to compile data.

The development of the survey began in February, 1993. Team players helped develop a 50-question survey instrument covering three major areas: district concerns, school concerns, and LMS concerns. The survey was mailed to 967 public school LMS on three separate occasions over a four month period. In addition, LMS attending their summer conference and the Arkansas Library Association's Annual Conference were encouraged to take surveys back to colleagues who had not responded. Mr. Frank Holman wrote letters to superintendents in districts which had not responded well to the mailings. Six months after the initial mailing, a total of 845, or 87% of the Arkansas public school library media specialists had returned a completed survey. Of the 75 counties in Arkansas, the response rate was:

100%	21 counties
90-99%	10 counties
80-89%	19 counties
70-79%	15 counties
60-69%	7 counties
50-59%	2 counties
40-49%	1 county

A breakdown of numbers of counties reaching 100% response by geographic region:

Ouachita Region	1%	(1 out of 10 counties)
Delta Region	19%	(4 out of 21 counties)
Southwest Region	30%	(6 out of 20 counties)
Ozarks Region	46%	(11 out of 24 counties)

District Data Statewide

District survey results showed nearly two-thirds of schools did not have a district technology planning committee and 71% did not have a technology coordinator. Planning ahead was not being done in 69% of schools because there weren't any electrical specifications for computer networks for new buildings. Financial support was a problem as well. Ninety-two percent of schools have not passed millage to support technology, and 87% have not made plans for future needs in technology.

School Data Statewide

Data collected revealed that 68% of the state's school library media centers are not automated. Of the centers which are automated, 45% use Follett's automation system. Fifty-four percent of the schools have satellite systems but only about a third of those systems are being used. Ninety percent of the schools are not involved in distance education. Types of computers being used in the schools are: Apple IIe - 39%; Macintosh - 10%; IBM/compatible - 42%; other - 9%. [This reveals a problem in that Apple IIe's are not compatible with the state-wide computer network system.] IMPAC has installed labs in 52% of Arkansas schools during the past ten years. Only about one in five schools is using networks and most of those use the Novell system. Library media specialists reported that in 53% of the schools, no more than 10% of the classrooms are equipped with computers and almost none are networked. When asked if teachers had access to specific technology the following responses were tabulated:

	Yes	No
Modem access	18%	82%
FAX machine access	23%	77%
ARK FAX Network	3%	97%
ARKnet/INTER/net	5%	95%
Email/FredMail	4%	96%
Channel 1/Whittle	28%	70%

Arkansas public schools are using cable television (61%), multimedia (74%), CD-Roms (39%), and laser video technology (19%). Computer use in schools is primarily for special programs such as Chapter 1, special education, and gifted and talented, but not in the regular classroom.

Library Media Specialists Data Statewide

Sixty-one percent of LMS have earned a masters degree. Nearly one-third reported receiving their library media education at the University of Central Arkansas, Conway, Arkansas, while 17% received their training at the University of Arkansas, Fayetteville. When queried as to whether they would like to have an American Library Association accreditation program in Arkansas, 96% said "Yes." Almost one-half of the LMS indicated they worked under a nine-month contract, the same as classroom teachers. A larger percentage (63%) reported not having clerical assistance in the library media center. Sixty percent of Arkansas school districts have evaluation forms designed for LMS. Eighty percent of the LMS said they would like to have a specific amount of their budget allocated for technology. A full 61% did not support the concept of year 'round school. There was an almost even split regarding flexible scheduling.

When LMS were asked to indicate areas in which they felt they had expertise, 47% indicated computer technology and 30% mentioned multimedia presentations. When asked if they were willing to share this expertise with others, 66% said "No." The researchers are currently processing this information in order to find those willing to share their areas of technical expertise. This will aid in the creation of workshops to be offered throughout the state.

LMS were also asked to list at least five areas they would like to have implemented. The survey placed responses in groups of five due to the constraints of the survey answer form, making it difficult to determine if responses were by groups or with the entire 25 being considered. This information is currently being analyzed. By percentage responding, the top five areas were: budget concerns; flexible scheduling; technology seminars for LMS; networking with LMS; and clerical assistance for LMS. The areas least marked were: library media certification; censorship; teleconferences; satellite systems; and Channel 1/Whittle.

Summary

Arkansas is indeed "The Comeback State." Watch as the Arkansas Leadership Academy and its many partners utilize technology in the classroom. Team members working together will provide the best possible educational opportunities for all students, and technology will play a vital role at all levels of the instructional process. This survey will assist in showing Arkansas public schools the direction they need to go to reach their goal.

This completes Phase 1 of the survey -- analyzing the data statewide. Phase 2 will compare data by the geographic regions of Ouachita, Delta, Southwest, and Ozarks.

Title:

Persistence and Small Group Interaction

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Persistence and Small Group Interaction

One approach to designing computer-based instruction (CBI) involves using the adaptive capabilities of the computer to provide individualize instruction (Kinzie, 1990; Carrier & Jonassen, 1988; Tennyson & Park,1987; Reiser,1987). However, practical limitations, such as the extensive time requirements and associated financial costs, limit the potential for individualizing CBI (Carrier & Jonassen, 1988, Bork, 1987). Another limiting factor is the shortage of computers and subsequent logistical constraints endured by most schools. In practice, most students work in groups, not alone, at the computer (Becker, 1986; Hooper, 1993).

Focusing on individualized CBI also ignores consistent research findings that demonstrate the effectiveness of cooperative learning methods on student achievement, their attitudes towards instruction, and other students (Johnson, Johnson, & Maruyama, 1983; Johnson & Johnson, 1991; Slavin, 1991). Furthermore, a growing body of evidence has accumulated which indicates similar benefits for completing CBI in cooperative learning groups (Johnson, Johnson, & Stanne, 1985, 1986; Dalton, Hannafin, & Hooper, 1989; Hooper, 1992; Light & Blaye, 1990; Nastasi & Clements, 1991; Jackson, Fletcher, & Messer, 1992).

From a design perspective, however, the pertinent issue no longer appears to be whether cooperative CBI benefits student achievement, but rather involves identifying factors which affect group performance. Perhaps the most important determinants of group performance are the quality and quantity of student interaction. Webb (1982b, 1985) found that student achievement benefits from frequent intra-group interactions which include both the giving and receiving of elaborated explanations which go beyond mere "terminal help". It is important, therefore, to recognize that the nature of intra-group interaction is likely to be a direct reflection of the internal dynamics within the group.

One factor that appears to influence the nature of interaction is ability grouping. Webb's research indicates the positive achievement affect that heterogeneous ability grouping has on high- and low-ability students, but not average students (1982a,b). In Webb's studies, when grouped heterogeneously, average ability students were frequently excluded from the peer tutoring relationships that often existed between high- and low-ability students. In other studies, heterogeneous-ability grouping benefitted the performance of low-ability students, but high-ability students did best when grouped homogeneously (Hooper & Hannafin,1988; Hooper, 1991).

Ability grouping influences the quantity and quality of interaction. Low-ability students interact more frequently and effectively when grouped heterogeneously by ability, but high-ability students interact equally effectively in homogeneous and heterogeneous ability groups. The rate of interactions decreases for low-ability students who are homogeneously grouped (Hooper & Hannafin, 1991), but increases for high-ability students who are homogeneously grouped (Hooper, 1992).

In addition to ability grouping, several other individual factors or personality characteristics may affect the intra-group dynamics. One such factor is a student's task persistence level. In a study of the affects of learner control on student performance, Carrier & Williams (1988) found a curvilinear relationship between an individual student's task persistence and subsequent achievement. Medium task persisters demonstrated higher achievement than both extremely low and high persisters. When given control of the amount and nature of instruction and practice to receive during CBI, high persisters persevered even though they know the material; their persistence, similar to the effects seen in high motivation or arousal (Yerkes & Dodson, 1908) apparently inhibited their learning. Low persisters stopped studying the lesson material prematurely, believing that they had sufficiently mastered the lesson content.

To date, however, the effects on performance of grouping students according to individual variations in persistence levels have not been investigated. In the present study we examined how homogeneous and heterogeneous groupings of individual persistence levels affected group performance and interaction patterns. We were interested in whether the presence of an average persister would enhance the performance of the high or low persisters, or conversely whether high or low persisters would detract from the performance of the average persisters. We were also interested in the affect of grouping on two other outcomes: students' attitudes and intra-group interaction. In particular, we were interested in examining the impact of collaboration on students' selection of cooperative learning partners and in examining how student interaction varied as a function of group composition.

Methods

Subjects

Participants in the study were 139 sixth grade students enrolled in five classes at a Midwestern public school. Of the total number, 68 students were male and 71 were female. One student was not paired, and was removed from the data being analyzed, leaving 138 students in the study.

Materials

The computer-based lesson and posttest were based on those used in previous research by Carrier and Williams (1988). The lesson content introduces four advertising concepts: bandwagon, uniqueness, testimonial and transfer. The lesson begins with a concept definition followed by a set of expository examples and nonexamples. Next, students attempt practice questions and choose whether to receive related feedback indicating the accuracy of their responses and elaborated feedback emphasizing the presence or absence of critical attributes. Students also decide whether to attempt additional practice items. The original materials were modified to include a maximum of six questions for each concept. Thus, for each concept students could select up to 18 options including examples, feedback and elaboration.

The lessons were presented in three segments. The first concept was used to assess students' levels of persistence. This lesson was completed individually by all students. Concepts two and three were presented on the second day and were completed in cooperative groups. Concept four was presented on the third day and was again completed in groups.

The posttests were designed to measure students' achievement and attitudes toward their partners. The achievement posttest includes two parts: twenty-five questions measure comprehension of the lesson material and four problem solving questions measure higher levels of cognitive processing. Comprehension questions involve classifying instances of the lesson concepts. Problem solving questions involve generating instances of lesson concepts. Coefficient-alpha reliability for the posttest was .91. The Partner Preference Questionnaire asks students to list the names of up to five students from their class class with whom they would like to work.

The interaction rate was determined by dividing the total number of instances of cooperative behavior by the total time an individual was observed. Thus, the interaction rate represents the average number of interactions per minute. Interaction was observed and coded by trained raters. The number of student groups active during each session was greater than the number of trained raters available. Consequently, we observed all groups by rotating raters during the lesson. Raters rotated every five minutes to reduce coding variation. Furthermore, approximately 40% of the groups were videotaped during the instruction to facilitate a qualitative analysis.

Before the study, raters were trained in observation and coding techniques. Rater training consisted of three stages. First, the lesson was videotaped with a comparable group of students. The videotapes of the pilot session were used to develop the coding instrument. The second stage of rater training involved training eight graduate students who had volunteered to be raters during the study. The raters were trained using a combination of discussion, tape review, and practice. During practice, individual rating differences led to review of tape segments and group discussion. The third stage involved testing raters performance to confirm consistency in the ratings given by the observers. The individual who conducted a post hoc videotape analysis was trained using similar processes.

Procedures

Students completed a 90 minute workshop, lead by the investigators, before the study. The purpose of the workshop was to enhance intra-group interaction and cooperation. The activities employed in the training session are outlined elsewhere (Hooper, Temiyakarn, & Williams, 1993). One week later, all students completed a computer based lesson alone. The purpose of the lesson was to assess student persistence. Based on the total number of options selected during the lesson, students were classified as High (H), Average (A), or Low (L) in terms of persistence.

Before working in groups, students completed the Partner Preference Questionnaire. Next, dyads were formed by randomly assigning students within each class to a dyad resulting in six possible combinations of persistence (HH, HM, HL, MM, ML and LL). Students completed the remaining three computer based lessons in groups over two successive days. One week later students completed the posttest and the Partner Preference Questionnaire.

Design and Data Analysis

Dependent measures included Interaction Rate, Achievement (divided into Concept Learning and Problem Solving), and Attitudes. A MANOVA was conducted using Interaction Rate and the two achievement measures as dependent variables. Independent variables included Persistence Level (High, Average, and Low), Gender (Male and Female), and Mix (Heterogeneous and Homogeneous). Significant overall effects were followed up with univariate ANOVA's. A separate 2X2 Chi square analysis was conducted on the Partner Preference Questionnaire. Independent variables were Time (Pretest and Posttest) and Partner Selection (Yes or No). Calculations were made using Systat (© 1990, SYSTAT, Inc.), and Testat, (© 1986, SYSTAT, Inc.). All tests of significance adopted an alpha level of .05.

Results

Posttests.

Table 1 reports the means and standard deviations on the posttests. A MANOVA on these data indicated significant effects for Persistence Level [Wilks' Lambda = .883, $F(6,226)= 2.42$, $p<.02$] and for Gender [Wilks' Lambda = .933, $F(3,113)= 2.70$, $p<$).05. No other effects were statistically significant.

Univariate follow-up tests indicated that Persistence Level was significantly related to Interaction Rate [$MS_{Error}= 1.653$, $F(2,115)= 4.71$, $p=.011$]. Average persisters interacted significantly more that high and low persisters (see means on Table 1).

Follow-up examination of the Gender effect indicated that Gender was significantly related to Concept Learning [MS_{Error}= 43.57, $F(1,115)$= 4.55, p=.035] and to Problem Solving [MS_{Error}= 1.87, $F(1,115)$= 6.84, p=.010]. In each case, males outperformed females (Concept Learning 15.81 vs. 13.23; Problem Solving 2.52 vs. 1.80).

Insert Table 1 about here

Interaction

A post hoc analysis of videotapes recorded during the experiment was conducted to validate the rating procedure conducted during the experiment. During the study all groups were rated by trained observers, but the post hoc analysis was conducted on only a subset of the groups. Comparison of these data indicated a strong relationship between the social interaction ratings that occurred during and after the study (r = 0.75, p < .001).

Attitudes

The Partner Preference Questionnaire showed a significant increase in the number of students who included their partner (Chi-Square = 37.0, p <.01). Before the experiment, eighteen students included their eventual partners on the Partner Preference Questionnaire. Following the experimental treatments, twenty-three more students listed their assigned partners as a preferred partner while only two people removed their partner from the list. In one of the two cases, in which the partner was initially listed but was not listed following the experimental treatment, notes recorded during the experiment indicate that strong negative social interaction occurred between the partners at the beginning of the first day.

Correlation Analyses

Correlations between Interaction Rate and overall achievement were analyzed to determine the relationship between collaboration and achievement (r = .20, p =.024). Furthermore, correlations between Interaction Rate and overall achievement were further examined to determine whether the relationship varied according to Persistence Level. This analysis indicated that the relationship was significant only for the low persisters (r = .47, p =.003).

Discussion

The purpose of this study was to examine the effects of persistence on students' ability to interact and learn in cooperative learning groups. In addition, the study assessed the effect of collaboration on students' attitudes toward their partners. Results indicate that although persistence did not affect achievement, persistence did influence the amount and nature of interaction in groups.

Average persisters interacted more frequently than did either high or low persisters. One possible explanation for this finding is that average persisters are more able and consequently less apprehensive about verbal interaction than other students. Carrier and Williams (1988) found a curvilinear relationship between persistence and achievement indicating that average persisters are more able than high and low persisters. Average persisters apparently used their better developed metacognitive skills to judge the optimum level of effort to invest. Higher metacognitive ability may also increase self-efficacy, allowing individuals to benefit from group activities. Students who display characteristics of low apprehension "... have well developed social skills, are outgoing, enterprising, original, verbally fluent, and fluent in thought. They possess self-assurance, and are spontaneous, expressive, and enthusiastic." (Bouchard, 1969). Consequently, students with higher levels of metacognitive ability may be more willing to engage in group interaction.

As expected, a significant positive relationship was found between the positive verbal interaction rate and achievement. However, the magnitude of the relationship is lower than that observed during other studies (e.g. Hooper, 1991; Webb, 1982c). Further investigation revealed that the relationship between verbal interaction and achievement was significant for low persistence students only. Even though low persisters interacted significantly less than average persisters, the interaction rate was a much better predictor of success for low persisters than for others.

The results of the Partner Preference Questionnaire were particularly interesting. Students were asked on two occasions to name up to five class members with whom they would like to work in a cooperative group. The first occasion was before students had completed any of the lesson materials and the second was immediately before completing the posttest. Two students who originally named their partner did not rename that individual on the follow-up survey. However, twenty-three students who did not originally name their partners did so following the group activity. In other words, an individual was significantly more likely to be named as a desirable partner after collaborating. This results support the notion that collaboration breaks down social barriers and helps to improve interpersonal relations among students. Similar results have been observed in many other cooperative learning studies. For example, Sharan and his associates (Sharan, 1980; Sharan, Kussell, Sharan, & Bejarano, 1984) have reported that cooperative learning improves students' self esteem and their attitudes toward peers and school work. Similarly, Johnson and Johnson (1989) indicated that promotive interaction among partners during cooperative learning produces a positive psychological climate and increases attraction toward one another.

Many teachers use cooperative learning to improve students' attitudes toward each other. However, the result of the present study is noteworthy because of the limited exposure to partners experienced by participants. Students worked with their partners on two occasions, generally for less than one hour in total. Apparently, even limited exposure to other students in a meaningful learning environment has the potential to enhance students attitudes toward each other.

Further research is needed to examine how students attitudes toward their partners evolve. One common approach employed by teachers involves changing group members frequently to avoid potential conflict between members. Yet, in practice, groups may become more cohesive and effective with experience. Charrier (1972) outlined a model of group development through which effective groups pass. Groups typically move through five stages of development: forming, storming, norming, performing, and adjourning. Storming is perhaps the most significant evolutionary stage, because by expressing and working through this stage of intense conflict, group members begin to assume the responsibility of managing the intra-group functions and dynamics (McClure, Miller, & Russo, 1992).

In the present study many partners apparently warmed-up to each other during the second day and became very active in their verbal elaboration of the content. For example, one group that began negatively appeared to work through their differences. One student dominated the mouse at the beginning of the first lesson and refused to select additional examples despite her partner's protest. However, the more persistent partner continued to seek elaborative information and the previously negative partner appeared to develop greater interest in the lesson content.

Furthermore, students attitudes toward their partners are likely to reflect the quality of intra-group interaction. Nine of the interaction rating forms included comments from raters concerning how well the members were elaborating on the lesson content. These nine groups contributed six of the twenty-three posttest partner preference conversions discussed previously.

Not all interactions within groups were positive. Despite being given explicit instructions and practice in how to interact in groups, some partners did not interact effectively. Indeed, some students were openly hostile toward their partners on both days. For example, on the first day one group member only pointed at the computer screen and did not interact verbally. On the following day, the silent member did not consult his partner and said loudly "Don't" when his partner tried to use the keyboard and then dominated the mouse and keyboard during the rest of the lesson. Students who fail to interact effectively are less likely to reap the potential affective benefits of cooperative learning.

Unexpectedly, the study also produced a gender effect for achievement. Males scored significantly higher on both posttests than did females. One possible explanation for this finding concerns the males' tendency to dominate the learning environment. Informal observations of the videotapes indicated that males tended to monopolize the computer and keyboard. For example, in one case, objections from a female were ignored by the male until the lesson was virtually complete. If these limited observations reflect a practice that occurred throughout the study, then females may have been alienated toward the lesson resulting in poor encoding of lesson content and poor posttest achievement.

Further research is needed to analyze intra-group interaction. Dynamic group interaction is difficult to measure accurately. In the present study, video tapes of the group sessions provided an opportunity for in depth observations. In future, however, research approaches that emphasize qualitative methodologies may be particularly helpful.

Further research is needed to test the hypothesis that grouping negated the effects of persistence. Although the initial persistence scores of students working alone appear to be very similar to those obtained in the original study, achievement scores failed to replicate the curvilinear relationship between persistence and achievement found by Carrier and Williams (1988). Furthermore, the type and frequency of interaction among different levels of persisters warrants further investigation.

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Table 1. Means and Standard Deviations by Persistence Level

		Interaction Rate	Concept Learning	Problem Solving
Persistence Level				
High				
Heterogeneous	M	2.68	13.64	2.08
	SD	1.28	7.23	1.38
	N	25	25	25
Homogeneous	M	2.55	15.89	2.57
	SD	1.09	6.65	1.40
	N	26	28	28
Total	M	2.62	14.83	2.34
	SD	1.18	6.95	1.40
	N	51	53	53
Average				
Heterogeneous	M	3.26	15.04	2.19
	SD	1.48	6.39	1.30
	N	26	26	26
Homogeneous	M	3.43	12.13	1.88
	SD	1.35	6.55	1.63
	N	16	15	16
Total	M	3.33	13.98	2.07
	SD	1.41	6.52	1.42
	N	42	41	42
Low				
Heterogeneous	M	2.67	15.44	2.22
	SD	1.13	6.00	1.54
	N	23	23	23
Homogeneous	M	2.62	13.81	1.75
	SD	1.26	7.38	1.48
	N	16	16	16
Total	M	2.65	14.77	2.03
	SD	1.17	6.56	1.51
	N	39	39	39

Title:

Effects of Learner Cognitive Styles and Metacognitive Tools on Information Acquisition Paths and Learning in Hyperspace Environments

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INTRODUCTION

Purpose

This study was designed to investigate the effects of the presence or absence of metacognitive skill tools available in the hyperspace on both field independent and field dependent learners. The learners were engaged in problem solving in an information rich hyperspace based on a lesson of the attack on Pearl Harbor. They were given the Group Embedded Figures Test (GEFT) in order to identify those who were predominately field independent and those who were predominately field dependent. The information acquisition paths that the learners took through the problem solving were automatically recorded and investigated. The students' solutions to the problem solving task were analyzed to determine the recall of the content and the level of the cognitive complexity based on the quality and the processes used to reach the conclusions. In addition, the amount of time spent on the key information (depth of information processing) was recorded within the audit trails so that the information processing time by different learners was identified as well. The significance of the research findings for instructional courseware designers as well as implications for future study is discussed.

Theoretical Framework

Metacognition and Learning

The theory of metacognition is concerned with the individual's awareness, planning and control over cognitive process and learning activities (Swanson, 1990; Haller, Child & Walberg, 1988; Flavel,1979). Metacognitive strategies such as teaching learners knowledge about what reading strategies to use and how and when/why to use them produce reading comprehension (Haller, Child & Walberg, 1988). In addition, studies indicated that subjects required to explain reasons for actions while solving problems demonstrated a positive transfer of tasks (Stinessen,1985). Lin (1993) compared metacognitive groups with cognitive, affective, and control groups. She found that metacognition had a significant positive impact on students' transfer of the problem solving tasks. It was suggested that metacognitive processes made students focus on and become consciously aware of the solution components. Because of this, learners were able to attend to information regarding the way to solve a problem. Unfortunately, it appears that metacognitive processes do not take place spontaneously. It requires the development of awareness of task, strategy, and performance (Wade & Reynolds,1989). Learners may also gain metacognitive skills through the teacher's modeling or guided practice (Billingsley & Wildman, 1990), prompted cues (Lin, 1993), or self-questioning (Wade & Reynolds, 1989). However, the existing instructional design models do not typically emphasize metacognitive strategies such as planning, monitoring, revising, and other self-regulating activities. (Osaman et. al. ,1992).

Field dependence/field independence

Cognitive style refers to an individual's characteristic approach(es) to perceiving, processing, and organizing information. It was proposed that the construct field-dependent/independent is one of the cognitive styles most significant to education problems and has been more extensively researched (Chinnien & Boutin, 1993). Research indicated that the field independent style is mostly related to the ability to perceive a particular relevant item in a "field" of distracting items. Conversely, field dependent people tend to be dependent on the total field and hence the parts embedded within the field are not easily perceived (Brown, 1987). As a result, compared to field independent learners, field-dependent individuals are more likely to have greater difficulty in learning when the learner himself/herself is required to provide organization as an aid to learning. (Wiktin, Moore, Goodenough & Cox, 1977). Davis (1989a) added in a review of studies on field-dependence that the field-dependent learner is more reliant on salient cues in learning. Davis further suggested incorporating metacognitive skills into future learning research of field-dependence/independence (Davis, 1989b).

Navigational paths of information in hyperspace

Hypermedia systems integrate text, sound, graphics, and video (Aversman, 1993; Wang & Jonassen, 1993) to present the knowledge within the network of ideas or use nodes and links to organize structure (Spiro & Jehng, 1990). The emergence of hypermedia has fostered the computer based learning a much freer and richer environment which provides freedom to the user to explore (Staton & Barber, 1992). Unlike traditional learning environment, it appears that hypermedia learning is self-directed. With this system the responsibility for identifying what is useful information and selecting search strategies for accessing that information is largely left up to the user (Small & Grabowski, 1992). Therefore, the learner or the user is required to interact and explore the information by developing their own paths or knowledge structure.

Due to the user-oriented nature of hypermedia, the learners need to decide where to retrieve information, what strategies to use for problem solving, and why or when to quit the environment. It is thus believed that metacognitive knowledge and skills are essential for successful in hypermedia system (Lin, 1993) because in the metacognitive process the learners need to plan for cognitive actions, monitor their progress, and reflect upon and regulate their own learning process (Rowe, 1988; Cardelle-Elawar, 1992). While it was proved that metacognition played an important role in oral comprehension, reading comprehension, problem solving, memory and the like (Flavel,1979), the research findings also showed that incorporated metacognitive strategies in hypermedia learning would enhance problem solving and transfer of tasks (Lin,1993).

The literature has shown that the hypermedia system eliminates linear linkage of text and allows users to freely browse through a knowledge base (Nelson & Palumbo, 1992). Yet, it has been observed that learners' motivation may be impaired if they become overwhelmed by the freedom in the hypermedia environment (Staton & Barber,1992). The recent development of hypermedia has henceforth put more concern on issues of navigational problems and the search strategies by different individuals. Jonassen (1988) advocated that it is important to investigate how learners navigate through hypermedia systems and how individual differences could predict those paths.

In concert with the above concerns, the present study demonstrates the significance of studying how field dependent and independent learners interact with the hypermedia system. It is especially important to explain whether metacognition plays an influential role for individual differences in cognitive style if the individual is cued to consider, as well as, evaluate his or her thoughts by an available tool to process metacognition during the problem solving process in a hyperspace environment.

Statement of research problems

This research study aimed to investigate how field dependent and field independent people respond to the presence or absence of metacognitive skill tools in information-rich hyperspace. The hyperspace is defined here as loosely structured hypermedia where text, charts, document, and graphics were integrated and hyperlinked (Chung, Frederick, Hsu, 1994). In the hyperspace environment, the expert structure was not created by the developers or programmers. The subjects were expected to bring their own expert systems of structure to solve the problem. This research investigated the following research problems

1. Will the presence of metacognitive skill tools have an effect on field dependent or field independent learners' recall of content and level of thinking process while providing solutions to the problems?
2. Will the presence of metacognitive skill tools have an effect on field dependent or field independent learners' depth of information processing?
3. Will the presence of metacognitive skill tools have an effect on field-dependent or field independent learners information seeking paths?

Significance of the Problem

The infusion of computer-based interactive hypermedia into instructional environments has made a dramatic change in education. Since then, the professionals have been investigating how interactive hypermedia materials might be designed so that they are developmentally appropriate. Jonassen (1988) proposed his insight into maximizing the hypertext learning. He said that a path analysis program needed to be developed to identify any prominent access path learners take through hypermedia environments. He also suggested relating the access paths to different learning styles. The advocation by Jonassen serves the basis of rationale for this study.

Aust and Klayder (1990) have a concern about an overabundance of information and predict that it may result in "information anxiety or knowledge starvation". In fact, often learners have a tendency to become lost or disoriented while using hypermedia environments. Specifically, it was found that "individuals often encounter loosely-structured information environments wherein there are no clear questions to be answered" (Chang & McDaniel, 1993). It is suspected that this problem could be related to a variety of learner characteristics. It is possible that the "learners lost in hyperspace" may be predominantly field dependent learners since field dependent people have difficulty with providing organization to learning (Wiktin et. al., 1977). In particular, it is predicted by the researchers that field dependent people may become efficient learners if metacognitive tools are provided in the hyperspace environment. Based on the research assumptions, it is important to prove the hypothesis to determine if the integration of metacognitive skill tools is a viable method for developing a better hyperspace environment for different learners. Moreover, since hyperspace is a loosely-organized hypermedia, the students are not provided with "expert structure" to the system. Conversely, the students need to develop their own structure of navigating, seeking and processing information in hyperspace. The findings of this study would have significant contribution to determine what an expert's structure is and thus help to develop a hypermedia learning environment.

METHODOLOGY

Subjects

Forty undergraduate students who were registered in an introductory computing course at a midwestern university participated in this study. The students automatically earned credits toward their course grade for participation. There were two males among the subjects. There was one subject whose ethnic origin was Asian and the rest were Caucasians. The computer experience reported by the subjects varied from fair to excellence. The familiarity of the research content, Pearl Harbor, ranged from fair to average.

Material I

In this study, a lesson called "Asleep at Dawn--The Attack on Pearl Harbor" was constructed on a Macintosh Hypercard stack by one of the researchers. This lesson provides a wealth of information about the Pearl Harbor attack. The content materials were based on the following books: *Pearl Harbor Final Judgment* (Clausen, H. & Lee B., 1992), *America Goes to War 1941* (Devaney, J., 1991), *And I Was There* (Layton, E. at el. 1985), *Pearl Harbor* (Shapiro, W. 1984), and *79th Congress of United States of America* (1946).

The materials were presented with the following distinctive features. First, the subjects were provided the introduction to the lesson. They were requested to play a role as an investigator to investigate the events surrounding the bombing of Pearl Harbor. Second, the main body of information about the Pearl Harbor attack was presented via hyperlinks (Appendix I). There are twenty topics that can be chosen from the main menu. Access to information chosen by the individual reflects his or her own paths and speed of searching for information among the topics. The subjects could quit whenever they felt they had enough information for the conclusions of their investigation. Third, there is a menu topic called "Four Key Questions" embedded in the main menu. The "Four Key Questions" comprises four questions which serve as guided clues to stimulate the subjects' critical thinking. In addition, a menu called "Mission" was created and placed on the menu bar. The "Mission" menu describes the tasks that the subjects need to accomplish throughout the Pearl Harbor lesson. Fourth, there are some cards with three asterisks labeled to denote that these cards contain key information for answering questions in the conclusions. Fifth, there are two questions posed in the conclusions where the subjects needed to determine the critical events that caused the attack and whom should be blamed. When the subjects clicked "Done" on the menu, the conclusion screen was provided and the subjects needed to supply their answer. This stack also includes a path tracking mechanism which records simultaneously the paths chosen by the subjects and time used by the subject for each level of information access.

In this study, even though either the "Four Key Questions" or "Mission" function as guidance which will help the subjects form an expert's knowledge structure in the hyperspace, the subjects were not particularly informed about why and when to get access to this information.

Material II

This lesson has everything covered in Material I except that Material II has metacognitive tools available on the menu bar called META. The META tools posed four different questions at one time. For each selected question, the subjects were prompted to enter their plans for the investigation and their reason for this particular plan (Appendix II). The plan and reason are not the answer to the question being posed but rather the students' current thought and actions taken to accomplish the investigating task. In other words, the questions were intended to help the subjects structure their paths of searching the information. The subjects had to check the META menu periodically until all four questions were selected. Unlike Material I, subjects using Material II were required to use the expert questions and to enter their metacognitive processes in terms of their plans and reasons for the plans.

Data Collection

Independent Measures

The Groups Embedded Figures Test: The Group Embedded Figures Test was administered before the treatment to measure the learners' cognitive styles. The GEFT has been used widely as a valid and reliable instrument to assess the cognitive style (Small & Grabowski, 1992).

Treatment Conditions: The subjects were randomly assigned to different treatment conditions during the hyperspace problem solving session.

1. Field dependents with metacognitive tools available (Experimental group).
2. Field independents with metacognitive tools available (Experimental group).
3. Field dependents without access to metacognitive tools (Control group).
4. Field independents without access to metacognitive tools (Control group).

Dependent Measures

This study attempted to investigate the effects of the presence or absence of metacognitive tools in the hyperspace environment on field dependents' and field independents' recall of content, level of cognitive process, depth of information process, and information seeking strategies.

1. Recall of content: The conclusions provided by the subjects were evaluated from two aspects: recall of content and level of cognitive process. A checklist of the critical events which caused the Pearl Harbor attack, or key characters who should be responsible for the surprise attack was developed by the stack developer as the scoring criteria for the recall of the content.

2. Cognitive complexity: The approach to scoring subjects' cognitive complexity on conclusion was to read them holistically and examine the reasons supporting their position. The conclusions were rated on a scale of one with simple description of the fact to five with integrated analysis of learning content. This rating scale was used to determine the cognitive complexity which was developed by McDaniel and Lawrence (McDaniel & Lawrence, 1990). Due to the subjective nature of essay tests, two independent scorers were involved to gain interrater reliability in scoring.

3. Depth of information processing was determined by time spent on each key information denoted by three asterisks. The key information was considered providing useful content for drawing conclusions of investigation.

4. Information Seeking Strategies were identified by the mean time learners spent on searching for a topic, the subjects' frequent use of the "Mission" menu and "Four Key Questions" as monitoring guidance, and descriptive data of the subjects' audit trails to reveal individual's navigational patterns. Qualitative analysis of the subjects' exit questionnaire was conducted as a support of the empirical data.

Pilot Study

Before the actual experiment, a pilot study was administered to confirm that no problems existed in the hypercard program or in the exit questionnaire. A student with similar background of the anticipated subjects volunteered to participate. Some minor changes were made according to the results of the pilot study.

Procedures

The whole experiment is divided into two sessions held on different days. The first session was scheduled for assessing the students' cognitive styles. The whole process of assessment was timed based on the instructions in the manual. Based on the scoring result, forty subjects (field independency =20; field dependency= 20) were selected and randomly assigned to one of four different experimental conditions. The experiment proceeded in the same location but different rooms for control and experimental groups respectively. Before beginning the lesson, all students were given a group orientation to the lesson by the researchers. The subjects were briefed on the use of buttons in hypercard and their mission throughout the lesson. People in the experimental group were also told to use the metacognitive tools available on the menu bar. Once instructed to start, the subjects in both groups worked individually in separate rooms. The whole computer lesson lasted approximately from one to one and half hours. Upon completion of the lesson, the subjects filled out an exit questionnaire.

Data Analysis Tools

The subjects' audit trails of working with the hyperspace were collected and analyzed by a statistical software package called StatView SE+. ANOVA tables were obtained to determine the main effects and the interaction between the two independent variables on the dependent variables. In addition, a thorough examination of the subject' paths and self-reported searching strategies were analyzed through a qualitative approach.

RESULTS

Recall of the Content

The ANOVA table concerning students' recall of content are presented in Table 1. The mean scores between the groups that received the metacognitive tools and those who do not have the access are not significantly different ($F=1.054$, $p=.3107$). Students performed similarly on the recall of content regardless of the availability of the metacognitive tools in the hypermedia learning, however, a significant main effect was found for the cognitive styles ($F=6.475$, $p=.015$). The field independent people outperformed the field dependent people in recalling the content. No interaction between treatments and cognitive styles was found.

Cognitive Complexity

A significant main effect was found for the treatments (Table II). Students who are not provided with metacognitive tools demonstrate a higher level of thinking in drawing conclusions than those who have access to the metacognitive tools ($F=4.523$, $P=.0397$). The mean scores of the field independents are found to be significantly higher than the field dependents ($F=8.551$, $P=.0057$). No interaction exists in this particular dependent variable.

Depth of information processing

There is no main effect found in the depth of information processing (Table III). Students spent approximately the same amount of time processing the key or critical information regardless of the cognitive styles or treatments that students were receiving. It was found, however, that there is correlation existing between the recall of content and the number of cards that had been read ($r=.265$, $p<.05$)(Table IV a). The students' level of cognitive complex shown in the conclusions is also correlated with total cards that were read ($r=.294$, $p<.05$) (Table IVb.).

Information Seeking Strategies

The searching strategies were studied from three perspectives: time on searching (how much time was spent on deciding on a topic), frequent use of monitoring or guidance (how often did the students check the "Mission" menu or "Four Key Questions") and navigational patterns (in what order the topic was accessed). No statistical main effects were found between the groups in spending time in deciding a topic from a variety of options on the main menu (Table V).

Even though no significant result was indicated on the frequent use of monitoring between the groups, there was a moderate difference in the use of monitoring by field independents and dependents ($P=.081$, $p<.1$)(Table VI). The field dependent people tended to constantly check their instructional objectives (Mission) and using guidance (Four Key Questions) more often than did the field independents throughout the hyperspace problem solving session.

As the subjects' audit trails were analyzed, a detailed picture of the navigational patterns emerges. There were three most prevalent navigational patterns: 1. Linear access: The subjects chose the topics on the main menu in the order of top to bottom or left to right (as defined by Small et. al., 1992; Chung et. al., 1994) 2. Non-linear access: The subjects chose the topics without any distinctive structured manners. The orders were jumped around. 3. Cycle access: The navigation in the hypermedia falls into a cycle pattern. The subjects kept going back and forth among the chosen topics. The navigational patterns only reveal the individual preferences of information access. The finding did not indicate that particular patterns emerged due to differences in cognitive styles or the manipulation of the treatments. It is worthy of notice, however, that five out of the top eight people who scored both high on recall of content and cognitive complexity tended to navigate linearly in the hyperspace.

Exit Questionnaire

Self reported searching strategies: In addition to the quantitative data, data gathered from the questionnaire were analyzed to provide an in-depth and valid interpretation of the students' information searching strategies. The major assertion generated from the students' report was that they selected the paths based on the condition that the information was vital to provide valuable knowledge for their conclusions.

> *"I chose what seemed to be the next important information."*
> *"I asked myself what kind of information I am going to find, how this information would help me in finding out more about the attack."*
> *"I chose the next path if it seemed like the information would be helpful for me in solving this problem"*

Another common strategy employed by the students was that they chose the paths which contained information pertinent to what they had previously known.

"(I chose the path based on) what I have previously found out"
"It seemed important to choose the next item that was somewhat related to the one I just looked at"

The use of the metacognitive process demonstrate an indicator of the students' strategies for searching information. The students' plans and explanation for planning revealed what is the next path she or he is going to take.

"I plan to find out what Pearl Harbor knew about what the Japanese were planning on doing. I want to do it this way so I can try to figure out why they withheld information about the intentions of the Japanese."

"I want to investigate on those individual leaders who seem to have some connection with the Japanese. If there was anyone in Washington that knew anything about the plans, I have to investigate all of the main people in charge of US operations. By looking indepthly at these various leaders, hopefully I can gain some clues on where information on Japanese plans"

In addition, there were some students who employed the guided questions to direct them to the next path.

"(I chose the next path for) gaining information that would provide answers to the questions."
"At first I wanted to find the important people. Then I just clicked around to find the answer to the key questions"

As expected, some people got lost in searching the information. These people did not demonstrate any strategies in their report.

"I was pretty random in my selection. Once again, I didn't have enough background information to have a real direction."
"Whether or not to go on"
"How to get back to the main menu."

Attitude toward metacognitive use: Descriptive data were obtained with regard to students' attitude toward the use of metacognitive tools in hypermedia. The assertion drawn from the analysis was that the students conceded that planning help them structure knowledge about the conclusions, yet, they found they were still not skillful at using their "working mind." Some comments related to this assertion are:

"Yes, I think that meta is people's working mind. It helped me form my ideas to write the conclusion, because it helped me formulate the questions that I wanted to ask at the end, and it also helped me write on the topic given."

"I do think it (metacognition) offered me some hints to get conclusion. However as far as the case "Pearl Harbor" was concerned, it's hard for me to make initial plans without a clear introduction. That is to say I need more knowledge about the background information. "

"I thought it (metacognition) was confusing, but I am not used to working on a computer, so it is all kind of strange. I think planning out your thoughts is very important, but I am just not familiar with the material or the computer"

DISCUSSIONS

Research findings in this study indicated that the use of metacognitive tools did not contribute to the students' better learning with hyperspace. On the contrary, when the students' cognitive complexity was evaluated based on their conclusions, the control groups outperformed the experimental group. In other words, the students did not benefit from planning or explaining their thinking process during the problem solving tasks. Through analyzing the students' protocols, one thing remains evident. It appears that the lack of prior knowledge about the lesson plays a vital role. Students' metacognitive process were carefully screened by looking through their plans and explanations. One student wrote all the way through in her planning: *"To get more information."* Another student expressed her opinion on planning, *"without background or introduction, it is very hard to form an initial plan."* When the student is lacking background knowledge, she or he will not have the knowledge foundation from which actual plans can be built up.

Small et. al. (1992) advocated that the decisions the students make are influenced by one or more personal or environmental constraints, such as prior experience, or the type or amount of information available. Their advocation demonstrated that the prior experience or knowledge brought by the students has influence on students' interaction with hypermedia learning. The implication of this result in this study is that there is a need for future research to investigate how to activate the students' prior knowledge or their "schemata" in the hypermedia learning environment.

Another explanation for the non-significant results of using metacognitive tools in the hypermedia could be that the students are still not familiar with the use of metacognitive strategies or are not used to employing the strategies in their learning. While some students felt that metacognition would help them form their knowledge structure, other students stated that they still did not know what metacognition was. This finding implies that more time on training student's metacognitive strategies is needed. Lin (1992) cites the work of DeStefano and Gordon (1986) and points out that the idea of training individuals to employ metacognition has been stimulated from the findings that many individuals cannot independently produce effective learning strategies or realize when, where and why to apply known strategies, but they can use learning strategies when instructed to do so. The length of time on training to achieve maximum outcome is still in need of investigation.

The findings do not indicate any significant difference in the depth of information processing between the treatment groups. This result implies that the learners spend the same amount of time on reading the information which will provide important clues for investigating tasks. The number of cards that the students went through; however, was correlated with the recall of the content and higher level of thinking process. In other words, the more the students spent time reading the information, the more the students could recall and the higher thinking level they were able to achieve. Future research which investigates how to motivate the learners to better spend their time in the task could definitely improve effective hypermedia learning.

The research finding shows that neither cognitive styles nor the experimental treatment (i.e. metacognitive tools) have an effect on students' navigational paths.

Both groups of people spent equal amount of time searching for a topic. Yet, the analysis of students' protocols show that the use of the metacognitive process helped the students structure their searching strategies. As to the navigational patterns, a trend indicates that people who are ranked in the top on their posttest (i.e. drawing a conclusion) tend to navigate linearly through the paths (i.e. to choose the topic in the order of top-bottom or left-right). Even though the trend needs more supportive empirical data or in-depth investigation of students' self-reported description, it appears that the assumption proposed by Spiro et. al.(1990) that linear organization may not permit or encourage the learners to learn by exploring in their full complexity requires further study . Since hypermedia are featured by the nonlinear structure, it is suggested to investigate how to organize the information in order not to discourage the students from a non-linear hypermedia environment especially when they are required to self-control the pace and paths.

Even though the field-dependent people constantly monitored the instructional goal or used guided questions relatively more often than did the independent people, the field dependent people did not demonstrate better performance in drawing conclusions. The reason behind this finding is unknown. Yet, Jonassen & Wang (1992) found out that the field independent learners were better hypertext processors, especially as the form of the hypertext became more referential and less overtly structured. With loosely-structured hypermedia like hyperspace in this study, Jonassen et. al.'s finding appeared to explain why field dependent people employed the monitoring strategies yet they still could not process the information as well as the field independents. The research findings by Weller et. al. (in press) could support the explanation for relatively poor performance of the field dependents as well. Weller et. al. pointed out that "field independent students learned computer ethics more effectively than did field dependent, even when field dependent students were provided with 'help' such as advance organizers and/or graphical organizers". As the researchers voice their concern about learner differences and hypermedia learning (Ginsburg & Zelman, 1988; Wang & Jonassen, 1993), there is a large research area left for those who are interested in hypermedia learning and learner characteristics to explore .

The use of hyperspace learning environment in this study helps to shape the instructional developers' view on how people bring their own knowledge structure into learning. The findings about the students' navigational strategies, paths of information processing in the system interacting with different cognitive styles and metacognition would be beneficial to the educators as well as courseware designers.

Table I: Effects on recall of the content

ANOVA table for a 2-factor Analysis of Variance on Y

Source	DF	Sum of Squares	Mean Squares	F-test	P value
Treatment (A)	1	12.023	12.023	1.054	0.3107
Cognitive Styles (B)	1	73.841	73.841	6.475	0.015
AB	1	19.114	19.114	1.676	0.203
Error	40	456.182	11.405		

The AB Incidence table on Y: Recall of content

	Dependent	Independent	Totals:
Meta	n=11 mean=4.364	n=11 mean=8.273	n=22 mean=6.318
Non-Meta	n=11 mean=4.636	n=11 mean=5.909	n=22 mean=5.273
Totals:	n=22 mean=4.5	n=22 mean=7.091	n=44 mean=5.795

*scores (0-31) on the conclusions for the recall ability

Table II: Effcts on cognitive complexity

ANOVA table for a 2-factor Analysis of Variance on Y

Source	DF	Sum of Squares	Mean Square	F-test	P value
Treatment (A)	1	5.818	5.818	4.523	0.04
cognitive Styles (B)	1	11	11	8.551	0.006
AB	1	3.273	3.273	2.544	0.1186
Error	40	51.455	1.286		

The AB Incidence table on Y: cognitive complexity

	Dependent	Independent	Totals:
Meta	n=11 mean=1.182	n=11 mean=2.272	n=22 mean=1.955
Non-Meta	n=11 mean=2.455	n=11 mean=2.909	n=22 mean=2.682
Totals:	n=22 mean=1.818	n=22 mean=2.818	n=44 mean=2.318

*scores (0-5) on the conclusions for cognitive complexity

Table III: Effects on depth of information processing

ANOVA table for a 2-factor Analysis of Variance on Y

Source	DF	Sum of Squares	Mean Square	F-test	P value
Treatment (A)	1	90.213	90.213	0.592	0.446
cognitive Styles (B)	1	46.25	46.25	0.303	0.585
AB	1	9.227	9.227	0.061	0.807
Error	40	6099.548	152.489		

Table III: Effects on depth of information processing (continued)

The AB Incidence table on Y: depth of information processing

	Dependent	Independent	Totals:
Meta	n=11 mean=24.317	n=11 mean=27.28	n=22 mean=25.797
Non-Meta	n=11 mean=22.366	n=11 mean=23.5	n=22 mean=22.933
Totals:	n=22 mean=23.34	n=22 mean=25.39	n=44 mean=24.365

*time (seconds) deveoted to reading relevant and key information

Table IVa: Correlation between number of cards (X) and recall of content (Y)

Count	Covariance	Correlation	R-Squared
44	76.07	0.265	0.07

Table IVb: Correlation between number of cards (X) and cognitive complexity(Y)

Count	Covariance	Correlation	R-Squared
44	27.121	0.294	0.087

Table V: Effects on time on searching for a topic

ANOVA table for a 2-factor Analysis of Variance on Y

Source	DF	Sum of Squares	Mean Square	F-test	P value
Treatment (A)	1	66.568	66.568	1.368	0.249
cognitive styles (B)	1	81.045	81.045	1.666	0.204
AB	1	32.618	32.618	0.67	0.4177
Error	40	1945.913	48.648		

The AB Incidence table on Y: time on searching for a topic

	Dependent	Independent	Totals:
Meta	n=11 mean=11.282	n=11 mean=6.845	n=22 mean=9.064
Non-Meta	n=11 mean=7.1	n=11 mean=6.107	n=22 mean=6.604
Totals:	n=22 mean=9.191	n=22 mean=6.476	n=44 mean=7.384

*time (seconds) deveoted to searching for a topic on main menu level

Table VI: Effects on the monitoring guidance

ANOVA table for a 2-factor Analysis of Variance on Y

Source	DF	Sum of Squares	Mean Square	F-test	P value
Treatment (A)	1	29.455	29.455	1.659	0.205
cognitive Styles (B)	1	56.818	56.818	3.199	0.081
AB	1	2.273	2.273	0.128	0.7224
Error	40	710.364	17.759		

Table VI: Effects on the monitoring guidance (continued)

The AB Incidence table on Y: monitoring guidance

	Dependent	Independent	Totals:
Meta	n=11 mean=7.717	n=11 mean=5	n=22 mean=6.364
Non-Meta	n=11 mean=5.636	n=11 mean=3.818	n=22 mean=4.727
Totals:	n=22 mean=6.682	n=22 mean=4.409	n=44 mean=5.545

*frequent check of guided questions and mission

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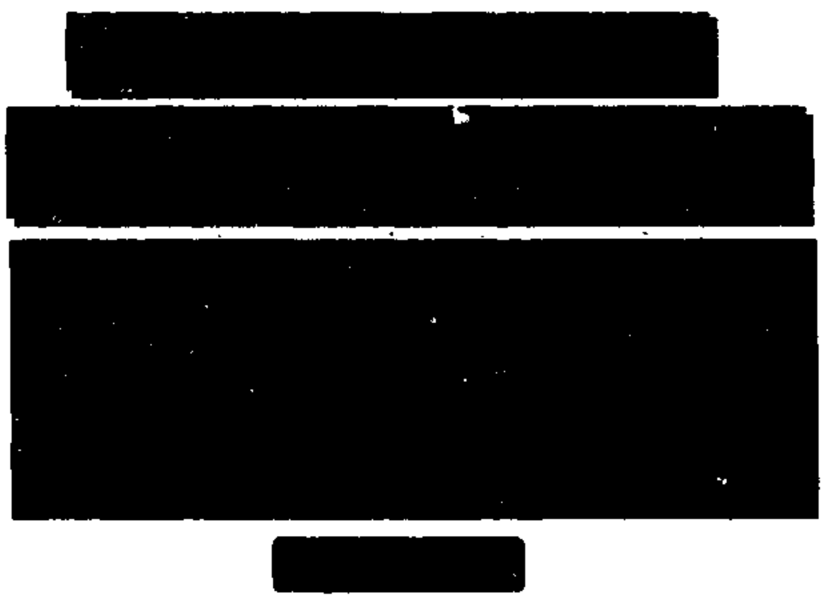
APPENDIX I

MAIN INFORMATION LEVEL

Key Questions	Leaders	Negotiations
Years Leading to War	Special Events of '41	1941 Calendar
Messages (U.S.)	Newspapers	Telegrams (Secret)
Hawaii Defenses	Maps	Japanese Battle Plans
Winds Codes	Japanese consulate in Hawaii	Attack Damages
FBI Hawaii	Doctrine of Military command	U. S. Intelligence
British Intelligence	Major Inquiries	DONE

APPENDIX II



APPENDIX II (continued)

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Title:

James D. Finn's Contribution to the Development of a Process View of Educational Technology

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History can be viewed as an interaction. It can be the interaction between the empirical and the hermenuetical (the goal-to understand), and the interaction of science and art, analysis and expression, description and interpretation, and events and thoughts.

This study is an intentional explanation James D. Finn's thinking which had an enormous influence on the development of the process view of educational technology. An intentional explanation focuses on the thoughts and conscious activities of an individual, or group of individuals, and examines the influence that these thoughts and activities had on later historical events and outcomes.

Finn's contribution to the development of the process view of educational technology can best be analyzed in light of his desire to upgrade the status of the audiovisual education movement to a professional field of study. Finn's influence on the first definition of the field in 1963 and his effort to change the name of the field to educational technology in 1965 are just some of the examples of his contribution to the process view of educational technology.

Finn covered much ground in his writing about the techniques of the field - the systems concept, the importance of programming, the difference between a scientific and an empirical approach to developing instruction -.to name but a few. But Finn's interest in the process view of the field can be traced to his earliest writings. In 1953 Finn evaluated the audiovisual field as a candidate for professional status. He identified six characteristics of a profession:

> (a) an intellectual technique, (b) an application of that technique to the practical affairs of man, (c) a period of long training necessary before entering into the profession, (d) an association of the members of the profession into a closely-knit group with a high quality of communication between members, (e) a series of standards and a statement of ethics which is enforced, and (f) an organized body of intellectual theory constantly expanded by research (Finn, 1953 p.7).

Of these six characteristics of a profession the two that were most important to the development of Finn's process view of educational technology were (1) an intellectual technique and (2) a body of intellectual theory expanded by research. In fact, Finn sought to have the intellectual technique of the field based on research and theory.

Finn (1953) argued that "the most fundamental and most important characteristic of a profession is that the skills involved are founded upon a body of intellectual theory and research" (p.8). Once he had established the importance of systematic theory and research for a profession, Finn further explained his position by saying that "...this systematic theory is constantly being expanded by research and thinking *within* the profession" (p.8). Finn was arguing that a profession conducts its own research and theory development to complement the research and theory that it adapts or adopts from other academic areas of study.

In 1953 Finn was generally satisfied that "the audiovisual member does possess an intellectual technique" (p.8), but it was not clear just what that technique was. Finn described the technique as thinking "reflectively in such varied areas as the critical evaluation of materials, the visualization of abstract concepts, the improvement of instruction, and in many aspects of planning and administration" (p.8). Finn did not further describe what he meant by thinking reflectively. It was not clear whether he was using the phrase as John Dewey had, in relation to the scientific method (Finn was certainly familiar with the work of John Dewey), or if he meant it as something altogether different. It seems likely that he meant it as the application of research and theory to professional practice.

But Finn believed that the audiovisual field was plagued by a "lack of theoretical direction" (1953, p.14). He attributed this to a general "lack of content" (p.14) in the field. He also charged that there was an absence of "intellectual meat" (p.14) in the meetings and professional journals of the field. In his argument promoting the development of a theoretical base for the audiovisual field, Finn warned that:

> Without a theory which produces hypotheses for research, there can be no expanding knowledge and technique. And without a constant attempt to assess practice so that the theoretical implications may be teased out, there can be no assurance that we will ever have a theory or that our practice will make sense (1953, p.14).

Finn spent much of his career rectifying this deficiency in research and theory in the audiovisual field.

Whether one agrees with Finn's criteria and reasoning about professions in general, or the audiovisual profession in particular, is not the issue here. What is important is that this argument was largely accepted by, and had a profound effect on, the leadership of the audiovisual field. It also established a direction for Finn's future research and scholarship. The view that technology was primarily a process was a favorite theme of Finn. Although he was the acknowledged leader of the early "educational technology is a process" movement (Heinich, 1968; Ely, 1970; AECT, 1977), Finn was not always consistent about the label that he used to describe what he meant by the complex processes involved in audiovisual education.

Finn's earlier writings (1955 1957) concentrated on the concept of automation in education. Analyzing the possibilities of automation for education, Finn wrote that "...automation is not a manless [sic], machine-operated production. *Its primary characteristic is a process - a way of thinking involving patterns and self-regulation* (my emphasis). It is here that the educational implications are tremendous" (1955, p.145).

Two years later Finn produced the first in a series of three articles about the potential for automation in education for *AV Communication Review*, "Automation and Education: General Aspects" (1957). In that article Finn identified the important characteristics of automation and its associated processes as: "..(a) the concept of systems; (b) the flow and control of information; (c) scientific analysis and long-range planning; (d) an increase in the need for wise decision making; and, (e) a high-level technology" (pp.115-116).

Initially, Finn considered automation to be an expansion, an outgrowth, of technology. The fifth characteristic of automation that Finn identified, that automation included "a high-level technology", showed that at this point in his thinking Finn drew a distinction between automation and technology. Soon, however, this distinction became blurred.

Finn frequently used the terms "technical" and "technology" in his early writings (1953, 1955, 1956). But it was in the early 1960's when Finn changed the focus of those educational processes which interested him from automation to technology.

Finn spent a substantial part of his professional life trying to dispel the image that technology was just machines. In 1960 (b) Finn wrote that "technology, however, is more than an invention - more than machines. It is a process and a way of thinking" (p.142). Continuing, Finn explained the relationship of technology to the instructional process by saying

> (one) must remember that, in addition to machinery, technology includes processes, systems, management, and control mechanisms both human and non human, and above all, the attitude discussed by (Charles) Beard - a way of looking at problems as to their interest and difficulty (broadly conceived) of those solutions. This is the context in which the educator must study technology (p.145).

In 1961 Finn made only minor revisions of his description of technology. In an article analyzing the audiovisual needs for the preparation of teachers, he argued that "technology...is much more than machines; technology involves systems, control mechanisms, patterns of organization, and a way of approaching problems" (Finn, 1961 p.209).

In opposition to the view that technology is a device or series of devices, Finn argued that machines were "symbols...and must be thought of in connection with systems, organizational patterns, utilization practices, and so forth, to present a true technological picture" (Finn, 1961 p.210). And later, as part of a speech delivered to the John Dewey Society in 1962, Finn said that "technology is not, as many of the technically illiterate seem to think, a collection of gadgets, of hardware, of instrumentation. It is instead, best described as a way of thinking about certain classes of problems and their solutions" (Finn, 1962 p.70).

In 1964 he wrote that "Technology is not just hardware-or even hardware and materials. Technology is a way of organizing, a way of thinking, involving at the center, to be sure, man-machine systems, but including systems of organization, patterns of use, tests of economic feasability "(1964, p.295).

In 1966 (b) he followed that with "Instructional technology [should] be viewed as defined in this paper-a complex pattern of man-machine systems and organizations based on concepts of feasibility" (Finn, 1966b, p.247).

It is unclear if Finn decided that technology, which in 1957 he considered a condition of automation, had to be determined and clarified as part of a desired automated state of education, or if Finn decided to change the label of the object that he was talking about all along, "automation" to "technology". In either case, there are certain themes which continued to appear throughout his writing.

There is a great deal of similarity and consistency about the way in which Finn described automation and technology. He argued that automation was a process and a way of thinking (1955, 1957) and that technology was a process and a way of thinking (1960b, 1961). He further stated that automation included systems, controls, scientific analysis and planning (1955, 1957) and that technology included systems, controls, and management and/or organization (1960a, 1961). Finn's discussions of scientific analysis and planning in automation (1957) are very similar to his discussions of management and organization included in technology (1961, 1962).

While Finn's descriptions of automation and technology remained similar over the years, there is one important facet that did seem to shift within Finn's writing on technology: the relationship of technology to problems. In 1960 (a) Finn viewed technology as "a way of looking at problems". In 1961 Finn stated that technology is "a way of approaching problems". It could be argued that "looking at problems" means defining problems, and that "approaching problems" means defining problems but also taking some action to solve a problem as well. The phrases "looking at problems" and "approaching problems" both infer a way to begin to solve problems. Both phrases infer a certain "attitude" (1960a) toward professional practice. This attitude would direct the intellectual technique of the profession.

In 1962 there is a not-so-subtle shift that occurs in Finn's outlook which carried on through his subsequent discussions (1965b, 1966b) of technology and problem solving. It was the view that technology is "a way of thinking about *certain classes* (my emphasis) of problems". It is clear in this statement that there were limitations to technology's problem solving ability. It seems to mean that technology either could not solve, or should not be used to solve, all problems. Considering Finn's optimistic view of technology one could easily conclude that his position prior to 1962 was that technology was essentially the technique which ould be used to look at or approach all educational problems.

It is difficult to assess what prompted Finn to make this further clarification in his position. Perhaps it was the fact that this 1962 statement was part of his address to the John Dewey Society. The prospect of talking with educational philosophers may have provided Finn with reason to reflect on his ideas concerning technology as a way of thinking. What is certain is that this shift in Finn's writing on technology remained for the rest of his professional life.

The implication of this shift by Finn is not recognized by those members of the field who describe educational technology as simply "a problem solving approach to education". It does not seem as if Finn intended educational technology to be viewed as an all encompassing approach to education as was inferred by later definitions of our field.

Another look at his analyses of technology reveals that even Finn, the great proponent of technology as process, conceded that machines and materials were a major part of instructional technology. This is best seen in his discussion (1965a) which was aimed at changing the name of the professional organization and the field to instructional technology. There he stated that "machines, materials, methods of use, [and] systems are all part of the pattern of rational mechanisms operating as means to educational ends. And, as Hoban has said, machines are central to this concept even though they alone are not technology" (Finn, 1965a, p.193). This statement is consistant with his prior writings on technology, all of which include machines as an essential component of technology. For Finn, it seemed that if there were no machines there could be no technology.

Conclusion

There are three conclusions which can be drawn from this brief exploration of Finn's writing about the intellectual technique of our field: 1) Finn was a man with a vision for his profession. But as is often the case those with long term visions they focus on broad ideas and do not always develop those ideas into specific concepts. This seems to be the case with Finn as we never get a specific statement of his definition of technology; 2) Finn changed his ideas over time , but so do we all. Here it is exemplified by his discusions on problems and the terms automation and technology; and 3) Finn may have been misinterpreted by others in our field. What is certain is that ideas which he himself articulated were changed or reoriented by the membership of the field. This is simply a playing out of the premise that ideas change over time.

No matter how one views his writing and his influence on the development of educational technology Finn had the long range vision which gave direction to his work, and he had the drive to gain that direction- to professionalize the audiovisual field.

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Note: The articles, reports, and chapters written by Finn that are listed above include the page numbers of the documents which were from the original source of these publications. However, many of the quotes cited above use the page numbers from the book *Extending Education Through Technology, selected writings by James D. Finn* edited by Ron McBeath, AECT, Washington D. C. 1972. This volume is a compilation of the best of Finn's writing and has been very useful in my research. I have checked many of the papers of this volume against the original and finds them to be most accurate. For practical puposes, in this study I have used that volume instead of many of the original articles.

Finn's six characteristics of a profession:

(a) an intellectual technique,

(b) an application of that technique to the practical affairs of man,

(c) a period of long training necessary before entering into the profession,

(d) an association of the members of the profession into a closely-knit group with a high quality of communication between members,

(e) a series of standards and a statement of ethics which is enforced,

(f) an organized body of intellectual theory constantly expanded by research (Finn, 1953 p.7).

The two that were most important to the development of Finn's process view of educational technology were (1) an intellectual technique and (2) a body of intellectual theory expanded by research. In fact, Finn sought to have the intellectual technique of the field based on research and theory.

Quotes

"...automation is not a manless [sic], machine-operated production. *Its primary characteristic is a process - a way of thinking involving patterns and self-regulation* (my emphasis). It is here that the educational implications are tremendous" (1955, p.145).

"..(a) the concept of systems; (b) the flow and control of information; (c) scientific analysis and long-range planning; (d) an increase in the need for wise decision making; and, (e) a high-level technology" (1957 pp.115-116).

"technology, however, is more than an invention - more than machines. It is a process and a way of thinking" (1960, p.142). Continuing, Finn explained

> (one) must remember that, in addition to machinery, technology includes processes, systems, management, and control mechanisms both human and non human, and above all, the attitude discussed by (Charles) Beard - a way of looking at problems as to their interest and difficulty (broadly conceived) of those solutions. This is the context in which the educator must study technology (1960, p.145).

"technology...is much more than machines; technology involves systems, control mechanisms, patterns of organization, and a way of approaching problems" (Finn, 1961 p.209)...machines were "symbols...and must be thought of in connection with systems, organizational patterns, utilization practices, and so forth, to present a true technological picture" (Finn, 1961 p.210).

"technology is not, as many of the technically illiterate seem to think, a collection of gadgets, of hardware, of instrumentation. It is instead, best described as a way of thinking about certain classes of problems and their solutions" (Finn,1962 p.70).

"Technology is not just hardware-or even hardware and materials. Technology is a way of organizing, a wav of thinking, involving at the center, to be sure, man-machine systems, but including systems of organization, patterns of use, tests of economic feasability" (1964 P.295)

Instructional technology [should] be viewed or defined in this paper-a complex pattern of man-machine systems and organizations based on concepts of feasibility and that proposals centering on hardware and materials be required to show some understanding of this concept on an operational basis. (Finn, 1966 p.247)

"This has resulted in a technological or empirical approach to solving practical problems of teaching and learning " (1966, p.283)

Conclusions

1) **Finn was a man with a vision for his profession. But as is often the case those with long term visions they focus on broad ideas and do not always develop those ideas into specific concepts. This seems to be the case with Finn as we never get a specific statement of his definition of technology;**
2) **Finn changed his ideas over time. This is exemplified by his discusions on problems and the terms automation and technology, but so do we all;**
3) **Finn may have been misinterpreted by others in our field. What is certain is that ideas which he himself articulated were changed or reoriented by the membership of the field. This is simply a playing out of the premise that ideas change over time.**

No matter how one views his writing and his influence on the development of educational technology, Finn had the long range vision which gave direction to his work and he had the drive to gain that direction- to professionalize the audiovisual field.

Title:

Effects of Instructional Elements in a Cooperative Learning Setting

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In recent years, Educational Technologists have examined how to implement cooperative learning strategies in settings that were originally designed for individual learning. Classroom research generally indicates positive results in favor of cooperative learning (Johnson & Johnson, 1989, Sharan, 1980; Slavin, 1990). However, research that examines how to implement cooperative learning with media has produced mixed results. Some researchers report that cooperative learning positively affected performance in CAI lessons (Dalton, Hannafin, & Hooper, 1989; Johnson, Johnson, & Stanne, 1985), while others have not found a significant effect for performance when learners used cooperative CAI (Carrier & Sales, 1987). Research on cooperative learning and instructional television suggests that when compared to individual strategies, cooperative learning does not always increase learning and motivation (Klein, Erchul, & Pridemore, 1993). Other studies report that performance in these settings is influenced by one's affiliation motives (Klein & Pridemore, 1992).

Results obtained from using cooperative learning with media may be influenced by the instructional strategies employed in these studies. Different instructional elements incorporated within lessons could influence the effectiveness of using cooperative learning with these media. Two instructional elements which may influence the success of cooperative learning with media are orienting activities and practice. Both have influenced learning outcomes in a variety of settings (e.g., Ausubel, 1960; Ho, Savenye, & Haas, 1986; Phillips, Hannafin, & Tripp, 1988; Salisbury, Richards, & Klein, 1985).

The purpose of the current study was to investigate the effects of orienting activities and practice on performance and student behaviors in a cooperative learning environment.

Method

Design. A 2 X 2 factorial design was used in this study, with orienting activity (advance organizer versus objectives) and type of practice (verbal information versus intellectual skill) as the independent variables. The dependent variables were achievement and student behaviors.

Subjects. Subjects were 80 graduate education majors (16 males, 64 females) at a large southwestern university enrolled in a required course in educational psychology. Subjects were stratified by sex and randomly assigned to one of 16 cooperative learning groups. Each group was constructed to include one male and four female students. Each group was randomly assigned to one of four instructional treatments (advance organizers/information practice, advance organizers/skills practice, objectives/ information practice, objectives/skills practice).

Materials & Procedures. All groups received three instructional television lessons from the series Instructional Theory: A nine lesson mini-course (Gerlach, 1973). Each lesson included a videotape and a workbook that provided instruction on the topics of stating objectives, developing assessment items, and designing effective practice activities. Each videotape was divided into several segments which presented information and examples on the content of the lesson. After each segment, the videotape instructed subjects to turn to a workbook for practice and feedback on the content presented in that segment. Variations in the materials occurred in the workbooks. Each workbook provided either an advance organizer or a list of instructional objectives for the lesson. The advance organizer provided students with an overview of the lesson for that day. The following is an example of the advance organizer provided to students for the lesson on writing objectives.

Perhaps the best known component of the systematic approach to instructional design is the instructional objective. Since the early 1960's, many educators have written instructional objectives. An objective is a statement of what students will be able to do after they have completed a unit of instruction. In this lesson you will be learning how to use objectives in order to improve your instruction.

The other set of workbooks provided a specific list of the instructional objectives for each lesson. The following is an example of the objectives provided to students for the lesson on writing objectives.

1. Explain why well stated objectives are essential to the development of effective instruction.
2. Identify examples of properly stated objectives, given examples of properly and improperly stated objectives.
3. Name the desired characteristics of objectives that are missing, given an improperly stated objective.

The workbooks for each lesson also differed on the type of practice given after each video segment. Eight of the 16 cooperative learning groups used workbooks that provided practice on verbal information presented in each videotape. The other eight groups used workbooks that provided practice on the intellectual skills. For example, Segment 4 of the lesson on objectives-based assessment provided information and examples on paper-and-pencil tests, interviews, and observations of student performance or product. Practice on the verbal information for this segment required students to summarize the key information in the videotape by listing the three types of objectives-based assessment. Practice on the intellectual skills for this segment required students to describe the best type of objectives-based assessment for the objective of sculpting a human head based on criteria discussed in an art class. After each practice question, written feedback was provided.

Students were provided with each lesson over three consecutive days. While students worked through the lesson, an observer watched the groups and recorded student behaviors Three days later, each student completed a constructed response posttest in their regular class to evaluate individual student mastery of the three lessons.

Criterion Measures. A paper-and-pencil posttest that consisted of 22 short-response items was used to measure performance. This posttest was divided into two sections. The first section contained 14 intellectual skill items to evaluate application of lesson content. The second section of the posttest contained eight verbal information items to evaluate knowledge of lesson content. Both sections of this test were worth a total of twenty points each. Individual answers to each item were checked against a scoring key and points were assigned for each response. An item was worth one point unless it required a multiple response. One person scored all of the items on this test. The Kuder-Richardson internal-consistency reliability of the posttest was .74 for subjects in the present study.

Student behaviors were observed during each of the three lessons and field notes were recorded by two observers. After data collection had occurred, a classification scheme for the field notes was developed based on research findings from Webb (1982, 1987). Webb suggested that student behaviors in small groups can involve on-task versus off-task interactions, helping behaviors, and working alone. The classification scheme developed for the current study identified four sets of student behaviors, including (1) helping behavior (asking for help, giving help when asked, giving unsolicited help), (2) on-task group behavior (taking turns, sharing materials, group discussion of content), (3) on-task individual behavior (assuming control, taking notes, working alone), and (4) off-task behavior (talking to other about something unrelated to the lessons and non-verbal actions such as reading a newspaper).

Using this classification scheme, both observers examined all of the field notes to calculate the total number of times these behaviors occurred for each of the 16 cooperative learning groups. Reliability of observations was based on both observers having similar totals for each set of student behaviors. The inter-rater reliability between observers was .84 for helping behaviors, .84 for on-task group behaviors, .79 for on-task individual behaviors, and .82 for off-task behaviors.

Data Analysis. MANOVA was used to analyze performance data. Individual student scores on both sections of the posttest were combined for this analysis. MANOVA was followed by univariate analyses on the knowledge and application portions of the posttest. Alpha was set at .05 for these statistical tests. MANOVA was also used to analyze each of the four sets of student behaviors. These behaviors were considered as a group-based measure in these analyses since a combined score was obtained for subjects in each cooperative learning group. Alpha was set at .05 for the multivariate tests. MANOVA was followed by univariate analyses on the student behaviors in a set. To account for the possibility of inflated statistical error, alpha was set at .015 for the univariate analyses.

Results

Performance. MANOVA revealed a significant interaction between orienting activity and type of practice, [$F(2, 70) = 3.87$, $p < .05$]. Univariate analyses revealed that the interaction was significant for the knowledge portion of the posttest, [$F(1, 71) = 4.70$, $p < .05$]. This interaction was disordinal in nature. Sheffe' multiple comparison tests revealed that subjects who received objectives and information practice obtained significantly more knowledge ($M = 11.6$) than those who received advance organizers and verbal information practice ($M = 9.4$), [$F(3, 75) = 3.27$, $p < .05$]. Sheffe' tests also indicated that subjects who received objectives and information practice obtained significantly more knowledge ($M = 11.6$) than those who received objectives and intellectual skills practice ($M = 9.3$), [$F(3, 75) = 3.57$, $p < .05$].

In addition to the interaction, MANOVA indicated a significant main effect for type of practice, [$F(2, 70) = 6.84$, $p < .05$], but not for orienting activity. Subjects who worked in groups that received skills practice achieved higher overall posttest scores ($M = 23.4$) than those who received information practice ($M = 21.4$). Univariate analyses revealed that subjects who received practice on the intellectual skills presented in the lessons performed significantly better on the application portion of the posttest ($M = 13.0$) than subjects who received practice on the verbal information ($M = 10.9$), [$F(1, 71) = 8.54$, $p < .05$].

Helping Behaviors. MANOVA indicated that the type of practice given to students significantly affected their helping behaviors, [$F(3, 10) = 6.59$, $p < .05$]. Follow-up univariate analyses indicated that students who received practice over the skills presented in the lesson gave significantly more help to their fellow group members ($M = 2.13$) than students who received practice over the information ($M = 0.5$), [$F(1, 12) = 15.36$, $p < .01$].

On-task Group Behaviors. MANOVA indicated that type of practice [$F(3, 10) = 7.28$, $p < .01$] and orienting activity [$F(3, 10) = 4.23$, $p < .05$] had a significant effect on students' on-task group behaviors. Follow-up univariate analyses indicated that students who received skills practice discussed significantly more of the lesson ($M = 9.75$) than students who received information practice ($M = 4.88$), [$F(1, 12) = 21.83$, $p < .01$]. In addition, students who received objectives discussed significantly more of the lesson ($M = 9.25$) than students who received advance organizers ($M = 5.34$), [$F(1, 12) = 13.79$, $p < .01$].

On-task Individual Behaviors. MANOVA indicated that the type of practice given to students significantly affected their on-task individual behaviors, [$F(3, 10) = 18.26$, $p < .05$]. Follow-up univariate analyses indicated that students who received information practice took more notes on the lesson ($M = 6.63$) than students who received skills practice ($M = 0.5$), [$F(1, 12) = 62.63$, $p < .01$].

Off-task Behaviors. MANOVA did not indicate a significant effect for type of practice nor orienting activity when off-task behaviors were analyzed. Furthermore, a significant interaction between type of practice and orienting activity was not found.

Discussion

The purpose of this study was to investigate the effects of orienting activities and type of practice on performance and student behaviors. Subjects assigned to cooperative learning groups received information, examples, practice, and feedback from three instructional television lessons. Each lesson included specific orienting activities (advance organizers or objectives) and different types of practice (verbal information or intellectual skills).

Results indicated that the type of practice provided to students had a significant effect on performance. Subjects who worked in groups that received skills practice performed better than those who received information practice. Examination of each section of the posttest suggested that performance on application items was affected by type of practice. While type of practice by itself did not influence knowledge acquisition in the present study, it was affected by a combination of type of practice and orienting activity. Subjects who worked in groups that received information practice and objectives outperformed all other subjects on the knowledge portion of the posttest.

A possible explanation for these findings may be due to the nature of the instructional elements provided during the lessons and the subsequent performance measure. Students in groups who received skills practice had the opportunity to perform tasks similar to those required on the application items. This practice strengthened student ability to apply concepts presented in the lessons. However, students who received information practice only had the opportunity to rehearse the knowledge provided in the lessons. Providing lesson objectives to these students may have been necessary to direct their attention and selective perception to relevant lesson content.

In addition to performance, orienting activity and type of practice influenced student behaviors in the current study. Groups given objectives discussed significantly more content than groups given advance organizers. This result may have occurred because subjects had extensive experience with using instructional objectives as a study tool and little experience with implementing advance organizers. While objectives influenced group behaviors, type of practice had a stronger affect on student behaviors. Groups who received skills practice exhibited significantly more helping behaviors, more on-task group behavior, and less individual behavior (taking notes) than groups who received knowledge practice. These results likely occurred because groups who were given skills practice found the lessons more interesting and engaging than those who received information practice.

This study has some implications for those who design instruction. The current findings suggest that instructional technologists can increase performance and student interaction by employing high-level practice and specific orienting activities when using cooperative learning with media originally designed for individual learning. Systematic application of the appropriate instructional elements in these settings will increase the success of cooperative learning.

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Title:

Design and Development of Hypermediated, Videodisc Inservice Training for Rural Social Workers

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THE NEED

Professionals who live in rural areas often have difficulty finding opportunities to receive further professional development without spending substantial amounts of time traveling to training sites. In an attempt to improve services to rural populations, distance education has become an increasingly popular form of continued training to adult audiences. The growing emphasis on distance education recognizes the needs of rural professionals who may not have the time or resources to travel to more central training sites.

As has been the case with others, the increasing workplace demands on social workers requires a feasible solution to providing in-service training for those who reside in rural areas. The workplace demands place social workers in the position of needing to know more information, yet having increased responsibilities that make it more difficult to leave the office. While distance learning opportunities have multiplied greatly in the past several years, the lack of relevant course work and access to the technology necessary to participate in these opportunities may prohibit the wide use of distance education for rural social workers.

The need to provide carefully designed training to meet theses challenges is critical, especially in light of the limited resources for staff development within the social work agencies. The assessment process, therefore, becomes vital in planning staff training to enhance these limited resources by concentrating them on the most essential needs.

Collaboration between two major institutions in a rural midwestern state identified specific training needs for child welfare workers and a five-year plan to meet them. In 1992, the Kansas Department of Social and Rehabilitation Services (SRS) contracted with the Kansas State University Social Work and Special Education programs to develop a series of training modules for child welfare workers that would emphasize the training needs of workers in the rural parts of the state. The first step of the training process assessed the workers' perceptions of their needs. The second step developed a plan to meet those needs. This article briefly describes the assessment process in a public child welfare agency that included the workers themselves as a primary source of knowledge about their own needs and then addresses the plan to provide the training.

Rationale

Of the several methods available for assessing training needs, three seem pertinent to the needs of child welfare workers. Pecora, Dodson, Teather, and Whittaker (1983) describe these three as the task-based survey, the knowledge-based survey, and the worker ability/characteristic survey. Each method relies primarily on input from job analysis data and selected groups of staff members and outside experts for the development of specific training needs. These needs are then presented to workers in a written format. While efficient, these methods are often perceived as placing further demands on workers' time with dubious promise of results. Therefore, none of theses methods met our criteria that the assessment must not add to the workers' frustration and must be a positive, relevant experience.

Child welfare workers can experience a sense of worth and involvement when concepts form adult learning theory a d social work problem-solving methods are incorporated into the needs assessment process. Basic tenets of adult learning theory support the involvement of workers in every stage of planning for training and suggest that workers be asked directly what it is they believe they need to know to perform better (Knowles, 1973). Social work problem-solving methods begin by establishing rapport and progress through identifying a problem, developing a goal and plan to reach it, implementing the plan, and evaluating the plan as well as the process (Hepworth and Larsen, 1986). Inclusiveness and mutuality are fundamental to the process. The method assumes that clients can evaluate the accuracy of their needs and wants, and can express these in the form of goals (Fox, 1987).

One research technique that encompasses many of these features involves using focus groups. In such a research technique, a facilitator meets with small groups to present the project and solicit input from the small group participants. The resulting information is used to develop effective strategies to meet the identified needs. The data gathered from this type of research can include qualitative pieces that might be not emerge or be overlooked with other types of data gathering.

Methods

Focus groups for this project provided the opportunity for SRS child welfare staff members to communicate their training needs directly. Several units were involved, including protective services, foster care, adoption, family-based in-home services, and family services.

Subjects for this study involved approximately 75 supervisors and 495 social workers, representing all twelve districts within the state. To reduce the potential of promoting resistance or even hostile feelings that had in the past resulted from forced participation, the researchers used a "invitational" type of selection. Posters announced the meeting times and stressed the voluntary nature of the focus groups.

Two researchers facilitated each focus group and concentrated on leading the process in the following order: (1) Brainstorming topics of perceived training needs, (2) organizing those topics into units of study, (3) establishing individual priorities, (4) discussing preferred methods of receiving training, (5) demonstrating multimediated training, and (6) gathering participants' feedback about the focus group session.

Conclusions

Results of the focus groups indicated training priorities and training delivery issues. The data on the training priorities consisted of 34 lists of training topics from the brainstorming sessions, which had been organized into two parts: (1) 34 lists of training units orders according to their mean rating, and (2) two lists of 20 training unites ranked according to the mean rating as prioritized by area directors an social services chiefs. Table 1 summarizes the frequency with which topics were listed by the focus groups.

Data indicated strong preference for interactive training that stressed variety. The videotape and workbook format used for the agency's basic training was regarded by most participants as a helpful way to deliver information. Staff members who had used this curriculum in small-group sessions were very positive about the benefits of having an opportunity for interaction when working through the material. The participants seldom used the supplementary materials providing with the training, except in the case of outlines concise handouts that they were able to share with clients. They preferred that materials developed of their own training be adaptable for use with clients.

TABLE 1. *Workers' Training Needs According to Focus Groups.*

TRAINING NEED	% OF TIMES TOPICS APPEARED
Survival Skills for Workers	15%
Abuse and Neglect	11
Legal and Court System	10
Families	7
Adolescents	7
Oppositional or Resistant Clients	7
Interaction and Interviewing Skills	6
Networking and Community Resources	6
Mental Health	5
Writing Reports and Documentation	5
Cultural Differences	5
Child Development	5
Computer Training	4
Understanding SRS System	4
Special Populations and Special Education	3

n= 403 items

THE SOLUTION

Based upon these identified needs, the following units of study were identified as high priority training items:

- Child Development
- Professional Ethics
- Stress Management
- Abuse and Neglect
- Adolescents
- Family Based Treatment Strategies
- Family Issues - Separation, Attachment
- Legal Issues
- Practice Skills I
- Practice Skills II

Because the focus groups identified a desire for interactive training with a video component, the project directors chose multimediated training that included videodisc, computer, and paper based materials. The computer offers the interactivity, the videodisc offers the video examples, and the paper component offers a workbook filled with practice exercises, longer pieces of text documentation, and short, concise informational sheets that can be sent home with clients.

It quickly became clear that the content area experts needed to learn about the capabilities and limitations of videodisc technology. That has been an on-going process. At first, there was no one on the project team who could direct the development of the videodisc component. Once someone was hired, the following abbreviated list of instructional design considerations was implemented within the design process for each of the videodiscs.

- Who are the users?
  - Background and educational level?
  - What is their computer skill level?
  - In what environment will this training be used?

- Independent Modules that can be used in any order

- Module Product Components
  - Videodisc
  - Computer Disk
  - Workbook Documentation in 3-ring binder for easy removal of pages
  - Glossary

- Record Keeping
  - Individual Computer Disk for Tracking Individual Data for SRS
  - Bookmark so Learners Can Take a Break and Come Back
    (This is particularly important for those with short timeslots)
  - Record of Progress

- Screen Design
  - Colors - use with care and purpose
  - Shapes - theme
  - Visual effect of Depth and Patterns
  - Special Effects used only where they add to instructional purpose, never for simple glitz effect
  - Layout and Font - Readability

- Movement - Logical Flow
  - Learning Objectives Must be Developed Prior to Content
  - Path must create logical choices and allow learner control
  - Transitions are Crucial
  - Prerequisites Identified Early in Design Phase

- Team Approach - Overlap Duties
  - Instructional Designer
  - Scriptwriter
  - Graphic Artist
  - Videographer, Standard Production
  - Videographer, Special Effects
  - Programmer

- Planning and Preproduction Tasks Approximately 75% of Effort
  - Module 1 Currently in Beta Test Phase
  - Modules 2-6 in various stages of preproduction
  - Different from linear video -- pay attention to in and out video/audio points, video & audio match, light levels, sound quality, media mix, animation many short segments that must fit seamlessly

- Some Features
  - Verbatim Option for Those Who Wish to See Words or Review Audio
  - Hot Words
  - Content Map
  - Workbook Reference

- Experimental Use of SVHS Video Master
  - Sufficiently good quality
  - Saves money

The delivery methodology chosen for this project is especially appropriate for rural areas because it can be used in local offices and can be utilized in in-service training and instruction for groups or individuals. The delivery format of the training modules, a self-contained computer based multimedia program, uses specific skill development methodology and takes into consideration the range of users' skill levels with computers and supporting technology. The ability of users to control the instructional process and to record their progress allows remediation when necessary or the option to move ahead when the competency is reached. Users also have the ability to learn or enhance skills they have through interaction with video images and the computer program. Program branching allows remediation of incorrect responses and provides for choices of relevant information, topics, and examples for students.

Comprehensive tests assess overall understanding and skill and students can be reinstructed in those areas in which their understanding or application is unacceptably low. After each curriculum component, a brief review determines whether the student understands the component well enough to go on to the next component. Each training module is concluded with a test on which a user must achieve a passing score in order to receive continuing education credit (CEUs).

Interactive videodisc-based instruction has the advantages of timeliness, flexible training periods, effectiveness, and multiple applications. It is capable of providing the type of staff development needed for busy rural human service workers who must fill different roles in providing services to their clients and in collaborating effectively with educational and other service professionals.

There are a number of characteristics unique to the rural setting that make training social workers in rural settings a challenging endeavor. As is true with many other professionals serving rural areas, rural social workers are usually generalists. They fill multiple roles, and the need to be informed is vital to providing comprehensive services to families.

Establishing expected competencies from field surveys and then designing video footage and computer programs to teach and evaluate are major steps towards providing essential training for social workers. The use of interactive videodisc-based instruction holds promise for delivering effective training that is individualized, updatable, and accessible.

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Title:

Using DVI to Teach Physics: Making the Abstract More Concrete

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INTRODUCTION

This paper reports on a study that used Digital Video Interactive (DVI) to help students learn selected concepts of physics. The purpose of the study was to investigate ways in which new video technologies, such as DVI, can be used to help students learn concepts of physics that traditionally have been difficult to teach. By making those concepts more visual in nature, the topic could become less abstract and more motivating for students to learn.

By teaming two features, the concrete visual images provided by video together with the control over that video, which can be obtained from digital techniques, we hope to be able to make the abstract concepts of modern physics more understandable to students. In this way, it may be possible to attract the interest of students who traditionally have not chosen to pursue the study of physics. This approach may make the physics of the twentieth century more attractive to all students, thus making positive improvements toward equity within science education.

The theoretical underpinnings of a project of this nature must build from research and knowledge about how students learn. Unfortunately, very little research has been completed on student learning of modern physics. Posner, et al. (1982) have looked at the learning of relativity as part of a study on conceptual change. Fischler and Lichtfeldt (1989, 1992) have tested a method of teaching quantum concepts to German school students. Very little research has been reported on the student preconceptions or learning in these specific topic areas, however research has shown that interactive, visual technology has had an impact on the learning process.

Several researchers report positive effects of interactive, visual technology on student performance. Mayton (1991) reports that students who use interactive, visually-based instructional materials outperform others. Abrams and Streit (1986) report greater learning gains. Bunderson, Olson, and Baillio (1981) report faster learning and better retention among students with access to such material. Finally, Cushall (1987) reports more positive attitudes and enthusiasm for the material when students use technology within science classes.

If teachers are to use technology effectively in their teaching, then they need meaningful experiences with using the technology as learners and users (Baird, 1991; Brooks & Kopp, 1989; Smylie, 1989). Future science teachers need experiences using the technology during the course of their training (Sununu, 1986; NSTA, 1990).

Concepts of physics are often presented in an abstract format and are difficult for students to understand. By making the instruction more visual, we hoped to aid the students' understanding of selected concepts in beginning physics. This project used digital video interactive (DVI) to produce and deliver data visualization exercises to students who were studying frames of reference.

The project included software design and production as well as formative and summative evaluation. This paper will describe the development and formative evaluation processes.

BACKGROUND

CD-ROM and videodisc technology can provide visuals for interactive instruction but they offer limited visual capability. Each can provide a moving image, but not in the real-time sense of being able to collect and display experimental data as it is collected. DVI technology has a wide range of capabilities and shows great promise for a variety of educational situations (Ripley, 1990). DVI provides real-time motion; students can collect and visualize data as well as interact with the image on the screen. The full motion image is contained to a window on part of the screen so the remainder of the screen can be used for other purposes, such as graphing data. With the increased emphasis on using computer-based multimedia for instruction, there is a need for evidence of its potential positive effect on learning.

There are many reasons to use computer-based multimedia for instruction; the potential for visual learning and interaction are two of those reasons. Research provides ample evidence for the power of visuals and interactive multimedia to enhance learning (Carlson & Falk, 1990-91; Dwyer, 1978, 1992; Knupfer & Clark, 1992). Computer-based activities provide opportunities for interaction in more than one sense. Interaction can take place between a student and a computer as well as between students who are engaged in cooperative group work.

Because this study contained a large number of females who were minimally computer literate, it was important to investigate the merit of grouping students as well as possible gender and attitude considerations prior to conducting the exercise. A review of the literature indicated that students benefit from working in heterogeneous groups as compared to working alone (Dalton, Hannafin, & Hooper, 1989; Gabbert, Johnson, & Johnson, 1986; Hooper, 1992; Johnson, Skon, & Johnson, 1980; Simsek & Hooper, 1992; Yager, Johnson, Johnson, & Snider, 1986). In addition, heterogeneous grouping of students is preferable to homogeneous grouping (Knupfer, 1993).

There are many positive benefits to cooperative, group work including the ability for students to observe, imitate, and learn from each other (Rysavy & Sales, 1991). Students learning with computer-based multimedia in individualized situations control the pace and sequence of instruction while those learning in small, cooperative groups express more satisfaction (Adams, Carson, & Hamm, 1990; Carlson, 1991). Also, cooperative learning has been rated particularly appealing to low-ability females (Dalton, et al, 1989). The combined strategy of providing computer-based technology and cooperative learning is especially positive for female students; this combination has revealed improved attitudes toward computers and perhaps even more important, it promotes equalized status and respect for all group members instead of competitive and individualistic learning (Johnson, Johnson, Stanne, 1986). Cooperative, computer-based learning reveals no significant differences in the performance of male and female students (Mevarech, Stern, & Levita, 1987; Webb, 1988).

A number of studies have been conducted to compare cooperative and individual learning strategies. According to Johnson and Johnson (1989), a cooperative learning strategy allows students to work together to increase performance and achieve shared goals; an individual learning strategy requires students to work by themselves to accomplish their own goals. Several reviews of research suggest that cooperative learning affects students performance, productivity, transfer of learning, time on tasks, and attitude (Johnson & Johnson, 1989; Rysavy & Sales, 1991; Sharan, 1980; Slavin, 1990).

Investigations about attitudes toward instruction that utilizes computers reveal mixed results. Some studies report no significant effects on learner attitude (Robyler, Castine, & King, 1988; Dalton & Hannafin, 1988), but the majority of studies indicate improved attitudes toward computers (Kulik & Kulik, 1987) or toward the subject matter at hand (Menis, Snyder & Ben-Kohav, 1980; Kulik & Kulik, 1986).

Keller's (1987) ARCS model suggests that motivation in an instructional setting consists of four components: attention, relevance, confidence, and satisfaction. Finally, Debe (1990) suggests that computer-based multimedia best can be utilized in education as a tool to help structure inquiry based on higher-order thinking. Debe draws attention to the similarities between collaborative interaction with peers and the team-based approaches underlying today's science.

This study grouped students into cooperative, heterogenous groups for a DVI exercise meant to stimulate inquiry and promote higher-order thinking to clarify a difficult, abstract physics concept. Students engaged in an activity that would draw their attention to a relevant task, and would hopefully build confidence and satisfaction through a successful experience with physics.

Initially, this study sought ways to improve the teaching of modern physics from two sources. The first source was the literature related to the teaching of modern physics. The second source was the people who work within the field; a series of questions were directed to the physicists, teachers, and students who are subscribers to the PHYS-L computer list.

A review of the literature revealed a dearth of information about ways to improve the traditional physics curriculum. Although some teachers and physicists have questioned which ideas of modern physics should be considered central to a student's development and which ideas are over emphasized in the traditional curriculum, those questions are rather limited in both number and scope. Instead, most of the literature on teaching modern physics concentrates on "tricks of the trade" along with experiments and demonstrations that are most appropriate to students who have a strong interest in physics. There is very little written about shaping the content and and delivery of the physics curriculum to become more appealing to students who lack a natural interest in the topic.

The series of questions to the physicists, teachers, and students who subscribe to the Phys-L list, seemed to offer promise. That group of people has an active interest in physics and views technology as an acceptable means of addressing the problems of teaching. Unfortunately, that attempt at gathering information did not bring any useful results. The few responses that directly concerned the physics curriculum and methodology seemed to suggest a "pet topic" rather than any deep thought. This type of response probably resulted from either a lack of creative thinking beyond the traditional formats for teaching modern physics, or hasty replies to e-mail without taking time to reflect on the topic. Perhaps this approach could be tried again in the future, following some discussion of concrete examples about how DVI could be use in teaching physics.

Some examples of DVI were developed and presented at the a series of physics conferences beginning with Winter Meeting of the Association of American Physics Teachers (AAPT). People were able to interact with the system and discuss various options for improvement. This feedback method yielded helpful suggestions concerning focus topics.

With the lack of response to the electronic questionnaire, research ideas were developed along three parallel tracks with the purpose of investigating appropriate teaching and learning strategies, as follows:

- Development of short lessons using DVI to demonstrate its utility to the physics teaching community.

- Development of concepts and relations among concepts in modern physics for different groups of students.

- Plans for testing some teaching material that used traditional paper as the medium but with an untraditional approach, such as visual quantum mechanics, with the idea of converting it to interactive learning materials using DVI.

Each path would converge on some major themes in the future. This paper describes the project in its current state, with both the successes and problems associated with using the DVI format. It addresses DVI demonstrations, presentation level video, student learning of modern topics in physics, nontraditional approaches of the content of modern physics, DVI as an experiment, hardware and software changes, support for the project, and accomplishments to date.

CONSIDERATIONS ABOUT DVI MATERIALS

The project considered the equipment, its capabilities, the curriculum, and the student audience as follows:

DVI Hardware

The project began by using the Action Media 750 system and exercises were constructed about both visual space-time diagrams and variable quantum effects. The new generation of hardware, the Action Media II system, added certain capabilities, but at the same time sacrificed others. The Action Media II system was used to construct exercises about physically changing reference frames as well as development of mock-ups of progress on the 750 System.

Topics in Modern Physics

The topics selected from the curriculum of the beginning level physics class were visual space-time quantum physics, relative motion, and Quantum Physics.

Real Time Video Capture

The video capturing feature allowed students to conduct a physics experiment, capture a video of the experiment on fixed disk, and then collect and analyze data from the captured video. Students could ask, "What if" questions, change the experiment appropriately, and immediately analyze the data from the new experiment by following its plot on a computer-generated graphic display of the data.

Student Audience

The level of the students was a major consideration in the materials design and the topic selection. The a large class of college students who were studying teacher education, were enrolled in the an introductory physics course that included this curricular material. These students were not science majors, but education majors who needed to study science. The project was visual in nature and promoted visual thinking, so it carried the possibility of using the material with younger students of high school age or upper elementary school age, who were visual thinkers.

DIGITAL VIDEO INTERACTIVE DEMONSTRATIONS

The ability of the DVI system to capture video in real time and manipulate that data was of central interest. This feature, called Real-Time Video (RTV) by Intel, allows individual users to capture video to the hard disk at 30 frames per second. Because the video information is stored on the disk in digital form, one may collect information from the images by performing analysis of them and may alter them in some simple ways.

The first attempt at using RTV resulted in gathering distance-time data about a moving object. Adhering to the theme of investigating topics of contemporary interest, a program was written which analyzes the motion of a spherical pendulum which can undergo chaotic motion. To accomplish this, a video camera was mounted so that it could view the end of the pendulum as it moved. Then the video signal of pendulum's image was captured by the computer. Upon completion of the video capture, an image analysis program found the location of the end of the pendulum and recorded its coordinates for each frame of the video. With this information available, the motion video segment could be played back while simultaneously displaying a graph of its coordinate points.

One limitation of the DVI is it's small window size, yet this feature also has the advantage of offering the opportunity to show four windows on the screen simultaneously. For consistency and clarity of thought, a decision was made to present consistent types of information within the windows. One window always displayed the video of the actual motion while the other windows revealed areas where the students could view plots of distance, velocity, or acceleration versus time, or distance versus velocity. For each graph, the points were plotted as the pendulum moved to the appropriate location on the screen. Thus, the students could watch two dimensional motion which they created and, at the same time, see the graphs of various quantities.

This application of DVI is somewhat similar to the standard approach of using range finders or "smart" pulleys to collect data from one-dimensional motion. For two-dimensional motion, Luchner and Dengler (1989), Keshishoglow and Seligman (1989), and Huggins (1988) have created computer interfaces which can collect information from one bright spot in a video scene. The DVI data collection scheme has both advantages and disadvantages in comparison to these other methods. Unlike the standard range finder, the DVI and other video methods are not limited to one dimensional motion. For the study of chaotic events this additional dimension is very important.

DVI has an advantage over the other video methods because the actual video scene is recorded on the fixed disk. Thus, the students can view their own experiment many times while they look at different ways of analyzing it. In the other methods, the experiment itself is not recorded visually; only numbers from it are recorded. Thus, while the students can complete many different analyses of the data, they cannot look at the experiment exactly as they conducted it.

The most obvious disadvantage of the DVI method is that its sample rate is limited to the frame rate of video (30 frames per second); range finders can sample the data at a much higher rate. Both the range finder and the older video methods can show graphs in real time as the data are collected. With DVI the computer is sufficiently busy collecting and digitizing the entire video image at 30 frames per second that it cannot also display graphs in real time. Thus, the multistep process described above was used. The lack of real-time graphical display does not appear to be critical to this type of measurement because students can view the video of the experiment as often as they wish and compare the video to the graphical data.

A second application of DVI turned the computer into a system for recording time-lapse video. Except for antiquated Super-8 film cameras, the equipment for time-lapse recording is very expensive. Thus, this capability has not been available to students since 8-mm film essentially disappeared from the market. The DVI system is programmed to record a video image in library routines, then DVI can be used to assemble them into a video sequence. Thus the students can record, playback, and analyze events which result in change over a long period of time. For example, students could record and analyze growth patterns within cells or crystals.

RESEARCH QUESTIONS

The goal of this project was to find out if DVI is an effective way to visualize data and if so, whether or not it can help students develop an understanding of the frames of reference physics concept.

Formative Evaluation Questions

1. How difficult was it for the students to understand how to use the software?
2. How difficult was it for students to actually use the software?
3. What did students think of the experience?
4. What suggestions did students have for improving the lesson design?

METHODOLOGY

Subjects

Subjects in this study included two classes of graduate students who served in the formative evaluation by reacting to the exercise as it was developed and providing a basis for revisions to improve the software functionality as well as other elements of the lesson design.

The graduate student classes were of two types. The first class of twelve students who tried the software did not necessarily have familiarity with computers or instructional design. These students were given extremely little introduction about what to expect prior to using the software, but had a follow-through explanation after the exercise. They used the software in discovery based mode as a test to see if the software was sufficiently self-explanatory to allow independent learning. Four collaborative groups of three students used the software and were allowed to discuss the physics problem at hand freely, but they were instructed to keep their reactions about the software confidential until the data were gathered.

All twelve students had difficulty with both using the computer equipment and understanding the physics concept of frames of reference. The reaction to the experience was generally negative and reflected frustration despite the collaborative structure of the exercise. The students did not believe that this exercise could stand independently, but suggested that the instruction include an introduction to both the equipment and the frames of reference topic.

Based upon feedback from the first group of graduate students, modifications were made to the software and to the method of introducing the material to the students. The second group included students who had experience with design for interactive multimedia-based instruction. This class was given slightly more introductory information about both the physics frame of reference concept and how to use the equipment.

Modifications to the software functionality included an improved screen design with navigational buttons that closely resembled a video cassette recorder (VCR) to be used during the data collection and analysis. Functions allowing the collection and analysis of data were clearly labeled and students were able to try the different functions at will.

Modifications to the frames of reference topic did not delve into depth on the concept, but instead provided brief, verbal information about the goal. Students received this information in the context of seeing how to use the camera to record a dropping ball from a stationary cart and a moving moving cart. Like the first group, the second class of twelve graduate students tried the exercise within collaborative learning groups of three and responded to the experience both in writing and verbally.
This group of students reacted more favorably, but still had problems with understanding the context of the physics lesson.

The frame of reference lesson was intended to use with undergraduate students who were taking an introductory course called *Concepts of Physics* in partial preparation for careers as elementary school teachers. Based upon the feedback from the formative evaluation, the lesson for the undergraduate students included the frame of reference concept within the first few lectures of the semester. This preliminary information released the students from the content struggle and helped prepare them to take advantage of extending their learning to a different level of experience.

The *Concepts of Physics* class utilized lectures, demonstrations, and laboratory exercises. The frame of reference concept was taught in lecture during the first couple of weeks of the semester as part of the regular curriculum and thus the concept was tested in the first exam of the course. Nothing further was mentioned about frame of reference during the course. During the last two weeks of the semester, the students used the DVI exercise. The exercise consisted of a pretest, the DVI exercise, and a posttest. Finally, four frame of reference questions were included on the final exam.

Armed with the prerequisite physics content, the students were then grouped into collaborative groups of three and were provided with more information about working the equipment than their graduate student colleagues had been given. The goal was to provide enough information to the students so that they would be able to use the equipment with comfort. The undergraduate students were much more positive about the experience and nearly 100 percent of them claimed that the DVI visualization experience helped them to understand the frame of reference concept. An analysis of their performance scores will be provided in a forthcoming report.

Although the exercise provided a stimulus to engage the attention of the first two groups of graduate students, only the undergraduate group had the benefit of perceiving the exercise as relevant to their course, confidence in knowing their goal, and satisfaction of realizing how the DVI exercise fit within the whole. Only the undergraduate students realized the four components of Keller's ARCs model (1987) and reacted favorably to the exercise.

RECOMMENDATIONS

This formative evaluation clearly points out the need to prepare the learners with adequate information about the topic of study as well as the equipment. Although developers of electronic educational material might view the use of such material as easy, others who are unfamiliar with the material are likely to need assistance in gaining perspective on the material prior to using it.

This DVI material needs to proceed to summative evaluation to measure both its perceived value and it effectiveness for helping undergraduate students learn about the frame of reference concept. In the future, it might be possible to try test the ability of the DVI exercise to extend the physics lesson frame of reference to younger learners, such a those in the upper elementary school. The frame of reference concept has traditionally been taught at the undergraduate college level, but the rich visualization made possible with DVI might enhance the experience to the point where it becomes valuable for younger learners, thus changing the science curriculum.

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Title:

<u>On Teaching Theory</u> 11th Annual Foundations Symposium: Dialogue on Applying Critical Approaches to Educational Technology

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ON TEACHING THEORY

Last year's symposium, as has been the case in many of the other foundations symposia, was concerned with the theoretical ideas that inform our work. This year's symposium is to expand on the theoretical work as well as provide some indications of how the theoretical work is carried out, i.e., what is the nature of our practice. This is not to be misunderstood as a "how to" session, but rather to give a sense of the struggles, tensions, joys and frustrations of our work.

What I have to share here is not magical or earth shattering. It is messy. This messiness is not rooted in a lack of rigor, but rather in the nature of the educational experience itself. This is part of the theoretical framework I presented at last year's symposium. My presentation was entitled "Postmodern Thinking in a Modernist Cultural Climate: The Need for an Unquiet Pedagogy".(1) Unquiet pedagogy is a term from Paulo Freire. Freire states that

> A pedagogy is that much more critical and radical the more investigative and less certainof 'certainties' it is. The more unquiet a pedagogy, the more critical it will become." (Freire, in Kutz & Roskelly, 1991)

Unquiet comes from the confrontation between one's private, personal world and the public world. We always find ourselves within a sociocultural context. An unquiet pedagogy, a critical pedagogy, confronts the social-school-life-world and acknowledges the conflict as part of the human condition. An unquiet/critical pedagogy is informed by and allows for multiple ways of knowing and experiencing the world (technical, practical and emancipatory forms of knowing).

An unquiet/critical pedagogy acknowledges student/teacher voice in the learning process. This pedagogy fosters and helps create democratic forms of schooling through confronting issues of social justice, the creation of community, the common good, and social construction of knowledge.

This notion of an unquiet/critical pedagogy as presented may seem to be "removed" from experience, too abstract and/or nebulous. I think that is because of the language used to describe it. It is not at all abstract (for me) in my teaching. I am referring specifically here to what I teach: I teach theory. I teach a course entitled Sociocultural Concerns in Education. This is an educational foundations graduate course required of all teacher education majors, and all master's programs within the department.

What I try to represent in this course is the complexity of the teaching/learning process, the sociocultural nature of schooling. I represent teaching and schooling within a political context (all education is political), and that teaching is not just a set of behaviors but an orientation to the world, a way of being in the world. I talk about teaching being a moral enterprise because we intervene in people's lives.

For many students, to talk in this way is an introduction to new language, to new understandings and conceptualizations of teaching (2). Hence, we are involved in theory, a discussion of theoretical positions and frameworks.

I do not look for concensus in my class. Students do not have to agree with me. I do look for a willingness to engage in a very (at times) disturbing/unsettling process of self-reflective study of teaching and schooling, and their/my own perceptions of "how things work". "How does what we do in here line up with your perceptions and beliefs?" "How do you, as a scholar/student/researcher/ educator position yourself in relation to this information?" "Does this information cause you to re-think your position?"

Roger Simon's text (1992) Teaching against the grain: Texts for a pedagogy of possibility, presented a challenging way for me to reflect on my teaching. Simon suggests that students fear theory classes, and because of this fear they are silenced (p.81 How does this happen? Many students do not want to appear foolish as they try to enter the world of theoretical discourse. If you fear ridicule, you fear being ridiculous, and hence students say, or behave, as if they have nothing worthwhile to say.

Another way students show a fear of theory is through an expression of anger/frustration. Simon refers to this as the "disruptive character of theoretical knowledge" (p.83). This is experienced not only during class discussion, but re-surfaces as they prepare for class, do assigned reading, etc. In the class discussions, it is represented by attacks on the language of the text, the language used to represent theory. This language is referred to as "jargon", using too big of words, unintelligible talk or writing. Simon interprets this language as adversarial. It is spoken from a position of feeling marginalized, subjected, and dominated (p. 83).

I sense too that theoretical discourse can be very alienating to students. They already have a common, general language/vocabulary, as well as seemingly common experiences that are easily represented by that vocabulary and language (their taken-for-granted ways of talking about and understanding their everyday experiences). To be expected to use and work with a new language that changes the nature of that experience can provide a challenge to your thinking that can be unsettling, unquiet. This alienation can cause a sense of being excluded from a discourse that is supposed to make sense to them, supposed to have some relevance to their everyday lives (their chosen profession of teaching; again, the disruptive character of theoretical discourse, theoretical language). (3)

Another manifestation of fear of theory is the way students talk when engaged in theoretical discussion. They appear to be hesitant, tentative (Simon, 1992, p.84).
Often times, as they begin their response they say "This is just my opinion, but...." I believe this points up the separation between subjective and objective knowledge, and which is more valid. This also suggests the major separation between theory and practice, the sense that "someone else" produces the theory, and as teachers, they just want to know how to use it. In this sense, perspective teachers don't do theoretical work, they teach. Theory is done at the university, teaching is done in the schools.

This new language also tends to legitimate a particular view of the world that is not familiar. This unfamiliar language suggests that their way might be less adequate. Unless a real open forum ex[illegible]s within the classroom, the pressure to give the professor what s/he wants can be unquieting: they still must get a grade for this class (Simon, 1992, p. 89). It is difficult to throw off all those years of schooling that required of them that they "Play by the rules".

Another text I use in my course is Mike Rose's Lives on the boundary: The struggles and achievements of America's underprepared (1989). This text helps to understand the alienation some students feel as they enter into the academic world. For those of us who have been in academia for a while. we can forget what a strange alienating place higher education can be. Mike Rose writes of education being an invitation into many forms of discourse. These discourses require that students not only learn new vocabulary, but understanding the language systems that help us engage the world in different ways (e.g. the language of the sciences, the language of philosophy, sociology, art, literature, etc.).

It is important to understand that I am not talking about individual inadequacies here, I am not talking about lazy students. I am not blaming students, nor am I apologizing for my teaching. I am talking about human capacities, individual histories and the social form of the institution. And I am saying that study is intensely hard work. Hence I cannot just look at theory as an academic issue, an academic question. Simon (1992) strongly states that theory in education has

> The potential consequences for the organization and disorganization of identities make a pedagogically motivated confrontation with theory a potentiallythreatening and noxious situation. In this sense,classroom language practices are not only a mode of social organization but, also potentially, a mode of disorganization. (p. 92)

How can we work in "theorizing ways" with each other? To return to Paulo Freire's notion of an unquiet pedagogy, a critical pedagogy, we can teach dialogically. The preconditions for dialogue to take place are demanding:

1. a profound love of humankind
2. humility
3. intensive faith in people (an a priori faith in the individual
4. trust (established through dialogue
5. hope (rooted in our sense of incompleteness, our vision of what could be: possibility
6. critical thinking. (Freire, 1970)

Dialogue is always rooted in our lived experiences within our context. This engagement of ourselves with each other and our world is most difficult as well as "messy". We spend much time in talking and listening to each other about our understandings of the world (issues under discussion), as well as engage in academic readings on the same issues. My intent here is to have our conversation, our dialogue, grounded in our experiences. We go back and forth between the theoretical literature and our lived experiences. (See Freire, 1970, and Simon, 1992).

Students in my class are also doing something else. They are engaging others outside the classroom in the conversation (See Carson, 1986). Students are doing field research, conducting interviews, reformulating what they learn through experience as well as through their study. I have provided a rather standard model for asking questions, problem-posing, describing, interpreting and evaluating their data from an interview process (see Research Project form, below).

What is critical here is how the students position themselves to their own studies, their experiences in light of their studies, and the experiences of others within their community. How do we construct a view of the "world" (issues)? How do we view ourselves within this theoretical discourse? Can we understand the arguments of our experiences, the texts, and our data?

As I stated in the beginning of this brief paper, what I do is not magical or earth shattering. It is one way for my students and I to become more active and critical in understanding each other and our context. It allows us to deal with conflict. They tell me they have a greater sense of having control over their own learning. Perhaps this will provide an experience where they are less alienated from the theoretical discourse. It is not perfect, and it is still messy.

ENDNOTES

1. Paper can be found in Proceedings Selected Research Papers. AECT/RTD 1993 Conference, New Orleans, LA. This is a brief statement of my position in the form of a talking paper. An expanded and more clear statement of my position can be found in Koetting, 1994.

2. Examples of this new language would be from social theory, including issues of social reproduction, cultural capital, achievement ideology, the politics of education, etc.

3. An example of this sense of alienation, exclusion, frustration is when some students are first introduced to ideas in social theory, they express a sense of "feeling stupid", inadequate, unable to understand. They complain they have to constantly look words up in the dictionary; they have always felt successful in school before, but in this class they feel lost and "dumb".

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RESEARCH PROJECTS

General guidelines:

1. Identify issue/problem to be investigated. You must define and describe the problem/issue in narrative form. You will need to be specific here in defining terms, establishing meaning right from the start. This will help in the next phase,

which is to develop your questions that will solicit information.

2. Develop your questions. What information are you looking for? What should be the nature of your questions? How can you avoid yes/no questions? You may develop this section in narrative, and you must include a list of the questions in an appendix. Be sure to get demographic data, e.g. male/female, age, schooling, etc. You should consider the nature of your questions when planning for the demographic data needed to interpret findings (#4).

3. Report your findings (data). What did the people say? This is an objective (i.e. descriptive as opposed to interpretive or evaluative) statement of your data. Detail is important here. Let the people speak for themselves, and report that in sufficient "quantity" that the reader can get a "feel" for the conversations.

4. What do (does) your findings (data) mean? How do you, as researcher/student scholar situate yourself in relation to your findings? Does it fit with what you expected? Does it match or give additional insight into what you think/study about? Does it match your beliefs?

5. What do you conclude from your work? What are the implications of what you just learned?

This is not a survey. This is an oral interview, a conversation.

Title:

Hypertext Interface Design and Structural Knowledge Acquisition

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Abstract

Hypertext is well-suited for educational applications where open learning and knowledge exploration is desired. In such applications, principles of good hypertext interface design should be employed to avoid navigational problems so as to maximize learning. Interface design, however, may also directly enhance acquisition of a particular knowledge structure. An interface that is based upon an expert's structural knowledge map may assist novice learners in developing a more sophisticated knowledge structure more closely resembling that of an expert. Pathfinder networks have been used successfully to differentiate expert and novice knowledge structures. The procedures described in this paper were used to design a structured interface for use in a research study currently in progress. Two microcomputer programs were used to develop the interface; The Knowledge Network Orientation Tool (KNOT) to create the pathfinder network, and Asymetrix Toolbook for the hypertext application.

Introduction

Inherent within knowledge is a network structure, or schemata, comprised of nodes (schema) and ordered, labeled relations connecting the nodes. Learning occurs when new information is integrated into these schemata through activation. Due to the limited capacity of working memory, most network nodes will be inactive at any given time (Anderson, 1983). Through the spread of activation, inactive nodes become active in working memory as new material provides a stimulus. As nodes are activated, they are marked so a path can be retraced to the starting node. Collins and Loftus (1975) claim that the activation of nodes in the network decreases proportionate to the strength of the links, introducing the idea of semantic similarity into the network. Learners generate elaborations for new information being learned (Haviland & Clark, 1974). Elaboration assists in subsequent retrieval of information, which is structured semantically. The generation and modification of knowledge structures stored as mental schema is a critical component of learning (Rumelhart & Ortony, 1977).

Hypertext computer systems are similar to the model of memory described above in that they store non-linear, interrelated units of information associated by links. While learners benefit from the ability to approach a domain from a variety of perspectives in hypertext, a persistent problem of hypertext systems is that of navigation. When too many choices are available, users have a tendency to become "lost" within the network (Conklin, 1987). Hypertext interface design should attempt to minimize this problem. It has been suggested that effective human-computer interaction depends in part upon communicating system structure and organization to users through the interface (McDonald, Dearholt, Paap, & Schvaneveldt, 1986; McDonald & Schvaneveldt, 1988). The authors cited above assume users will develop conceptual models of a system that can be characterized as schemata. By providing an explicit structure in the interface that is based upon a structural representation of the domain, users will develop conceptual system models that reflect characteristics of the domain being studied (McDonald, Paap, & McDonald, 1990).

Structural Knowledge

Although research has suggested that graphical browsers in general do not facilitate the acquisition of an expert's knowledge structure by novices (Jonassen & Wang, 1992), we anticipate that by using a specific type of graphical browser, learners may modify their pre-existing schemas (through activation and elaboration) differently than if an alternative type of browser were used. By using a pathfinder network as the browser, learners may develop schemas that are more consistent with that of an expert. The conceptual model that hypertext users develop is a mediating type of knowledge termed structural knowledge. Designing a hypertext interface after an experts knowledge structure as represented by a Pathfinder network may help users to develop a more effective user model, assisting learners in acquiring higher-order procedural knowledge.

Defining Structural Knowledge

The distinction between declarative and procedural ways of knowing is common in cognitive psychology (Ryle, 1949; Gagn_, Yekovich, & Yekovich, 1993; Jonassen, Beissner & Yacci, 1993). Structural knowledge is an intermediate knowledge between descriptive and procedural knowledge. Structural knowledge describes how declarative knowledge is interrelated. In addition to knowing that, learners need to know why in order to know how. Thus, structural knowledge mediates the translation of from declarative knowledge to procedural knowledge by showing how declarative knowledge is interconnected (Jonassen, Beissner, & Yacci, 1993). Structural knowledge is essential to the development and use of higher order procedural knowledge applied within any content domain.

Structural Differences between Expe ts and Novices

Research has suggested that experts understand at a deeper, more abstract level than do novices (Chi, Feltovich, & Glaser, 1981). In addition, experts have a difficult time verbalizing their knowledge, since much of their knowledge has become automatic (Cooke, 1990). Further, experts and novices differ in the facts and rules in memory, as well as how those facts and rules are organized in memory (Chi, Feltovich, & Glaser, 1981; Murphy & Wright, 1984). Experts possess a different knowledge structure than novices, and know when and why specific facts or rules should be applied to specific cases. Although representing expert knowledge is of particular interest to expert systems research, other computer-based instructional models such as hypertext systems may benefit from explicitly providing novices with an explicit expert knowledge structure.

The Relationship Between Structural Knowledge and Hypertext Interface Design

The knowledge representation and acquisition models discussed above have implications for hypertext-based instruction. The limited capacity of working memory restricts learning. Formal learning usually consists of information presented in a sequential fashion, either through verbal or textual presentation. A learner therefore must break down sequential material into manageable chunks that can be transferred from working memory to long-term memory In addition, the goal of learning is the tuning and refining of one's mental knowledge structure. This means that a learner must add chunks of information in working memory to long-term memory by integrating these chunks into pre-existing schemata through spreading activation. As noted above, experts have well-developed mental schemata that differ from those of novices. We anticipate that novices may benefit from hypertext-based instruction that incorporates an expert's knowledge structure for two reasons. First a useful conceptual model for the hypertext system is provided for the user. Second, an explicit cognitive structure of knowledge domain becomes a component in the spreading activation process. If a link can be made between the user model and representation of the domain, novice learners should benefit from incorporating an expert's knowledge structure into a hypertext user interface.

Assessing Structural Knowledge: Pathfinder Networks

A variety of techniques for analyzing and representing structural knowledge have been identified (Jonassen, Beissner, & Yacci, 1993). We selected Pathfinder networks as our technique.

Pathfinder Associative Networks

Pathfinder associative networks (PFNets) are configurations in which concepts are represented in a node-link-node format. The network is constructed from proximity ratings of all possible pairs of semantic terms. Each link between PFNet nodes is assigned a value representing the strength of the relationship. The links can be directed or undirected, and are calculated based upon the minimum distance between concepts. A link is constructed if the distance between concepts is greater for every possible path than for the paired terms. PFNets are similar to MDS networks, except that PFNets do not require ratio assumptions about the proximity data, and are not bound by the hierarchical constraints in most other clustering techniques (Dearholt & Schvaneveldt, 1990).

Using the Knowledge Network Organizing Tool

The Knowledge Orientation Network Tool (KNOT) is a series of computer programs available on multiple hardware platforms for constructing, analyzing, and assessing pathfinder networks. The program uses an algorithm that analyzes a proximity data file created by semantically differentiating all possible pairs of selected concepts or terms. The examples that follow are part of a research study being conducted by one of the authors of this paper. For that study, the KNOT microcomputer program was used in conjunction with Asymetrix Toolbook as a relatively inexpensive and readily available means of providing an explicit structure in the hypertext interface. Although the examples here use the Microsoft Windows environment on the IBM PC, the procedures demonstrated here can be applied to the Macintosh environment using the Macintosh version of KNOT and an authoring tool such as Hypercard

Constructing expert and novice maps. Expert and novice maps are both constructed using the same procedures. A number of individual KNOT program modules are used to construct and analyze PFNets. The IBM PC version of the software contains both command line and graphical user interface (GUI) versions. The command line version was used in designing the structured interface discussed here. Constructing a PFNet requires at least three steps. First, the terms representing the domain must be defined. Second, the terms are stored in an ASCII text file entitled TERMS, for use with the RATE program. Third, the RATE program is used to semantically differentiate all possible pairs of terms.

Define the concepts that represent the domain. Proximity data is based upon the rater's differentiation of paired terms representing the content domain. In the design for this study, eighteen terms representing the major categories of moral philosophy were used.

Rate all possible pairs of terms. Ratings can be acquired by using the RATE module within KNOT, which will randomly present the rater with all possible pairs of terms. A proximity file is created after all pairs are rated. The RATE program uses a 9 point scale for differentiation., with the end points representing a high degree of similarity or dissimilarity. Instructions for individual raters and the direction of the ratings (whether 1 equals highly dissimilar or similar) can be specified and written to an ASCII file entitled INSTRUCT. For our study a single subject matter expert was consulted to rate the terms used to differentiate 18 concepts describing moral philosophy.

Use the Layout function to generate the pathfinder network. Once the proximity data file has been created, the LAYOUT program module within KNOT is used to construct a PFNet from the proximity data. Figure 1 shows the PFNet produced by the proximity data resulting from our rater's data. In this example the following parameters were used: q=-1, r=.

SEE FIGURE 1 APPENDIX D

Assessing differences between two or more PFNets

The similarity of two or more PFNets can be assessed using the NETSIM.EXE program. NETSIM generates a relatedness coefficient ranging from 0 (very dissimilar) to 1 (identical). NETSIM can be used for comparing individual PFNets from a group of experts, comparing expert and novice PFNets, or for comparing PFNets from the same user generated before and after instruction. Although PFNets can be assessed visually for similarity, the NETSIM function will more accurately assess the differences between expert and novice networks.

Hypertext Interface Design and Knowledge Acquisition

Given the navigation problem users usually experience with hypertext, the structured interface under discussion was designed as a single Toolbook page with a recordfield for individual text nodes embedded on the background of the page. The 18 nodes comprising the PFNet act as buttons, which display the text window and textual information specific to each individual node.

The windowed interface

The text window is hidden from view until the user selects an option from the menu interface. Once selected, the text window containing information specific to each individual node fills approximately fifty percent of the screen. The interface remains visible behind the window. A scroll bar allows the user to view all the text within the window. In order to provide an explicit knowledge structure in the interface itself, the text window cannot be resized, and multiple windows cannot be opened simultaneously. Links between nodes are represented as "hot words" in the text, which are surrounded by a rectangular box. Users also have the option of closing the window to once again make the entire menu interface visible. Figure 2 shows an open window with the interface in the background.

SEE FIGURE 2 APPENDIX D

Providing users with an explicit structure

Since users frequently returned to the interface map, the underlying knowledge structure was made explicit. As users interact with the system, the concepts of moral philosophy are learned within the context of the knowledge structure provided by the interface. Given the research and theory under girding Pathfinder networks, we predict that a learner's PFNet resulting from this interface will differ from a PFNet generated if a different interface (such as alphabetical listing of the terms) were used. Further research is needed to substantiate this assumption.

Designing a hypertext menu interface from a PFNet

Designing a hypertext menu interface with an authoring system such as Toolbook can be accomplished in a variety of ways. Once a list of terms are paired, the *.LO file can be displayed
on the screen using LAYOUT.EXE and sent to the printer. Consider the following design options:

Freehand drawing. Use the *.LO printout as a template and reproduce its main features such as number and position of nodes links in Toolbook (or Hypercard) with as much accuracy as possible.

Cut and Paste. Configure your computer to run KNOT from within Windows (this is not recommended by Interlink). Once the *.LO file appears on the screen, reduce the screen to an active window (by using the ALT - ENTER keystroke). Take a "snapshot" of the window using the ALT - Print Screen keystroke. Minimize KNOT on the desktop, and paste the screen print into a draw or graphics application. Copy and Paste the image into Toolbook.

Optical scanning. Scan the *.LO printout to a file. Depending upon the file format used, an import filter that will allow the file to be imported directly into the active book may be available within Toolbook.

Conclusion

The advent of a number of microcomputer hypertext authoring systems allows designers to create a variety of instructional and supplemental materials. If knowledge acquisition is enhanced through the use of Pathfinder networks, we encourage their use in the interface design. The procedures described in this paper were used to design an instructional module to research the effectiveness of PFNets as a blueprint for interface design and the effects of such an interface upon the learner's post-treatment knowledge structure. Clearly, more research is needed to determine the potential uses of PFNets with hypertext systems. We have presented a design model for constructing a PFNet interface. We encourage readers to experiment using PFNets with hypertext in other domains.

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Title:

An Assessment of the Computer Literacy and Computer Attitudes of Incoming First-Year Students at the University of Wisconsin-Eau Claire

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Computers are an unavoidable fact of life. They are used to gather, store, process and distribute information. More than ever before, the nation's workers are required to use computers to conduct business. And that means the nation's educators must address the demand both to teach and use computers in the classroom.

According to the U.S. Census Bureau's report, "Computer Use in the United States, 1989," more than 75 million Americans reported using a computer in some way. That figure was up from 47 million in 1984 (U.S. Department of Labor, 1992-1993). All indications are that the trend toward increased computer use will continue. For students graduating from post-secondary institutions, it is essential to have skills in microcomputer applications in their chosen career field.

In response to the computer age, many educators have embraced computer technology as an effective teaching tool. The effectiveness of computers as instructional tools has been documented in a variety of disciplines (Fleming, 1988; Hague & Mason, 1986; Sadler, 1987; Wiley, 1987). Classroom integration of computer technology is necessary to meet the future demands of society and the workplace.

Curriculum designers in post-secondary education seem to have abandoned the debate over whether computers should be used in the classroom and have turned their focus on the questions of when and how computers can be used effectively in education (Loyd & Gressard, 1984). But before computers can become an integrated part of the educational environment, educators need to know what computer literacy students possess before entering the classroom. Educators also must understand what attitudes students harbor toward computers. Understanding students' fears and anxieties will help educators craft instructional methods to overcome specific negative attitudes (Arch & Cummins, 1989).

Although limited research has been done to identify students' computer literacy levels, less effort has been devoted to understanding factors affecting students' attitudes toward computers as they enter post-secondary educational institutions. An assessment of students' computer literacy and attitudes would help educators in curriculum planning and in developing strategies to incorporate computer use successfully into various instructional settings. Such a literacy assessment would be useful particularly for educators who teach classes using computers as part of their instructional methodology. Identifying the existing computer literacy of first-year students will help teachers effectively plan curricula that would strike a balance between computer training and content instruction.

The status of students' computer literacy is of interest to many educators, including instructors who teach introductory computer courses and to instructors who teach other subjects, such as writing and mathematics, in a computer lab. Due to the varying levels of computer literacy among first-year college students, instructors who teach courses with a computer component often are faced with the difficult task of teaching students with a wide variety of ability levels (Harrington, 1990). Although the computer software used by students in many college courses is fairly simple and easy to use, the students still spend a significant portion of class time mastering software. The computer technology, then, could interfere with, or detract from, students' ability to focus on course content.

In an effort to learn more about students' computer literacy levels and attitudes about computer use, a study was performed during the summer of 1993 to evaluate the computer literacy of first-year students entering the University of Wisconsin-Eau Claire. It is hoped educators may use the study in a wide variety of subject areas to help plan classes and adapt teaching methodologies to meet students' needs.

Research Questions

The following questions guided the study:
1. How long have students been using computers as they enter the university as first-year students?
2. What kind of computer experience, if any, do incoming first-year students have? (e.g. word processing, desk-top publishing, programming, spreadsheets, data bases, graphics packages)
3. Where did students obtain their computer experience? (e.g. school, work, home)
4. Is there a relationship between student experience levels and attitudes toward computers?
5. Is there a relationship between student major and computer attitudes?
6. Is there a relationship between student gender and the level of computer literacy?
7. Is there a relationship between student gender and computer attitudes?

The answers to these research questions will be used to identify the existing computer literacy of incoming first-year students in order to help develop curricula that is relevant to the students' needs and to help develop instructional methods which take into consideration students' attitudes toward computers.

Review of the Literature

A number of studies have been conducted in educational settings to measure students' computer literacy, which refers to students' knowledge about computers and computer operations (Oates, 1983), and to identify how computer attitudes affect students' ability to use computers (Strickland, 1989). In a study at the University of Virginia, Loyd and Gressard (1984) found that levels of computer experience varied greatly in the students they studied. Their study indicated that students with more computer experience were significantly more confident in their use of computers than were students with little computer experience. Researchers viewed increased confidence as a positive factor which influenced students' general attitudes toward computer use. There is some evidence, however, that general attitudes toward computer use differ by gender, with women being less confident of their abilities and distrusting computers more than their male counterparts (Lockheed, 1985).

A study conducted at Purdue University (Sullivan, 1989) also measured students' knowledge of and previous experience with computers. Sullivan's study sought to gain a systematic knowledge of students' computer backgrounds. Sullivan found that although half the students surveyed had some previous experience with computers, many did not use computers regularly and had no motivation for using computers in their classes. Sullivan suggested that more complete information about students' computer literacy could help educators eliminate misconceptions about students' abilities and attitudes and develop curricula that more closely meets the needs of students.

Since 1985, students in freshmen computer literacy courses at Bentley College have participated in a study regarding their pre-college computing experience (Harrington, 1990). The annual surveys indicate that the number of students with a background in programming is decreasing, while the number of students with some background in productivity software is increasing. The school has used the results of the study to tailor its computer literacy course to students' backgrounds.

In addition to examining how students' computer experience affects current learning, several studies have been done to measure how past computer experience and attitudes about computer use may be linked. Howard, Murphy and Thomas (1987) found that increased computer experience reduced students' computer anxiety. Their study found that students' attitudes toward using computers could be improved by providing students with more computer knowledge and experience; more hours of computer experience at the college level seemed to promote higher levels of confidence and improved attitudes among students.

The researchers suggested that students who enter introductory courses with minimal experience and little knowledge about computers are more likely to suffer from high computer anxiety; therefore, classes that include computer training should be designed with the needs of these potential students in mind (Howard, Murphy, & Thomas, 1987).

Lee (1986) also studied the effects of computer experience on computer attitudes. In a study at the University of North Carolina at Charlotte, Lee found that past computer experience significantly affected performance in classroom activities in which students used computers. Lee suggested that minimal experience with computers may be sufficient to reduce anxiety, because there was not a significant difference between the performance of students whose computer skills were classified as "low experience" or "high experience." Other researchers also have hypothesized that inexperience and unfamiliarity with computers can cause high levels of anxiety and that such anxiety can interfere with students' academic performance (Hedl, O'Neil, & Hansen, 1973; Johnson & White, 1980; Johnson & Johnson, 1981).

Attitude also was found to be linked to computer use in a study conducted at a large midwestern university (Arndt, Clevenger, & Meiskey, 1985). The researchers found that high levels of computer use were associated with positive attitudes toward computers. Students with greater amounts of computer experience and relaxed attitudes toward computers were found to be less likely to view computers as threatening (Arndt, Clevenger, & Meiskey, 1985).

Gender also has been studied as a factor related to students' computer literacy and computer attitudes. In a study at a private liberal arts college, Arch and Cummins (1989) found that males tended to use and like computers more than did females. The researchers found that females tended to approach computers in a lab less frequently than males, and females had a more negative attitude about computers and their ability to use them. However, structured instruction in the use computers helped both males and females achieve a more positive attitude toward computer use and more confidence about their computer skills (Arch & Cummins, 1989).

Another study (Morahan-Martin, Olinsky, & Schumacher, 1992), which was conducted in 1989 and 1990 at Bryant College, provided evidence that gender differences are present in the computer experience, skills and attitudes of incoming college freshman. Although no differences were found in the amount of computer experience, males had more experience and skills than females in specific types of computer use, particularly programming.

Two studies conducted with students in New Jersey also showed a gender difference in attitudes toward computers (Wilder, Mackie, & Cooper, 1985). These studies found that both males and females perceive computer use as being more appropriate for males. The researchers suggest that students' attitudes toward, and gender-related perceptions of, computers are affected by previous school experiences.

Additional studies also have found that factors such as gender, age, experience and interest in computers can affect students' attitudes toward and use of computers (Lockheed, 1985; Smith, 1988) The findings of these and other studies suggest that additional research needs to be done to identify factors that could influence students' ability to use computers. A 1982 literature review by Lawton and Gershner (1982) found few empirical studies about issues related to computer literacy and attitudes, further suggesting a need for additional research in the area of factors affecting computer literacy and attitudes.

Methodology

The survey used to measure first-year students' computer literacy and to study factors affecting their attitudes toward computers was administered June through August of 1993 at the University of Wisconsin-Eau Claire. The University of Wisconsin-Eau Claire is a liberal arts college with an enrollment of approximately 10,000 students.

The questionnaires were distributed via student orientation packets to the university's 2,000 incoming first-year students. A written questionnaire was considered an appropriate data collection instrument because it permitted a large number of people to be surveyed in a brief period of time. Researchers had no contact with students and students received no oral explanation of the study. Written instructions included with the questionnaires asked students to return completed surveys to a drop-off box located at the registration site. Responding to the survey were 444 students (152 women and 289 men).

Designed to collect information from students regarding computer abilities and attitudes, the questionnaire asked students to record the amount and type of their previous computer experience, the source of experience and their attitudes toward using computers. Demographic data, including age, gender and major also were collected.

Questionnaire responses were tabulated with the help of UW-Eau Claire's Computing and Networking Services (CNS). The SPSS computer program was used to perform the analysis and to calculate frequencies for each question. CNS also helped cross-tabulate survey data on experience, age, major and gender with computer attitude questions in an effort to understand factors influencing both student computer literacy levels and students' attitudes toward using computers when they entered the university. For the purpose of the cross-tabulation, experience was separated into three categories: low-, mid- and high-experience users. The categories are defined as having 0 to 12 months of experience, 13 to 36 months and more than 36 months, respectively. Because there was not a significant rage of ages, age data added little information to the study.

Computer Literacy

The results of the study indicate the majority of students surveyed had some degree of computer literacy when they entered the university. Nearly 90 percent (86.7) of respondents said they possessed some computer experience. More than 70 percent had three or more years of experience. Most cited word processing as providing their chief experience with computers. Approximately 66 percent said they had basic word processing skills, while 33 percent described their word processing skills as advanced.

The study found that when students were asked to assess their computer literacy with more specific skills, such as graphic, desktop publishing and spreadsheet programs, their literacy declined sharply. For example, 47 percent of students said they had no experience with graphic programs and nearly 75 percent reported less than a year of computer graphic experience. Roughly 66 percent said they had no desktop publishing experience and 85 percent had less than a year of desktop publishing experience. Spreadsheet program experience also was limited. Forty-two percent reported having no experience with computer spreadsheets and 78 percent said they had less than a year of experience with spreadsheets. Nearly all students (97 percent) listed high school as the source of their computer experience.

Computer Attitudes – Experience

Cross-tabulating survey data collected about students' levels of computer literacy with responses to attitude questions revealed that increased experience was not equated with higher confidence levels. Overall, greater computer literacy did not positively improve students' attitudes toward using computers. Indeed, it seemed that the old adage "familiarity breeds contempt" (or at least mistrust) applied. Nearly 61 percent of high-experience users (those with 36 months or more of experience) reported strongly avoiding computers, compared to 21 percent of students with no computer experience and 24 percent with less than a year of experience. According to the questionnaire categories, 72 percent (314) of students were classified as high-experience users (having 36 months or more

361

of experience); 9.6 percent (42) as mid-range users (having 13 to 36 months experience); and 18.3 percent (80) as low-experience users (having 0 to 12 months experience).

Confidence levels also appeared to slide as experience rates climbed. For example, 22.3 percent of high-experience users strongly agreed or agreed with the statement, "I feel confident using computers," compared to 35.8 percent of mid-range users and 45.8 percent of low-experience users.

High-experience users also were more critical of their computer abilities. Nearly 55 percent strongly agreed or agreed with the statement, "I am no good at using computers," compared to 30.9 percent of mid-range users and 29.2 percent of low-experience users. In addition, relatively few high-experience users said they enjoy using computers (8.6 percent strongly agree or agree with the statement, "I enjoy using computers," compared to 2.4 percent of mid-range users and 0 percent of low-experience users.

Computer Attitudes – Major

Intended major appears to play no significant role in shaping student attitudes toward computer technology. Students of all ages and majors indicated a desire to avoid using computers. For example, 63 percent of science majors, 56 percent of business majors and 50 percent of humanities majors reported avoiding computer use.

Confidence levels were highest among humanities majors, perhaps because these students are not required to have highly developed computer skills. Roughly 31 percent strongly agreed or agreed with the, "I feel confident using computers," statement. Approximately 23 percent of science majors and 20 percent of business majors responded positively to the question. Humanities majors also reported grater enjoyment regarding computer use (12 percent); while 8.6 percent of business majors and 3.6 percent of science majors agreed or strongly agreed that they enjoy using computers.

Science majors were most critical of their computer abilities, with 57 percent indicating they are "not good" at using computers, compared to 51 percent of business majors and 44 percent of humanities majors.

Computer Attitudes – Gender

Gender difference was found to be a factor in students' attitudes toward computers. Nearly 58 percent of women reported avoiding using computers compared to 49 percent of men. Female students expressed less confidence in their computing abilities; 23 percent of women, as opposed to 34 percent of men, agreed or strongly agreed that they are confident using computers.

Gender appears to play less of a role in determining students' enjoyment of using computers than does choice of major. Roughly 9 percent of women and 8 percent of men strongly agreed or agreed that they enjoy using computers. Women, however, were more likely (55 percent) to describe themselves as "not good" at using computers, compared to 41 percent of men.

Conclusions

The study provides useful information about the computer literacy and attitudes of students entering the University of Wisconsin-Eau Claire. Approximately 90 percent of respondents have some computer experience. Nearly 70 percent said they had used word processing. Such news should be encouraging to instructors who plan to use computers as part of their instructional methodology. It appears reasonable to expect most incoming students to have some level of computer literacy, particularly in the area of word processing.

However, a lower number of students report having experience with graphic, spreadsheet or desktop publishing programs. Instructors who plan to incorporate these computer applications into their classroom likely will need to spend more time on computer training for students or identify other opportunities for students to improve literacy with classroom specific programs.

The response to the attitude questions indicate an area of challenge and opportunity for educators. While a number of studies indicate that students' attitudes improve and anxieties decrease with greater computer experience (Lee, 1986; Loyd & Gressarde, 1984), it appears more needs to be done to lessen students' fears about computer use, to help them build confidence in their abilities and to see the connection between computer use and success in the workplace.

A number of approaches may help achieve these goals. Mandatory training is one method which could be used to increase students' computer literacy and allow them to build confidence. Computer courses could become a required part of the curriculum, just as math and English are mandatory classes for most students.

A second approach would involve developing training to address students' anxiety levels. For example, the curriculum for a publication production class in which most students were familiar with desktop publishing could be taught differently than a class in which few of the students had computer experience or in which experience levels varied widely. In a Kent State University study of computer anxiety considerations related to the design of introductory computer courses, Howard, Murphy, and Thomas, 1987) found that initially segregating low-experience and high-experience users during the training process had beneficial outcomes for both students and instructors. For example, students with less computer experience could receive introductory information while more advanced students could work on enrichment exercises. Another option would be to allow more experienced students to serve as mentors or tutors to less experienced students.

The information gathered in the study offers some indication that gender differences do affect students' attitudes toward computers. An understanding of the differences in these attitudes and how they affect literacy rates could help educators make better educational choices about the selection of teaching methods and curricula. In a study of sex differences in attitude and computer use among college students, Arch and Cummins (1989) found women were more likely to improve their computer literacy and attitudes if they were required to participate in a structured, classroom-integrated approach to computer use. Such evidence may prompt instructors to design methodological approaches that accommodate the learning needs of both men and women, giving specific attention to students who would benefit from more structured training.

Other studies support the tenet that men and women may view computers differently and may require varied forms of training in order to be successful in computer use. A Bryant College study (Morahan-Martin, Olinsky, & Schumacher, 1992) found that females perceived computer skills as more useful for their careers than did males, but males were more willing to purchase computers than were women. Such evidence of gender differences suggests that determining the reasons behind the gender differences and developing alternate approaches may be required to help male and female students improve computer literacy and attitudes toward computers.

It is hoped the results of the study can be used to help educators conduct the task of curriculum planning and to develop courses that take into consideration students' attitudes and computer literacy. Additional research is recommended to further identify trends and patterns regarding college students' computer literacy and attitudes.

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Abstract

A study was done at the University of Wisconsin-Eau Claire in April 1992 to assess the computer skills of freshmen. Information about students' computer skills was obtained through the use of a questionnaire. The questionnaire was distributed in four sections of a mass media writing class in the UW-Eau Claire Journalism Department.

Information was gathered about the amount and type of students' previous computer experience, the source of the experience, and their attitudes toward using computers. Demographic information, such as age, sex, and major, was also collected.

The study found that 98 percent of the students surveyed possessed some computer experience, with 80 percent of the respondents reporting more than a year of computer experience. Ninety percent of the students had used word processing, and most of the students (94 percent) reported gaining computer experience in high school.

Over half the students who reported a high level of computer experience (more than one year) also stated that they look forward to using computers and that they have confidence in their computer abilities. Students with less experience more frequently reported avoiding computers and lacking confidence in their computer abilities.

The findings of the study suggest that most students entering the university will have some computer experience, with word processing being the most commonly occurring computer skill. Increased experience seems to create a positive attitude toward computer use and to improve students' confidence about their computer skills.

This study was a pilot study for a research project that will be performed later in 1992.

Title:

The Effects of Search Tool and Cognitive Style on Performance in Hypermedia Database Searches

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Abstract

This study investigated the effects of interface tools and learner cognitive styles on performance in searches for information within a hypermedia database. The subjects, 75 students in a university ESL program, were blocked for field dependence and assigned to four treatments which differed by the search tool available. The subjects searched EarthQuest, a social studies and science hypermedia database, for facts to answer practice and posttest questions on science topics. Field-independent subjects had significantly better achievement than field-dependent subjects in both the index/find and map treatments but not in the browser or all tools treatments. The active engagement, transfer of concepts to new contexts, and high information processing demands that accompany effective use of the index, find, and map tools may explain the greater achievement by field independents. The interface design and instructional use of hypermedia databases should reflect the range of cognitive styles of users.

The Effects of Search Tool and Cognitive Style on Performance in Hypermedia Database Searches

The use of hypermedia systems for learning and information retrieval has grown very rapidly in recent years. Hypermedia cover a wide range of applications, from online documentation and help systems to authoring tools for instruction and learning (Jonassen & Grabinger, 1990). Some educational researchers have been intrigued by the possibility that hypermedia can be structured to reflect the semantic network of a subject matter expert's knowledge and then used for instruction to help learners acquire not only knowledge but also the expert's knowledge structures (Jonassen & Wang, 1993). Others see different potentials for the use of hypermedia in education. Duchastel (1990) argues that the greatest impact will be for information retrieval, allowing easy access to the vast amount of information that will be available electronically in the very near future. In explaining his position, Duchastel stresses what he considers the essential characteristic of hypermedia: information organized in a network that provides the user with "the capability to quickly access additional information related to the information currently under consideration" (1990, p. 136).

However, accessing information from a hypermedia system is often not an easy task, especially for novices. Users may encounter a number of common problems (Hammond and Allinson, 1989). They may get lost or have difficulty gaining an overview or finding specific information. They might wander without an orienting goal or strategy, or they may find the interface tools difficult to use. Such problems have prompted research on the manner in which users interact with hypermedia.

The focus of some research has been on the effectiveness of different tools for searching hypermedia databases. Jones (1989) investigated the use of menus embedded in the text for browsing compared with indexes for searching encyclopedia articles in a hypertext system. Both success on finding facts and score on an incidental learning posttest indicated no advantage of one tool over the other. Using a hypermedia-based city guide, Hammond and Allinson (1989) studied exploratory and directed searches under five tool use conditions: hypertext links alone, with maps added, with an index added, with tours added, or with all of these tools. A posttest over factual knowledge gained from exploration and a search for specific information in the database showed no significant effect for the tool used in either task. Wright and Lickorish (1990) had learners use two hypertext databases, one with a book-like structure and the other with a hierarchical structure, which they searched by either a map or an index. To answer questions, users had to compare information from different sections in each database. The results showed no significant differences for the two search tools.

The studies reviewed above provided learners with little or no practice using the tools before engaging in search tasks. In the present study, learners received a 45-minute hands-on orientation to searching a database and a 30-minute practice search of the database. Cronbach and Snow (1977) provide theoretical and experimental support for their recommendation that study treatments should be long enough to allow learners to gain experience with instructional procedures.

Another factor which may account for differences in information retrieval from hypermedia is the individual characteristics of users. One of the most extensively researched characteristics is field dependence, a psychological construct identified and elaborated primarily through the work of H. A. Witkin and his colleagues (Goodenough, 1986). The field dependence construct describes differences of ability in perceptual and cognitive problem solving. In tasks that require disembedding parts of a field from the overall organization of the field, field-dependent individuals will tend to experience the parts as "fused," whereas field-independent individuals tend to experience the parts as distinct from the field as an organized whole (Witkin, Oltman, Raskin, & Karp, 1971). This stylistic tendency in perception is also displayed in intellectual functions, as what is termed cognitive style. An ability to disembed simple figures from complex designs is reflected in an ability to solve a cognitive problem by isolating a critical element and using it in a different context. Thus, as Witkin and colleagues (1971) explained, a field-independent person is capable of a more analytical cognitive functioning than a field-dependent person, who uses a more global approach.

The few studies that have investigated cognitive style as a factor in use of hypermedia systems found performance differences between field independents and field dependents. Repman, Rooze, and Weller (1991) presented a hypermedia lesson on computer ethics to study the effects of advance organizers and structural organizers as a function of the cognitive style of junior high students. Different mixes of a map, an outline, and screen titles differentiated four treatments. Although field-independent learners outperformed field-dependent students in all treatments, the absence of any benefit from advance or structural organizers on the field-dependent learners was contrary to what the investigators expected.

En-route performance differences were found by Stanton and Stammers (1990) when they compared field-independent and field-dependent adults using hypertext training modules. Post-hoc classification of the users by the ways they accessed the hypertext structure indicated that the more field-dependent users tended to move from details to main points in the modules. The authors concluded that this "bottom-up" strategy reflected the tendency of field-dependent individuals to develop a mental model through hands-on experience rather than to fill in a model formulated previous to the interaction as would be expected of field-independent users.

When Jonassen and Wang (1993) investigated different methods for making structural knowledge of hypertext information accessible to learners, they observed treatment differences by cognitive style. A browser treatment used pop-up windows to identify the semantic nature of each hypertext link. A semantic selection treatment required the learner to choose the semantic type from a list at each link in order to navigate across links. A control treatment offered no structural information at the links. On a posttest recall task, field-independent learners did better in the control and semantic selection treatments and worse in the browser treatment. The authors suggested that this result reflected the preference of field-independent learners to restructure information rather than accept the structure provided by materials.

The cognitive style studies described above examined the exploratory behavior and related learning of users. In contrast, the present study set specific information retrieval tasks and focussed on search task performance.

The purpose of the present study was to investigate the effects of search tool and cognitive style on performance in hypermedia database searches. The search tool variable had four levels: browser, index/find, map, and all tools. The cognitive style variable had two levels: field independent and field dependent. Performance was measured on searches in the database to find specific information. Besides search achievement, patterns of tool use were of interest in this study. Also, attitudes of the learners toward the tasks were obtained.

It was hypothesized that the four treatments would differentiate between learners with analytical (field independent) and global (field dependent) styles of cognitive processing. Therefore, interaction of the treatment search tools with the cognitive styles of the learners was expected. The browser, map, and all tools treatments were expected to be used with similar effectiveness by field-independent and field-dependent learners. However, the index and find tools were expected to be more advantageous than other tools for field-independent learners and to be less useful for field-dependent learners.

This hypothesis is based on the comparatively greater benefit for field dependent learners when material is encountered in a structured or organized manner (Davis, 1991). The browser and map tools would provide a more consistently structured user-content interface than would the index and find tools. Use of the index and find tools would involve disembedding words and concepts from their context at a screen and transferring them to other contexts at other screens. The expectation that field-dependent learners would not perform better than field-independent learners in any treatment reflects the results of cognitive style research, which Davis (1991) found provided no evidence of an advantage for field-dependent learners except when the context has social relevance.

Method

Subjects

Subjects were 75 adult students (40 males, 35 females) enrolled in an intensive preadmission English as a second language (ESL) program at a large southwestern university. These students came from more than a dozen different countries. Their reading comprehension level in English was two semesters or less below American freshman student proficiency.

Materials

Materials in this study included a HyperCard database, a print-based orientation packet, a print-based practice packet, and the Group Embedded Figures Test.

The content material for the study was a HyperCard database called EarthQuest (Stevens & Smith, 1990). This published hypermedia program is designed for secondary social studies and science instruction. The content is arranged hierarchically under five major headings: Earth (an earth science focus on planets, land, water, air, and life), Journey (a historical approach to invention and politics); Environment (interrelationships and ecological issues for land, water, air, and life), & World Tour (a geographical overview of nations by continent). Information is presented on over 80 screens by text, graphics, animation, and sound. Many of these screens include pop-up windows with scrolling text. EarthQuest provides five basic tools for navigation and search within the database. Graphic/text buttons on each screen can be clicked to move to the content they represent. Browser icons can be used to navigate between any contiguous screens at the same level and up or down the content hierarchy. An index lists the contents of the database as one- or twoword topics which can be selected to reach the content screens for those topics. A find feature searches the database for typed text strings. Maps display a hierarchical arrangement of the content and allow searching by category, subcategory, and individual screen topic. Each of these five tools can be used to reach any content screen in the database.

EarthQuest was modified for three of the four treatments in this study. The browser treatment had the index, find, and map tools disabled. The index/find treatment had the browser and map tools disabled. The map treatment had the browser, index, and find tools disabled. The all tools treatment used an unmodified version of EarthQuest.

The orientation packet contained handout directions to familiarize learners with the search tools. The directions explained how to use each tool to conduct searches of the database to find specific information.

The practice packet contained handouts giving practice search directions and questions. Each of the five search questions asked for the name of the database screen where information was located as well as the answer found there. The first three questions required searches for isolated facts. The other two were cause/effect and main point/support questions that each required information from two screens. Some of the search questions provided hints about options selection. One of the fact-finding questions was, "Living things are found only in a very thin layer of the Earth's crust. How thick is that layer?" The cause/effect question, along with directions for it, was "Land can move and change shape, such as to make mountains and valleys. What are two causes of this kind of change? (Hint: Play movies.) Get your answers from two screens."

The Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin, & Karp, 1971) was used to indicate the cognitive style of each learner in the study. The GEFT measures the ability to locate a simple figure within a larger complex figure which has been designed to obscure or embed the simple figure. A low score on this timed group-administered test indicates perceptual field dependence, whereas a high score indicates perceptual field independence. In broader terms, the GEFT assesses a global versus analytical dimension of cognitive style.

Procedures

Instruction took place during two 75-minute class sessions for each of six classes within a five-day period. The students were asked to volunteer their participation in a study using a computer program in the ESL computer lab. Their incentive was a daily class activity grade for each session.

The GEFT was administered to the participants at the start of the first session. Each learner then received an orientation packet. Using an overhead computer screen display of EarthQuest, the investigator led the learners through the orientation directions while the learners performed searches in the database at their individual computers. During this 45-minute orientation, all learners used an unmodified version of EarthQuest.

Before the second session, the GEFT scores were used to block the learners for assignment to the treatment groups. For this blocking, the learners were designated as field dependent if they scored from 0 to 9 on the GEFT (n = 31) or as field independent if they scored from 10 to 18 on the GEFT (n = 44). This grouping was based on the bimodal shape of the GEFT score distribution, which indicated a dichotomy of the learners. Equal numbers of learners were randomly assigned to each treatment: All Tools, Browser, Index/Find, and Map.

For the second session, the learners were assigned to their respective treatment versions of EarthQuest. During the 30-minute search practice, learners used the practice packet to search the database with their assigned treatment tools. They received feedback by turning to the following page in the handout, where the answer was given above the next question.

After the practice, a posttest was administered. The learners were allotted 30 minutes to search EarthQuest for answers to the posttest questions using their assigned tools. At the end of the second session, the learners completed an attitude questionnaire.

Criterion Measures

The dependent variables in this study were achievement on posttest searches, tool use during posttest searches, and learner attitudes.

The posttest was parallel in format to the practice searches but from a different content area in the database. Each answer received one point if the information was correct and another point if the location of that information in the database was correct, to give a total of 14 possible points. Identification of the location increased the probability that learners would actually perform searches in order to answer the questions rather than rely on their prior knowledge of the content. The Cronbach alpha reliability coefficient of the posttest was .66.

Tool use during the posttest searches was recorded for each learner by means of a tracking script added to the EarthQuest program. This script captured data on the tool the learner selected to navigate to each screen and the time when each screen was accessed. These data were compiled to give both the number of screens accessed using each tool and the time spent at those screens. The four measures for patterns of tool use were number of screens accessed using treatment tools, number of screens accessed using graphic/text buttons, time at screens accessed using treatment tools, and time at screens accessed using graphic/text buttons.

Attitudinal data was obtained by a 4-point Likert-type questionnaire consisting of 12 items. The questions asked learners to respond to statements about the value of the lesson and their enjoyment of it, the ease of use of the database, and their understanding of the directions and questions. Two questions specific to each treatment asked about the usefulness and ease of use of the tools assigned for that treatment. The alpha reliability of the questionnaire was .85.

Design and Data Analysis

A 4 X 2 (search tool X cognitive style) posttest-only experimental design was used, with random assignment to treatment groups after blocking by cognitive style.

Due to unequal cell sizes in the study design, homogeneity of variance for the posttest scores was a concern. The Bartlett-Box F test (Glass & Hopkins, 1984) indicated that the scores were homogeneous in variance among cell groups ($p > .25$).

An alpha of .05 was used for all statistical tests. Posttest achievement was analyzed with ANOVA; tool use and attitudinal data were analyzed with MANOVA. If multivariate significance was found on analysis of the tool use and attitudinal data, univariate tests were then performed. For any significant main effects found for the search tool variable, Tukey multiple comparisons followed.

Results

Achievement

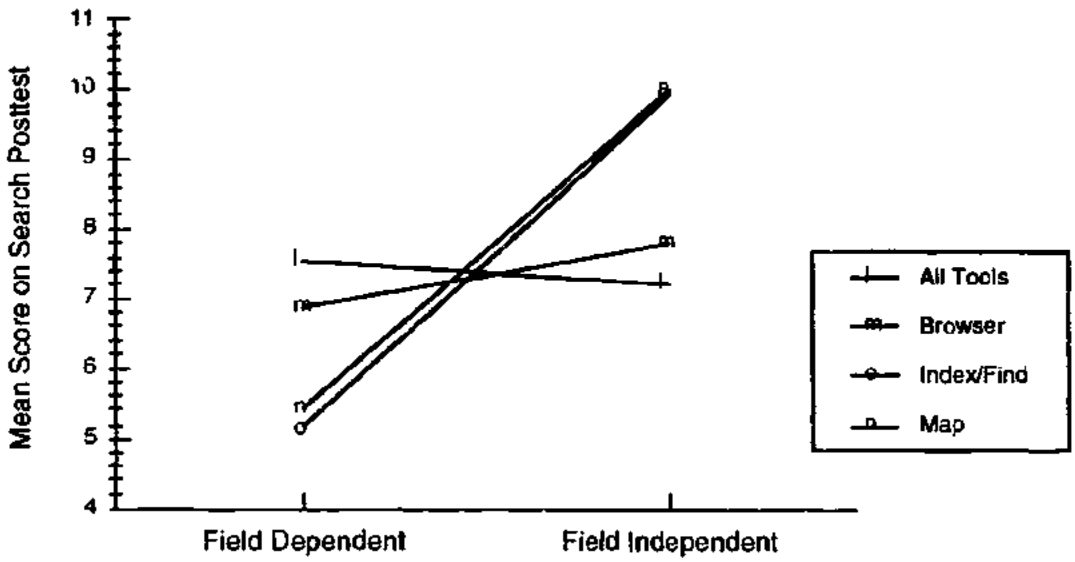
Table 1 gives mean posttest scores by level of search tool and cognitive style. The mean posttest scores by level of search tool were 7.37 for the all tools group, 7.39 for the browser group, 8.16 for the index/find group, and 8.32 for the map group. The mean scores by level of cognitive style were 6.35 for the field dependent group and 8.84 for the field independent group.

Table 1
Search Test Scores by Search Tool and Cognitive Style

	Search Tool				
Cognitive Style Total	All	Browser	Index/Find	Map	
Field Dependent					
M	7.56	6.88	5.14	5.43	6.35
SD	2.83	3.18	3.29	3.36	3.16
Field Independent					
M	7.20	7.80	9.92	10.00	8.84
SD	3.99	2.82	2.61	1.59	3.00
Total					
M	7.37	7.39	8.16	8.32	7.83
SD	3.40	2.93	3.66	3.23	3.28

ANOVA revealed a significant interaction between search tool and cognitive style, $F(3,67) = 3.48$, $p < .05$, $ES = .37$. This interaction is illustrated in Figure 1. A simple main effects test (Ferguson & Takane, 1989) suggested that within the index/find treatment, fieldindependent learners ($M = 9.92$) performed significantly better than field-dependent learners ($M = 5.14$), $F(1,67) = 12.27$, $p < .001$, $ES = .70$); within the map treatment, fieldindependent learners ($M = 10.00$) also performed significantly better than field-dependent learners ($M = 5.43$), $F(1,67) = 11.74$, $p < .001$, $ES = .68$. No other significant differences were found when simple main effects tests were conducted.

Figure 1. Effects of search tool and cognitive style on search test achievement.



ANOVA also indicated that cognitive style was significantly related to achievement, $\underline{F}(1,67) = 12.65$, $\underline{p} < .001$, $\underline{ES} = .41$. Field-independent learners performed significantly better on the posttest than field-dependent learners. ANOVA did not reveal a significant main effect for search tool treatment.

Tool Use

MANOVA revealed that search tool treatment had a significant effect on tool use, $\underline{F}(12,108) = 3.85$, $\underline{p} < .001$. Univariate analyses indicated that differences occurred for the number of screens accessed using treatment tools, $\underline{F}(3,67) = 8.21$, $\underline{p} < .001$, $\underline{ES} = .57$, and for the number of screens accessed using graphic/text buttons, $\underline{F}(3,67) = 4.68$, $\underline{p} < .01$, $\underline{ES} = .43$.

Tukey multiple comparison tests suggested that learners in the browser treatment ($\underline{M} = 32.37$) significantly accessed more screens using their treatment tool than did learners in the index/find treatment ($\underline{M} = 8.57$) and in the all tools treatment ($\underline{M} = 14.33$). Tukey multiple comparison tests also indicated that learners in the browser treatment ($\underline{M} = 38.12$) significantly accessed more screens using the graphic/text buttons than did learners in the index/find treatment ($\underline{M} = 14.86$).

MANOVA also revealed that cognitive style was significantly related to tool use $\underline{F}(4,51) = 3.11$, $\underline{p} < .05$. Univariate analyses indicated that differences occurred for the number of screens accessed using treatment tools, $\underline{F}(1,67) = 14.13$, $\underline{p} < .001$, $\underline{ES} = .43$. Fieldindependent learners ($\underline{M} = 27.86$) significantly accessed more screens than did fielddependent learners ($\underline{M} = 12.93$).

Learner Attitudes

Three of the 75 learners were not included in the analysis of questionnaire data due to incomplete responses or unreturned forms.

Data on learner attitudes were measured on a 1 to 4 scale with 1 as "strongly agree" and 4 as "strongly disagree." Learner attitude results indicated a general liking for both the program and the tasks, with a mean response of 2.16. The highest response (M = 1.70) was to the statement, "EarthQuest is a good program." The lowest response (M = 2.65) was to the statement, "I had enough time to answer the questions."

MANOVA revealed that cognitive style had a significant relationship with attitude, $F(12,43) = 2.60$, $p < .05$. Univariate analyses indicated that significant differences occurred for two of the 12 items. Field-independent learners (M = 1.93) responded more positively than the field-dependent learners (M = 2.33) to the statement that the assigned treatment tool "was useful for finding the answers to the questions," $F(1,64) = 5.77$, $p < .05$, $ES = .28$. However, field-dependent learners (M = 1.44) were more positive than the field-independent learners to the statement, "EarthQuest is a good program," (M = 1.89), $F(1,64) = 4.55$, $p < .05$, $ES = .25$.

Discussion

The purpose of this study was to investigate the effects of search tool and cognitive style on performance in hypermedia database searches. Learners assigned to one of four interface tool treatments searched for specific information in the EarthQuest database. Cognitive style was defined in terms of field dependence, as measured by the GEFT. The results of this study support the hypothesis for an interaction of search tool with cognitive style.

As expected, the search achievement in the index/find treatment was significantly better for the field-independent learners than for the field-dependent learners. This superiority may be a reflection of "more active approaches to learning, such as hypothesis testing and employment of verbal mediators" (Goodenough, 1976, p. 676), approaches which a variety of studies have associated with field independence (Witkin, Moore, Goodenough, & Cox, 1977). In order to navigate from screen to screen in EarthQuest when using the index and find tools, the learners had to physically select a word or phrase by either typing it into the find dialog box or choosing it at the index. When the screen accessed by this action was in a different section of the database, the learners encountered a new context. It therefore appears likely that active approaches, such as hypothesis testing or the use of verbal mediators, were important for searches employing the index and find tools. Fieldindependent learners, being more inclined to engage in hypothesis testing or to use verbal mediators, would be expected to have an advantage when using the index and find tools.

The search achievement results also confirmed the expectation of no significant difference by cognitive style in the browser and all tools treatments. Cognitive style research offers an explanation for this. Field-dependent individuals tend to use "more intuitive spectator approaches" to learning (Goodenough, 1976, p. 676). When searches in EarthQuest were performed using the browser tool, a click of the browser icon accessed a contiguous screen at the same level, higher, or lower in the content hierarchy. Often there was no need to enter a different section of the database. This less active style of interaction would benefit field-dependent learners.

The similarity of the all tools treatment results to those of the browser treatment for search achievement can be understood from the patterns of tool selection revealed by the tracking data. When the all tools learners accessed screens by treatment tool, 70% of the time they used the browser, compared with 28% for the index and find tools and 2% for the map. Since the all tools learners predominantly used the browser, it is not surprising that their performance was similar to that of the browser learners.

Search achievement results for the map treatment were contrary to expectation. The field-independent learners assigned to use the map tool outperformed the field-dependent learners under this treatment with a difference and an effect size close to those found for the index/find treatment. The hypothesis had predicted search achievement of the map users similar to that of the browser users. It was assumed that using the maps would provide the learners with a structured interface that could accommodate the more global approach of field-dependent learners. However, unlike the other tools, the maps were not available on every screen. The learners had to access them on separate map screens. To move through the map hierarchy from main sections to subsections in order to access individual screens, at least one additional map screen had to be selected. The map screens thereby took the learners out of the context of a content screen. Field-independent learners, with their greater ability to transfer concepts to new contexts, appear to have an advantage at this kind of map interface.

Additional support for these explanations comes from information processing research on cognitive style differences. In a review of these studies, Davis (1991) concluded that little or no difference was found between field-independent and field-dependent learners when a limited amount of information was processed. However, field-independent learners were consistently more efficient in situations with higher information-processing demands. Reflecting Marchionini's observation that "it takes less cognitive load to browse than it does to plan and conduct an analytical, optimized search" (1987, p. 70), in the present study it appeared that the browser tool placed less information processing demands on learners than the other tools.

The results for patterns of tool use revealed that while using their treatment tools, the field independents accessed more screens than did the field dependents. This adds support to the suggestion that the field-independent learners were more actively engaged when searching the database than were the field-dependent learners.

The attitudinal results indicate that EarthQuest was generally well-received, although cognitive style differences appeared in the attitude questionnaire responses. The fielddependent learners strongly agreed that EarthQuest was a good program; the fieldindependent learners were less positive, but also agreed that it was good. Locus of control may be an important factor in this difference in attitude. Field-independent learners tend to be more internally motivated and less influenced by external goals, compared with fielddependent learners (Witkin et al., 1977). Locus of control could account for differences in attitude found by Small and Grabowski (1992) in student use of a hypermedia system. Although all of the field-dependent subjects in that study were satisfied with only the hypermedia lessons, most of the more field-independent subjects said they would probably consult other sources as well. In the present study, the field-independent learners may have considered the EarthQuest lesson an inadequate way to achieve their language learning goals, whereas the field-dependent learners appeared to be more accepting of the lesson as part of their classwork in English.

The results of this study have implications for the design of hypermedia and its use in the classroom. Decisions about which interface tools to provide for database search and information retrieval should take into account the cognitive styles of users. Tools such as a browser, which can be used effectively without placing high information processing demands on the user, should be made available for field-dependent individuals. Index, text-string find, and other tools that allow more analytical and optimized searches would provide fieldindependent users with an efficient method for information retrieval. In a variety of settings, students with different cognitive styles could learn more, and perhaps be better motivated, if activities involving information retrieval accommodated the cognitive processing approaches of those students.

An avenue of future research on cognitive style factors in the use of hypermedia could involve the formulation of criteria for interface tool design. Hutchins, Hollan, and Norman (1986) use the term direct engagement to identify the nature of user interaction with computers. When there is greater direct engagement, the computer interface becomes more transparent and the user more involved in the illusion of acting directly upon the objects in the task domain. Hutchins and colleagues suggest that this feeling of directness is "inversely proportional to the amount of cognitive effort it takes to manipulate and evaluate a system" (1986, p. 95). Perhaps a measure of direct engagement could be applied to the tools used in hypermedia systems. A tool which provided greater direct engagement would lessen the cognitive effort, or information processing demands, of the learner and would especially benefit those with a more field-dependent cognitive style.

The current growth in the use of hypermedia both in education and communications suggests that it deserves the attention of educational technologists. Jonassen and Grabinger (1990) envision the possibility of an extensive impact of hypermedia on our lives that would require a new form of literacy: "If large amounts of our reading in the future will be by unguided and unconstrained electronic text, new strategies (a hypermedia literacy) will be needed" (p. 21). If our work as educational technologists is to include facilitating the use of new information forms, we need to consider how cognitive style and other individual characteristics affect the performance of learners.

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Title:

Authentic Activity as a Model for Appropriate Learning Activity: Implications for Design of Computer-Based Simulations

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It is an often stated conviction that producing transfer is the main job of education. Yet, an increasing body of research shows that the way knowledge is presented to students in school and the kinds of operations they are asked to perform often result in students knowing something but failing to use it when relevant. Brown, Collins, and Duguid (1989) have concluded that this condition, variously referred to as a transfer problem or the problem of inert knowledge, occurs because classroom activities lack the contextual features of real-life problem-solving situations.

Today, there is widespread interest in learning through authentic use as the theory base for situated learning matures and as innovations in computer-based multi-media systems outstrip development of theory-based instructional strategies (Dick, 1991). Increasingly, theorists and educators are promoting reality-centered projects, theme-based learning, and other kinds of activities situated in real-life and life-like contexts as ways to engage students in meaningful learning (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Clinchy, 1989; Wager, 1994). At the same time, the availability of powerful low-cost computers has stimulated interest in the design and development of simulations. Simulations have long been used to deliver instruction in educational, military, and industrial settings on the basis that they increase the ability of participants to apply what they have learned in the classroom to the real-world or transfer situation.

In this paper, we discuss the implications of authentic activity considered as a model for appropriate learning activity, particularly in the design of computer-based simulations and project-based learning activities. We suggest that there is much more to transforming the conventional classroom into an authentic learning environment than incorporating features of real-life situations into school work. The provision of computer-based simulations and reality-centered projects does not insure that a student will assume a positive orientation to learning nor derive the benefits of in-context learning. Much additional support is required to strengthen the tendency of the learner to engage in intentional learning processes and to help the learner progressively assume responsibility for learning.

The following discussion is divided into three sections, with each section organized around one of three questions and each question serving as a heading for one of the sections:
(a) What are the characteristics of real life problem-solving situations, and what is different about problem solving in school?
(b) What are the characteristics of educational simulations, and what do people learn from them?
(c) What are the characteristics of an authentic learning activity, and how is it related to problem-solving in real life and simulated situations?

Question 1. What are the characteristics of real-life problem-solving situations, and what is different about problem solving in school?

In the cognitive apprenticeship framework, understanding develops through application and manipulation of knowledge within the context of the ordinary practices of the target culture--in other words, through authentic activity. This principle represents the primary rationale for using authentic activity as the model for appropriate learning activities. As Brown et al. (1989) suggested, conventional classroom tasks frequently lack the contextual features that support transfer from the school setting to the outside world. For advocates of situated approaches to learning, the provision of authentic activity in schools is a way to increase cognitive engagement, support meaningful learning, and facilitate transfer.

In this section, we list characteristics of real-life problem-solving tasks that are relevant to the design of authentic learning environments:

- Conditions are frequently ill-structured and problems are ill-formulated. Hence, as Spiro, Feltovich, Jacobson, & Coulson, (1991) suggested, understanding develops through experience in multiple case contexts and from multiple perspectives within the same context.
- Practice using skills is embedded in performing the activities that justify developing the skills in the first place (Brophy & Alleman, 1991).
- The reasons for learning something or performing an activity are clear. Individuals assume responsibility for establishing and monitoring their goals and strategies when the reasons for performing procedures, even tedious ones, are understood within the context of a broad global task environment (Honebein, Duffy, and Fishman, 1994).
- Projects frequently have depth, complexity, and duration (Berliner, 1992). People have opportunities to engage in active and generative problem-solving activities that involve personal values and beliefs. As a result, they experience a feeling of ownership over the activity and its goals, and thus, the tendency to engage in intentional and self-regulated learning processes is enhanced.
- People work together in situations where the intelligence to solve a problem or perform an activity is distributed across a group of peers, a learner-mentor system, and/or an electronic performance support tool (EPSS) or other form of cognitive technology (Pea, 1993). The quality of interactions between participants is frequently of primary importance in undertaking a project or accomplishing a goal.
- People work on solving problems that do not already have known solutions. When people work collaboratively on solving real-life problems, they share in substantive conversation, which has a different quality from conventional school talk (Newmann, 1991). An individual's orientation toward learning is qualitatively different when learning is embedded in the context of achieving personally relevant and valued goals versus working for a grade or some goal that is far off in the future.

Question 2. What are the characteristics of an educational simulation, and what do people learn from them?

The theoretical assumptions underlying the design of simulations are varied, as are the purposes for which they are used and the contexts in which they appear. According to Cunningham (1984), a simulation duplicates some essential aspect of reality for purposes of experimentation, prediction, evaluation, or learning. An educational simulation is designed to increase one's ability to respond appropriately in a real-world or transfer setting. Participants practice decision-making, problem solving, and/or role playing in the context of a controlled representation of a real situation (Smith, 1986).

From an instructional design perspective, educational simulations support predetermined learning outcomes by providing participants with opportunities to deal with the consequences of their actions and to respond to feedback. Within Pea's (1985) framework of distributed intelligence, computer-assisted simulations have the potential to reorganize mental processes by "closing of the temporal gaps between thought and action [and] between hypothesis and experiment" (p. 85). Pea has proposed that by allowing the user to engage in "what-if thinking" through a partnership between user and technology, deep qualitative effects are made possible on how problem solving occurs.

In reviewing the literature on simulation, the definition of fidelity appears to vary depending on the context to which it is applied and the theoretical orientation of the author. For example, in proposing a model for assessing the fidelity of task simulators used in industry, Bruce (1987) proposed three criteria: (a) physical similarity, (b) functional similarity, and (c) task communality. The fidelity of a simulator within Bruce's fidelity verification model is determined by assigning a value to each of these categories and combining them to produce a fidelity index for a particular training device. In contrast, Smith (1986) believes that the essential reality factor in a simulation is not the form of the simulation but the information-processing demands it imposes on the learner. He has referred to this characteristic of a simulation as its "cognitive realism," the degree to which the simulation engages participants in a decision-making or problem-solving process that parallels the mental activities required in the real situation.

Contrary to what intuitively may seem the case, research does not support the idea that maximizing realism or fidelity of a simulation results in maximizing learning outcomes (Alessi, 1987). With this in mind, Reigeluth and Schwartz (1989) have recommended that the best way to handle complexity in a simulation, when designing for a novice learner, is to start with low fidelity and to add fidelity and complexity progressively. Similarly, Blumenfeld et al. (1991) have proposed that a great strength of simulation for instructional purposes is its potential to allow students active exploration in simplified environments. They believe that when extraneous details are minimized, interactions between variables are easier to notice than in a highly realistic simulation or in the transfer environment itself.

Reigeluth and Schwartz (1989) have described three major elements in the design of a simulation that they believe determine its effectiveness: the scenario, the underlying model. and the instructional overlay. They have suggested that the scenario (the situation and the learner interface with the simulation) and the model (usually a mathematical formula in computer-based simulations for establishing causal relationships but can be some other basis) should duplicate to some degree the essential characteristics of the transfer situation. In other words, the characteristics of the scenario and the model determine the fidelity of the simulation, although how to identify the essential characteristics of the transfer situation is not addressed. Reigeluth and Schwartz have concluded, on the basis of their own analysis of simulations, that the instructional overlay (the features in the simulation that function to optimize learning and motivation) are generally the weakest aspect in educational simulations.

One element of the instructional overlay that Reigeluth and Schwartz (1989) feel should receive more attention from designers is the provision of artificial feedback. Alessi and Trollip (1985) have distinguished between natural feedback that the real-life situation provides, and artificial feedback that the designer builds into the simulation. One of the strengths of simulation for instructional purposes is its potential to shelter learners from costly forms of natural feedback (skidding into a snow bank) and to provide real-time artificial feedback (turn in the direction of the skid.)

The simplifying conditions method proposed by Reigeluth (1993) appears to take advantage of strengths inherent in simulation without sacrificing authenticity of the learning activity. In this method, experts identify a simple kind of case that is as representative as possible of a real-world task and the ways in which this "epitome" version of the task differs from more complex versions. Over time, complexity and variation are added to the learning activity in a systematic manner with the expectation that the method preserves the potential benefits of in-context learning. Reigeluth has claimed that this is a more holistic way to sequence instruction than the traditional parts-to-hole approach and is compatible with context-based design models. In the following section, we will return to this and other issues previously raised when we discuss what we see as the similarities and differences between real-life situations, simulations, and authentic learning activity.

Question 3. What are the characteristics of an authentic learning activity, and how is it related to problem-solving in real life and simulated situations?

Buchanan (1992) has suggested that since conditions are ill-structured and problems are ill-formulated in many areas of human endeavor, all but the most clearly linear design problems assume a fundamental indeterminacy. von Bertalanffy's (1967) distinction between open as opposed to closed systems is relevant to this view. He has written that closed systems such as cybernetic or feedback systems are open to information but do not exchange matter with the environment. Open systems, on the other hand, such as organisms and other living systems are maintained in a continuous exchange of components. Instructional design within an open systems framework requires a shift in preferred metaphor for education from transmission of information to building representations of meaning.

From a constructivist perspective, the most pertinent issue facing designers is what educational goals are worthwhile. Authentic activity represents a holistic and generative view of appropriate learning activity that treats learning and motivation as interdependent processes and places emphasis on self-directed learning and on development of metacognitive ability necessary to support it. Authentic learning situations retain some of the complexity and messiness of real-world problem-solving situations, as well as some of the advantages of simulation discussed previously.

One way to think about authentic learning activity is as a simulation where the instructional overlay is designed to support a related set of values: collaboration, autonomy, multiple perspectives, pluralism, activity, reflectivity, generativity, authenticity, and ownership (Lebow, 1993). In this view of instruction, ends are integrated with means. For example, a goal of instruction, to develop interpersonal skills for sustaining cooperative group work, is also a means to achieving the very same goal by practicing group process skills in the context of personally relevant goals. Another goal, to develop the ability to reflect on one's own learning processes, is also a means to self-correction and self-regulation of the learning process. In effect, instruction within an authentic learning activity is a model for the values that instruction is designed to support.

Carroll (1990) has suggested that in order to facilitate transfer, promote metacognitive and affective learning, support an adaptive motivational pattern to learning and encourage a high degree of ownership and personal relevance, educators should provide training on real tasks. Similarly, Spiro, Vispoel, Schmitz, Samarapungavan, and Boeger (1987) believe that "cases and examples must be studied as they really occur, in their natural contexts, not as stripped down 'textbook examples' that conveniently illustrate some principle" (p. 181). Honebein et al. (1994) have concluded that understanding developed in a simplified environment is different from understanding in the transfer environment. They have argued that the complexity of the learning environment in the early stages of learning should reflect the complexity of the authentic context to the extent practical. Otherwise, when instructional designers simplify the learning environment, they may unwittingly alter the metacognitive and affective demands of the authentic task complex. From this perspective, the role of instruction changes from controlling student learning through imposing a simplifying structure on the environment to developing new strategies, tools, and resources that support the student in functioning within the authentic learning context.

Our understanding of authentic activity as a model for appropriate learning activity is somewhat different than the one expressed above. We see authentic activity as involving a more complex view of fidelity than simply a concern for optimizing the degree of realism and the level of complexity in a learning situation. Anderson (1990) has suggested that if we want to explain human behavior, we should seek understanding in the individual's assumptions about the environment and in the information-processing demands that the environment imposes. On this basis, the optimal degree of fidelity and complexity required in a simulation to effectively transfer new learning is determined by the affordances of the environment and the frame of reference of the learner. What matters most is not the realism of the simulation or the processing level of the learner, but whether the learner practices what is essential for the transfer situation. Thus, a good test is also a good learning activity and instruction and assessment are inseparable within an authentic learning environment (Snow & Mandinach, 1991).

A fundamental principle of instructional design that follows from an open systems view is that the orientation of the individual to learning is part of the context. For example, students often study so as to produce the outcome that they expect the teacher to assess (Schmeck, 1988). When authentic activity is the model for learning activity, the meaning that the individual attributes to learning, including expectations, attitudes, and beliefs, is a focus for the design effort. From a post-modern perspective, the individual's perceptions have value and represent a basis for mutual inquiry rather than an obstacle to be maneuvered around (Doll, 1989; Gough, 1989).

In summary, when authentic activity is the model for appropriate learning activity, the perceptions of the learner and the affordances of the environment represent an integral and inseparable context of learner/environment. The implications for instruction are primarily twofold: design must support the learner in establishing a learning enterprise within the larger global task environment, and the learning situation must afford the kinds of activities that are essential for success in the transfer environment.

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Title:

Identifying Values: The Front-end of Systemic School Restructuring

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I. Introduction

American public education has periodically experienced the need for restructuring. In recent decades, there has been increasing a perception, research and practice in fundamental restructuring. A systemic approach to school restructuring, Educational Systems Design, has emerged in response to questions regarding the main trend of current education and its efforts toward change. Researchers have introduced the principles and processes of educational system design by reflecting the relationship between educational systems and their environment (Banathy, 1991; Banathy, 1992; Reigeluth, 1991; Reigeluth, 1993; Lieberman, Zuckerman, Wilkie, Barinas, & Hergert, 1991). These writers share the underlying belief that changes in society generate the need for concurrent changes in education.

With this in mind, it is of the greatest importance that stakeholders who participate in redesigning their educational system examine and clarify their individual values concerning learners, and education and its relationship to the environment, and that they articulate shared values, and state them clearly. This is important because values underlie visions, guide choices, decisions, and actions made in the course of design, and serve as a practical tool for evaluation (Rokeach, 1973; Isaacson & Bamburg, 1992; Checkland, 1981; Banathy, 1991; Mohrman & Cummings, 1989; Senge, 1990; Pruzan & Thyssen, 1994; Goulet and Dolbec, 1991; Fambrough, 1991).

Recent theoretical research (Banathy, 1991; Banathy, 1992; Reigeluth, 1993; Meyer & Pruzan, 1991; Sergiovanni, 1989; Schlecthy & Cole, 1992; Miles & Ekholm, 1991; Smith & O'Day, 1990; Rehm. Schweitz, & Granata, 1992; Nadler, 1981; Ackoff, 1981) addresses the need for articulating values in all stakeholder groups and/or further suggests frameworks for exploring options for educational system design. Empirical studies support the notion that values explicated and shared by stakeholders are one of the key elements in the success of educational system design (Breidenbach, 1989; Lieberman, Zuckerman, Wilkie, Barinas, & Hergert, 1991; Reigeluth, Norris, & Ryan, 1991; Reece, 1991). The findings of these studies, however, remain at a superficial or general level.

II. Conceptual Framework and Literature Review

Educational System Design and Values

Banathy (1991) addresses values clarification as a core process following re-visioning of the future educational system and preceding to create a new image of educational systems that is compatible with the larger society. He notices, however, that those processes are fundamentally iterative due to the "feedforward and feedback nature of the inquiry" (Banathy, 1991). Reigeluth (1993) echoes Banathy's notion by asserting that consensual values among stakeholders should be a ***must*** for them to agree on since different values by their nature will lead to different images and features of the system.

The ethical processes related to systems design (Meyer & Pruzan, 1991; Pruzan & Thyssen, 1994) have been an increasingly debated issue. In an ethical approach, "a broad cross-section of stakeholders" (Weisbord, 1992, p. 5) participate in values clarification through ongoing value-based dialogue. Thus, communication regarding stakeholders' values is considered to be a necessary condition as well as a result of the self-designing capabilities of an educational system (Meyer & Pruzan, 1991).

Reigeluth proposes to examine societal and learner needs by carefully analyzing current change and hypothesizing about future change in our society (Reigeluth, 1993,). Banathy (1991; 1992) proposes a more multi-dimensional and comprehensive framework designed to help stakeholders self-reflect on their current system, articulate core values and ideas, and synthesize these values and ideas into a new educational system.

Thus Banathy's framework demands that stakeholders make decisions relevant to choices among a great number of alternatives. As they encounter these decision-making points, dialogue among the stakeholders evolves around the question of '***why***' a given decision should be as its is and not other wise. The conversational process for answering this question leads stakeholders to realize, articulate, and consent to values; as Banathy (1992, p. 34) states:

> "As they probe into the WHY's of a decision, they begin to articulate their values, assumptions, and knowledge/experience base that underlie and support a particular decision. These emerging 'rationales for making decisions' will produce an ever-increasing wealth of descriptions of values and ideas. Those which they agree upon become the 'CORE VALUES' and 'CORE IDEAS' that will continuously guide - even drive - the design."

Furthermore, Banathy (1992) points out the importance of recognizing two essential qualities of values in systems design. First, one should consider the emergence of values as an evolutionary process. As one proceeds with systems design, substantial core value are reinforced, modified, and realized. Second, one should pay attention to internal consistency among values since all dimensions are interactive and interdependent. Hence, each decision and the values behind it have to be approached within the systemic context of the framework by seeking and re-ensuring internal consistency.

Schlechty and Cole (1992) propose that systemic standards should be created, and their basis should be a set of values concerning how schools ought to be. Then, this coherent set of values and beliefs can provide the ground work for envisioning a system. The Center for Leadership in School Reform (Schlechty and Cole, 1992) began with 10 values when it worked with schools, school districts, and communities for systemic change. This values list presented multiple levels of values by reflecting learners' characteristics and those of the organizational and societal levels. As the authors mention in their article, however, these values were imposed on local stakeholders as a norm (although local stakeholders agreed to use them). Based on previous research (Banathy,1991; Reigeluth,1993; Meyers & Pruzan, 1991; Pruzan & Thyseen, 1994), values articulated in this way without stakeholders' participation cannot function as well as it should. Moreover,Schlechty and Cole do not provide the readers with the values criteria used to examine the comprehensiveness of those values that are used to be creating systemic standards.

On the other hand , Banathy (1991) presents three categories of values as well as examples of values in each category. While emphasizing that stakeholders should develop their own sets of values, sets of terminal and instrumental values are presented based on Banathy's perspective on the categories of educational functions and purposes, learner and learning, and systems design that will guide change.

There are several case studies that examine educational systems design efforts and their outcomes. These attempt to identify the main factors contributing to or hindering the success of change and to draw conclusions or make recommendations that are generalizable to any public educational system, based on a systemic view.

Breidenbach (1989), in her case study of a major metropolitan public school district, found that *the values and beliefs shared by advocates* were one of the 10 main factors contributing to this district's successful design process. In a nationwide case study, Reigeluth, Norris, and Ryan (1991) also found values (beliefs) to be *one of the keys to a successful change process*. Meanwhile, Reece(1991) emphasizes values, especially based on local needs, as *one of the 6 major components* in his case study examining the restructuring practices implemented by a school.

From the above literature review, the following conclusions can be drawn. Articulation of values should be a front-end step in educational systems design and should be formulated with respect to the interrelationship of systems and their environment. However, none of the available studies provide stakeholders with substantial guidance for articulating their core values. Given the importance of values clarification by stakeholders and the lack of previous in-depth studies, it is important to establish comprehensive categories to aid in the articulation of core values and to serve as guidelines for applying these values in the design of educational systems.

III. Objectives and Research Questions

The overall purpose of this research is to determine comprehensive categories of values, as well as the values in each category that need to be articulated and consented to by stakeholders through a qualitative case study approach. The term values, as used in this study, is defined as the ideals that a design tries to approximate (Ackoff, 1981, p. 125, calls it '"ultimate values") regardless of means or ends, or either values or ideas (Banathy distinguished between these two concepts).

IV. Methodology

The present research approach involves a qualitative case study methodology. As Cronbach (1975) points out, a qualitative case study allows for "interpretation in context (p. 123)." Especially in addressing 'why' questions, the fundamental questions necessary to clarify values, case study has been an effective strategy (Yin, 1986). In addition, a case study approach can help a researcher explain the background of a situation as well as what happened, include vivid materials such as interviews, quotations, newspaper articles, and the like, obtain information from a wide variety of sources, present it in a variety of ways, and suggest to readers what to do or not do in similar situations (Hoaglin, Light, McPeek, Mosteller, and Stoto, 1982).

Research site

Using a purposive sampling strategy (Kidder, Judd, and Smith, 1984; Merriam, 1988), an elementary school was selected for analysis in the study based on the following criteria:

- A public school that is currently undergoing systemic restructuring
- A school that has values articulated and shared by stakeholders
- A school that is in the relatively early implementation stage so that participants still have vivid memories of which values they have identified or ignored and of why and how they have done so. In addition, the impact of planning can be more easily distinguished in the early stages of implementation than later, after many new factors have emerged.
- For convenience, however, I arbitrarily limited the study to a school in the area of the researcher's residence.

Contact and consent

An initial contact with this school was made through a phone call to the principal. Before starting each research interview, I explained the purposes and scope of the study and formally obtained a signed consent form from each informant.

Data Collection Techniques and Procedures

Prior to the first site-visit, I analyzed available documents, including an annual report, local newspaper clips, and some promotional pamphlets which were already available. This provided me with preparatory information about the site. Upon visiting the school, I discussed my research plan with the principal. At this pre-research meeting, I obtained more documents, which included Indiana 2000 application and PBA(Performance Based Accreditation) documents. These materials allowed me to gain an understanding of the general context of the school, which included historical, demographic, and social background relevant to the restructuring process.

The primary data collection technique involved interviews with the stakeholders most involved in redesigning of their school system. These included an administrator, two teachers, two parents, and one community member. I mainly conducted semi-structured interviews, since my research was focused on approaching the perspectives of the informants being interviewed (Patton, 1980). These interviews were guided by a list of questions or issues to be explored (See Appendix A: Interview Questionnaires), but neither the exact wording nor the original order of the questions was used during the interviews. In addition, structured interviews were added to obtain some standardized information (Merriam, 1988). Information was collected about the past, the present and the future by asking: What has the school done, how, and why? What have they been doing, how, and why? What are they doing, how, and why?

Key informants were interviewed individually at least twice. Follow-up interviews were made either through a meeting or phone call. I took notes during the interviews, which were audio tape-recorded. Verbatim transcriptions were made from the recorded interviews. This practice ensured that everything said was preserved for analysis (Merriam, 1988). As a "non-participant observer" (Merriam, 1988) I observed classroom activities., after I left the room and summarized my observations as soon as possible either on- or off-site. Then I took time to remember more substance and elaborated the scenes and dynamics at the site. Table 1: Calendar of Data Collection depicts the order of the interviews, document collection, and observations as they occurred. Data from documents and observations were recorded for the purpose of verification purpose.

Data Analysis Techniques

The techniques of *'unitizing'* and *'categorizing'* (Lincoln & Guba, 1985, p. 344) were used to analyze data. Data analysis frequently began with a review of my research proposal, as Goetz and LeCompte (1984) suggest. Then, all data from interview transcripts, documents, and observation notes were read through several times from beginning to end. While reading, I jotted down notes, comments, and observations in the margins (Goetz and LeCompte, 1984). Through this process, I identified *units* of information as the basis for defining categories. Then, selected information was summarized and categorized through the use of *codes*. (See Appendix B: The Summary of Contact Form).

A *'start list of codes'* (Appendix C: Start List of Codes) was created in the early stages of data collection. This list was inductively developed based on findings from the document analysis and some initial interviews. *Definitions of codes* (Appendix D: Definition of Codes) were developed for each code since defining codes helped the researcher to consistently apply codes over time. The codes in this list, however, changed and developed as research experience continued. Some codes did not work and t were thus discarded or reorganized. Other codes became too general, resulting in subcodes. However, new codes still emerged progressively during data collection. Accordingly, coding was a form of continuing analysis (Merriam, 1988) which allowed for ***inductive*** examination of data.

Interview data analysis

The data consisted of verbal accounts, coming from 3-4 hours of interview interactions. Interviews were conducted between late-March and Mid-June, 1993. Upon completion of all interviews, the contact summaries were edited and sent to the informants. Each informant was called after they received the summarized interviews --interview summary reports --for initial verification of content. All informants but the community member verified the interview summary reports (See Appendix E: Interview Summary Report). Minor editing was done through phone calls or personal contacts, according to participants' preferences. Upon conducting these verification contacts, there was one follow-up interview.

February 18, 1993	Exploratory phase of research
March 4, 1993	First meeting with principal; collection of several documents; short tour of building
March 11, 1993	Final permission obtained from principal; received potential interviewees' list
March 26, 1993	First research interview with principal
April 2, 1993	Second interview with principal
April 20, 1003	First interview with VR; collected an additional document
April 29, 1993	First interview with MM; briefly visited computer lab
May 6, 1993	First interview with CT; second interview with MM; collected documents
May 7, 1993	First interview with KW
May 11, 1993	Observed VR's and CD's morning classes
Mary 12, 1993	Observed morning classes at the computer lab
May 13, 1993	Second meeting with CT
Mary 14, 1993	Second interview with KW
May 20, 1993	First interview with MMc
May 25, 1993	Second interview with MMc
June 1-4, 1993	Delivered interview summary reports for member checks
June 10-18, 1993	Follow-up interview to validate and revise summary reports
Aug. 16, 1993	Data collection for research question #2 (primary value categories) based on the findings done through the primary analysis

Table 1. Calendar of Data Collection

Document Analysis

Documents were also summarized and coded on the summary sheet. These summary forms were used for analysis but also facilitated rapid retrieval when necessary. Primarily, the content analysis focused on measuring the frequency and variety of information, confirming the emergent hypotheses, and advancing new categories and hypotheses (Merriam, 1988).

Observation analysis

Data collected through observation was summarized and coded on observation summary sheets. The main focus in the observation was to answer the question, "Are they really practicing what they said they value?" The main purpose of the observation was for ***triangulation.*** Observation through the analysis of facts in detail was attempted to (1) identify the practices that were relevant to the value categories identified through interviews and document analysis and (2) examine any significant inconsistencies between values and practice.

Developing categories involves seeking recurring ***regularities*** in data by comparing one unit of information with the next. Once the relevant sets of categories are derived from the data, they can be filled out and made more vigorous by searching through the data for more and better units of information (Merriam, 1988,). Through these processes, the sets of value categories were formulated to reflect the interrelationships of the value components. An alternative display, a ***matrix,*** was utilized for better analysis (See Appendix F: Matrix)

Upon completion of data analysis, the emergent value categories were sent to informants in order to find the data for research question 2, ***"primary and secondary value categories."*** The list of value categories was provided to participants with Likert Scaling, which has a code from 1 to 5, from least to most important. (See Appendix G: Primary vs. Secondary Value Categories Inventory.) Definitions of value categories were provided on a separate sheet in order to help the informants have a clearer idea about each term in the categories (See Appendix H: Definitions of Value Categories.) Then, I computed the total scale scores for each value category by summing informants' scores on all the values. This process was an additional attempt to construct ***"negotiated outcomes"*** Lincoln & Guba, 1985, p. 41) which is done through negotiation of meanings and interpretations with the informants from which the data has been chiefly obtained.

Context of Study Sites

Demographics of school building

The study site was a relatively large elementary school of 530 students. The faculty describe their school as being somewhere between rural and suburban. However, they think they are close to being a suburban school.

There were drastic changes and growth in the school community between 1989 and 1991 with the construction of a new large school building in 1990. 50% of the families and 75% of the faculty are new. In 1989, the school had 11 staff members but by 1992 it had 52. Most parents were employed in light manufacturing or service sector jobs. Four to five percent of the students are ethnic minorities, and some use English as a second language. One of the faculty members said that most of the families are non-conventional, that is two-parent and two-income, or single parent and single income families. 10% of the school population is enrolled in the before and after school custodial program.

Process of restructuring

The current restructuring effort was initiated by the faculty who saw that what they were doing was not successful and thus wanted to make changes. (See Table 2: Calendar of Events for their restructuring history.)

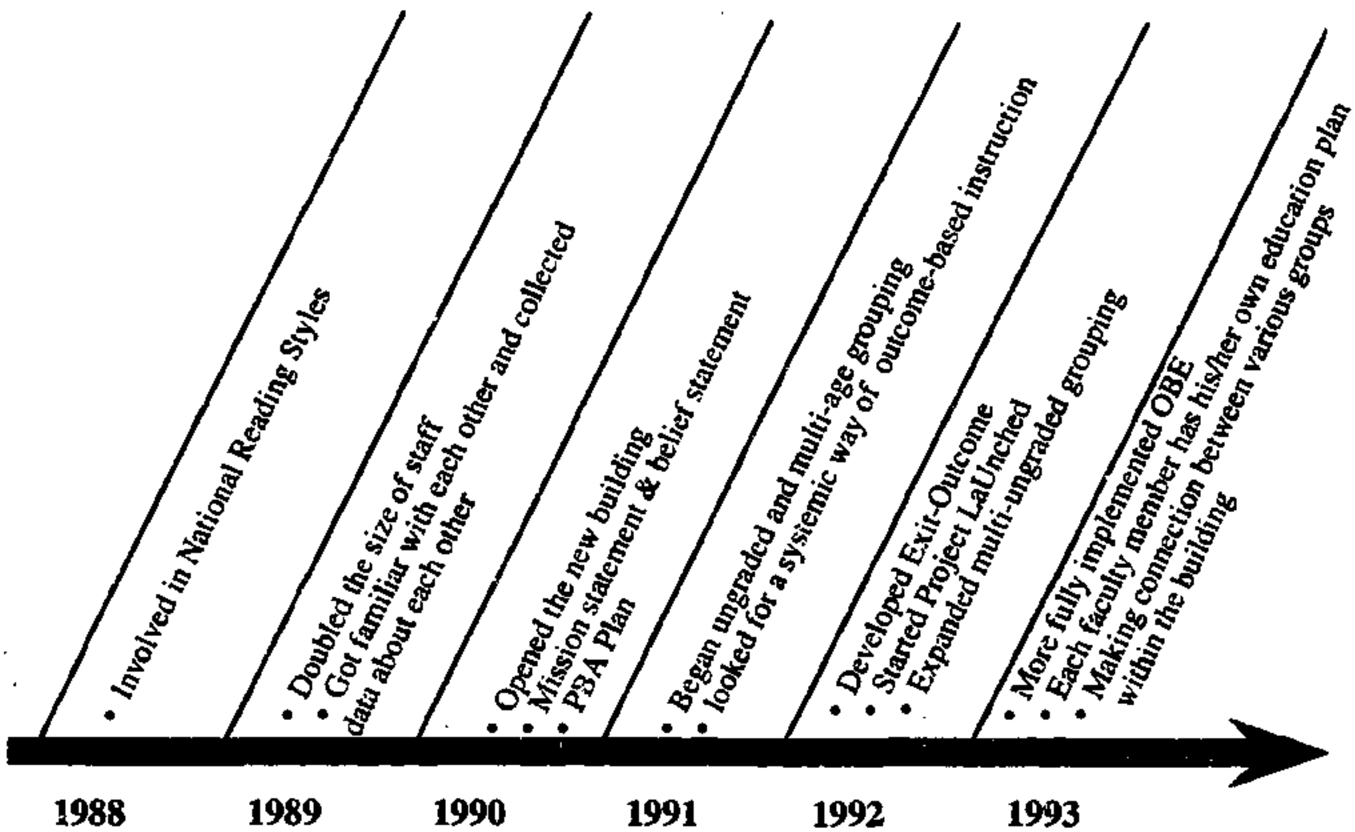

Table 2.
Calendar of Events

V. Final Analysis

<u>Categories of Values</u>

The definitions for the value categories came from specific data sources in the research. I searched informants' values, identified them, and labeled them. Once labeled, I defined them through my own interpretations. For example, *nature of a learner* describes the fundamental attributes of a learner, the ways a student learns better, and the ways he or she demonstrates what he or she learns.

Category 1: Nature of a Learner and Learning

There emerge two value categories from the informants' dialogues: the value area in regard to the essential natures of a learner as well as learning.

Nature of a learner. In this category, informants fleshed out their values and ideas about what fundamental attributes a learner possesses. They talked about individual learners' attributes in a variety of aspects. They also discussed about how a learner learns better.

Nature of learning. Informants' assertions in this category can be grouped into two subject areas. First, what are the attributes of 'learning'? Second, what should 'learning' do for learners?

Category 2: General Principles of Restructuring

The category of ***general principles of restructuring*** appears to be a significant value area that was frequently discussed among the informants. This category describes fundamental and underlying values of school restructuring. This category emanates from the following values identified from different informant sources:

The reasons for restructuring. Informants appeared to discuss the reasons for restructuring in terms of gaps, which might occur due to changes in the larger society and student population, or between needs and educational reality.

The attributes of restructuring. Informants discussed the fundamental qualities that make restructuring "a real restructuring," not something else. They talked about these attributes in regard not only to the process of change but also to the ultimate target for change.

The ultimate goals of restructuring. Respondents expressed their values about for whom or for what reason they should restructure, that is, the ultimate beneficiaries of restructuring.

Category 3: Procedural Principles

Procedural principles for school restructuring appeared to be another vital value category. This category describes any strategic value or idea relevant to the factors leading to successful restructuring. This procedural principles category became apparent from a wide range of values the informants discussed, and four general themes were especially apparent.

(1) People: The informants clarified their values with regard stakeholders who were to be involved in the restructuring process. The relevant issues include staff development, administrative leadership, parent involvement, and community involvement.

(2) Structure: The informants also discussed organizational structural issues, which included communication and choice as critical factors in the change process.

(3) Culture: Respondents spoke about ownership, collective wisdom, macro-perspectives, and caring as be required during the restructuring process.

(4) Resources: They commented on resources to be attained for assuring or helping their restructuring process.

Category 4: Outcome of Learning

It appeared that the category of 'outcome of learning' was a significant value area overtly discussed among the informants, which is related to what they wanted students to know and demonstrate when they leave school. Many of their dialogues in this category reflected their values about ***the nature of learners and learning*** and some of ***the general principles of restructuring.*** Their articulated values about learning outcomes, in general, appeared to emphasize the following concepts: 'a whole person -- more than just intellectual excellence,' 'self-driven and continuous process,' 'challenge and achievement,' and 'real life.'

Category 5: Process of Learning

A process of learning value category emerged, which described the value area regarding the means for achieving learning, that is, how students should achieve expected learning outcomes and how schools should help students learn. Most of the values clarified by the informants in this category were consistent with their beliefs about '***the nature of learner and learning.***' It appeared that the following themes were the most common among the informants: learning arrangement and programs, learning strategies and methods, learning situation, and the role of learners in the learning process.

<u>Category 6: Assessment</u>

The category of ***assessment*** emerged from among the frequently discussed themes as follows. ***The nature of assessment*** was discussed with respect to the nature of learners, that is, individual differences. ***The purpose of assessment*** also was apparent in the informants' discussions, being mainly discussed in terms of 'progress.' Informants also discussed the ***parties involved in evaluation.*** Ultimately, the informants seemed to value collaborative assessment involving both parents and children.

<u>Category 7: Learning Environment</u>

The category of 'learning environment' emerged from the clarified values. This category describes the school environment, which is considered to support the '***learning process***', and which in turn is that designed to ensure that learners achieve expected '***learning outcomes.***' The informants appeared to address most frequently the following themes in this value category. First, they express the value regarding **the nature of the learning environment.** Second, ***the scope of the learning environment*** was defined, which tends to be broader in that it emphasizes interaction with the outside community. Third, they spoke of ***resources*** as a tool for promoting the achievement of educational goals. Their comprehensive perception of resources, including both internal and external components, appeared to consistently reflect their values about the scope of the learning environment.

<u>Category 8: Organizational Structure & Culture</u>

The category of ***organizational structure and culture*** emerged from the values discussed by the informants and in the documents analyzed. These values revealed either a formal or informal organizational arrangement (Nadler, Gerstein, & Shaw, 1992). First, a governance structure was an apparent theme among the informants, who appeared to share an identical value, that is, a value-laden decision making structure where all the stakeholders share responsibility for specific areas. This value seemed to be well reflected in the statement, "Learning is a shared responsibility of the child, staff, parents and the community'(Annual Report, PBA). Second, the roles and responsibility of people at school was frequently reflected by the informants. Third, the visible behaviors and attitudes revealed in a daily life was discussed in a variety of ways(Nadler, Gerstein, & Shaw, 1992)..

<u>Category 9 Function of education within the larger society</u>

Another emergent value category was ***function of education within a larger society***. This category describes informants' perceptions about education on a broader scope, in the context of the larger society. This category appeared to be discussed in terms of two themes. First, the informants talked about their perceptions relevant to the ***function*** of education. Second, they expressed their values about education's fundamental ***relationship with other systems*** in the larger society.

<u>Primary vs. Secondary Value Categories</u>

In order to identify which value categories the informants considered more significant in terms of redesigning their educational system, once having constructed the above value categories through the final analysis process, I provided each informant with a list of value categories along with a 5-point scale, where a higher number indicates greater importance (See Appendix G: Primary vs.

398

Secondary Value Categories Inventory). The study's definitions of value categories were included (See Appendix D: Definitions of Value Categories). This was intended to help the informants have clearer idea about each term presented on the inventory sheet.

Inf. / Cat.	DF	VR	MM	KW	MMc	KW	TOTAL
1	4	5	5	5	5	3	27
2	4	4	4	4	4	3	23
3	3	3	4	4	4	2	20
4	3	3	3	5	3	2	19
5	5	5	4	5	4	5	28
6	4	5	5	5	4	5	28
7	4	5	4	4	5	5	27
8	3	5	5	4	5	4	26
9	3	3	3	4	4	5	22
10	3	3	3	3	3	5	25
11	5	4	4	4	3	5	25

Figure 1. Significance Level of Each Value Category

Based on the data presented above, Figure 1, I found the order of respondents' value priorities to be the following:

1. Outcomes of learning & Process of learning
2. Nature of learner & Assessment
3. Learning environment
4. Function of education within the larger society
5. Nature of learning
6. Organizational structure
7. Organizational culture & General principles of restructuring
8. Procedural principles of restructuring.

In general, the informants appeared to place a priority on clarifying values directly related to learners and their benefits. In other words, it seemed imperative for them to clarify and get to a consensus on values regarding who learners are, what they should learn, how they should learn, and how they should be assessed. On the other hand, they showed less regard for values related to the design process itself and to school as an organization.

Interestingly, the staff who worked within the organization showed the least concern about organizational values. But a community member attributed the highest numbers to this value category. This result confirmed the following comment by the community member her comment, "...If they think and try to operate as an organization, I think schools end up with more focus. Staff and students will begin to have a better understanding of what it is they're trying to accomplish as a part of the organization. On the other hand the school itself will have a better understanding of their role in the larger community as an organization. And then consequently they will become less isolated." (CT, 4.7) This community person emphasized the macro level -- the organizational and societal level -- as did the principle (DF).

When I analyzed the responses of internal informants (staff and parents), 'the nature of learner' category appeared to be their most primary concern. This can be interpreted to mean that the people working close to the students believed that consistent and shared understanding of learners' natures among stakeholders should be in advance of any other values.

These informants appeared to show he least regard for 'strategic values,' that is, how to change their systems and programs. This finding may be due to two possible reasons. One is that the stakeholders may have been unaware of the importance of how to attain the final goals of their plan. Or, second, they may have been more interested in 'product' than 'process.'

Values concerning the learning dimension were highly emphasized. On the contrary, values involving the organizational dimension were least emphasize, which might reflect what the community member (CT) said: "They don't tend to think of their school as an organization." (CT, 4.7.)

Values regarding the social dimension were considered to be relatively important (4th from the top). This result might reflect the fact that the concept of educational systems being restructured has been well accepted. This seems to show that the stakeholders understand their school system in the context of the larger society.

Shared Values in Each Category

The shared values were demonstrated through one further analysis of my interpretations shown on the matrix developed primarily for identifying value categories (See Appendix I: Matrix).

Values regarding Nature of Learners and Learning

1) Individual learner differences should be recognized. Learners learn in many different ways. Learners also can show their achievement in numerous ways.
2) Learners learn better what they are comfortable with, within a context, and when they are internally motivated.
3) Learning is a process that does not stop and that also takes time.
4) Learning is making sense of the world.

Values regarding General Principles of Restructuring

1) Education should respond to change in society.
2) Restructuring is a process of re-examining and challenging the assumptions upon which we practice and, when appropriate, of replacing invalid assumptions.
3) Restructuring is a continuous learning process involving a long-term plan and continuous revision.
4) Restructuring is change in people's mindset & attitude toward the nature of learners as well as change in structure.
5) Restructuring should focus primarily on what is best with respect to each learner's achievement.

Values regarding Procedural Principles

1) Continuous and focused professional development and staff self-efficacy are driving forces in restructuring.
2) Collaborative and collegial administrative leadership is required.
3) Supportive and involved parents are crucial for successful restructuring to occur.
4) Diverse and strong ties with the community are important.

5) Choice should be always available through 'schools within a school': We need to balance the process of supporting people who try innovation with not loosing people who feel uncomfortable with change.
6) Through a value-laden change process, all stakeholders should develop ownership from the early stages of change.
7) Collective wisdom is better than an individual's or small groups' ideas.
8) Streamlined communication is critical for effective communication in the school.
9) Resources, including time to collaborate, money, legitimacy of change, and networking with other organizations will help restructuring happen.

Values regarding Outcomes of Learning

1) A whole person: A learner achieves excellence not only intellectually but also socially, emotionally, and physically.
2) A learner develops the ability to become a productive and responsible life-long learner.
3) A learner respects him- or herself, others, and the environment.
4) A learner sets and meets higher standards.
5) A learner has problem-solving skills.
6) A learner has high order thinking skills.

Values regarding Process of Learning

An overarching core value is that the learning process should be consistent with findings about the nature of learners and learning. Based on this belief, informants shared the following core ideas:

1) The process of learning should allow for learning based on individual uniqueness. It should allow for learning at individual learners' speeds and needs, be connected with their learning styles, help them feel comfortable with the learning process, and capitalize on learners' strengths and also strengthen their weaknesses.
2) The process of learning should allow for learning within a context, that is meaning-centered learning. It should allow learners to make sense of their school experience by connecting it with real life.
3) The process of learning should have a cumulative and consistent direction so as to allow for students' continuous progress.
4) The process of learning should promote learners taking more responsibility for their own learning by allowing for 'choice' by learners.

Values regarding Assessment

1) Assessment should be consistent with the process of learning used at CC. Student outcomes achieved by the learning program are the things that need to be assessed.
2) Assessment should focus on students' continuous progress. Feedback given to learners, by nature, should encourage learners' continuous progress.
3) Assessment tools should be comprehensive, multi-dimensional, and non- artificial.
4) Collaborative assessment should be pursued in which students' responsibility should be promoted.

Values regarding Learning Environment

1) Learning environment should 'promote the richest opportunity for a child's success in school' (PBA): It should be warm, supportive, and safe.
2) Learning is not confined within classroom walls.
3) A variety of resources available within both the educational system and the larger society should be used fully .

Values regarding Organizational Structure & Culture

1) A value-laden decision-making structure exists. All stakeholders share responsibility for specific areas of decision making.
2) Parent involvement at the instructional level is most important; students take responsibility for and ownership of their learning; teachers coach with respect to learning; administrators help and coach teachers by building their strengths based on individual differences.
3) There is a streamlined communication structure among staff, school and home, and school and community.

Values regarding the Function of Education within the Larger Society

1) Education should provide for life-long learning.
2) Education is a part of the world. Education should coordinate with other systems in the larger society for life-long learning.

VI. Conclusions

This study investigated a comprehensive and systemic model of value categories to be discussed and elaborated by stakeholders in redesigning an educational system, and the values in each value category that have been articulated and consented to by stakeholders at an elementary school, CC. Developing values and ideas shared among stakeholders is the fundamental process of educational systems design. This is primarily because values allow stakeholders to elaborate their vision and guide systems design (Banathy, 1992). But also, the process of elaborating and sharing values is considered to be the necessary condition as well as a result of the self-designing capabilities of an educational system(Meyer and Pruzan, 1991)

This study identifies three value domains, comprised of 10 value categories that emerged from the main stakeholders' values and perspectives (Figure 1. A Model of Value Categories).

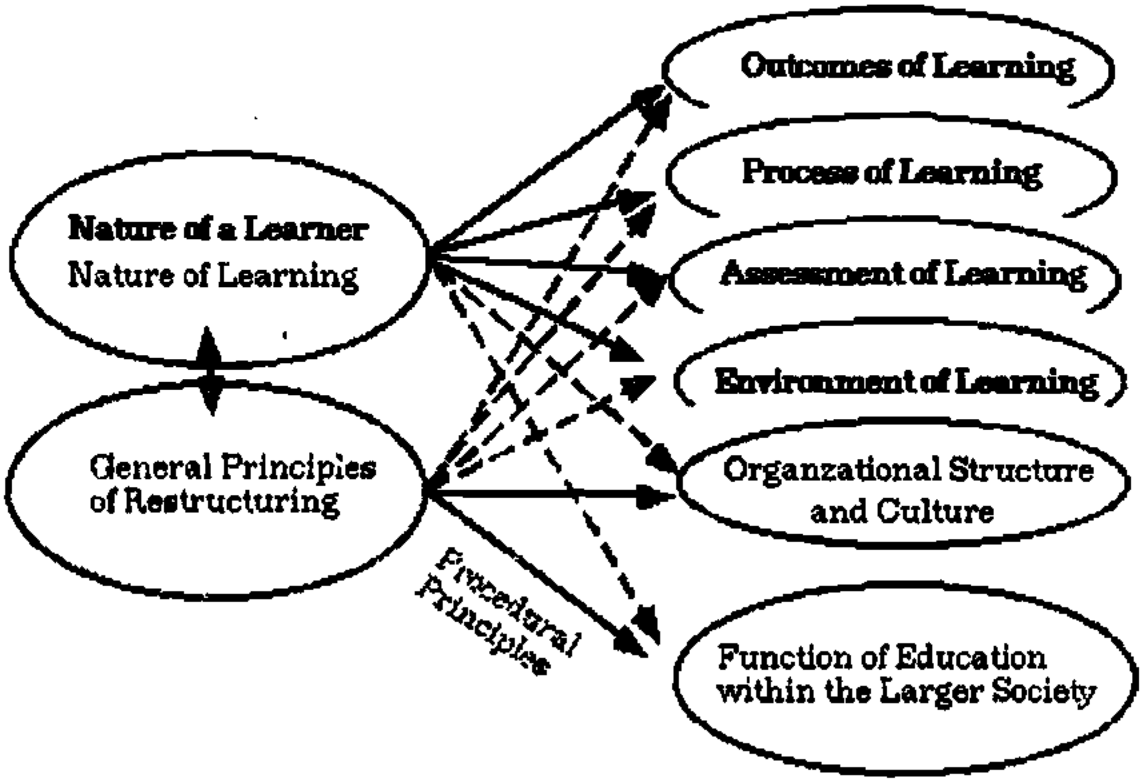

Figure 2. A Model of Value Categories

Seminal Values

Seminal values are fundamental beliefs that ***inspire*** the image of a new educational system and *lead* the whole process of restructuring. These values consist of two categories. The first is ***Nature of a learner and learning,*** reflecting the fundamental attributes a learner possesses and how a learner learns better, as well as the fundamental attributes and functions of learning. These value areas are considered to be highly important in terms of need for clarification.

The second category is ***General Principles of Restructuring,*** reflecting the reasons for restructuring, the nature of restructuring, and the ultimate focus(es) of restructuring. However, the stakeholders believed this value category has no priority in terms of their restructuring concerns.

Strategic Values

Strategic values are primarily instrumental in helping restructuring ***proceed*** or in achieving the desired outcomes of restructuring. These values comprise the category of ***procedural principles***, expressing strategic or tactical values and ideas that are perceived to be key factors in successful restructuring. These factors include people, structure, culture, and resources. However, this value category seemed to garner the least interest among the study's main stakeholders.

Core Values

Core values further embody seminal values and thus are both illustrative and specific expressions of values. Core values substantially ***guide*** and ***influence*** the choices and decisions made in the course of re-designing an educational system. Therefore, they 'enhance the creation of the image and the design of the system" (Banathy, 1991, p. 126). Core values can be discussed with respect to three different levels according to their scope: the earning level, the organizational level, and the social level.

Learning Level. This level is comprised of stakeholders' values that are directly relevant to considerations of learning, which include ***outcomes of learning, process of learning, assessment of learning,*** and ***environment of learning.*** The analysis above shows that the study's main stakeholders believe that their values regarding the learning level should be considered and articulated most strongly among the various levels involved restructuring their school system.

Organizational Level. This level is composed of perceptions relevant to the organizational level --***Organizational Structure & Culture*** (Nadler, Gerstein, & Shaw, 1992)-- on which the stakeholders placed value as an ideal for bringing out the learning valued by themselves.

Social Level. This level describes stakeholders' perceptions of education on a broader scope, ***the Function of Education within the Larger Society.***

The informants appeared to place priority on the value areas directly related to learners and their benefits. In other words, it was imperative for them to clarify and reach consensus on values regarding who learners are, what they should learn, how they should learn, and how they should be assessed. This perspective seems to reflect Banathy (1991)'s "a learning experience-focused system"(p. 115) in which the learners' system is the core around which the system is built. And the stakeholders placed much more value on the outcomes of redesigning than on the process itself or on the reflection on the rationale behind change. That is, it appeared that it was more urgent to get a consensus on values regarding the nature of learners/learning and the ideas embodying these qualities which include the outcomes of learning, the learning process, assessment, and the learning environment. General restructuring principles, organizational structure and culture, and the societal context relevant to supporting learning systems seemed to be relatively minor issues.

Articulated Values

The values articulated and shared by the stakeholders appear to be constructed with internal consistency with respect to each other. Furthermore, many of the values and ideas were transferred or fleshed out in other value categories. Thus, the informants appeared to understand the interactive and interdependent natures of all the values in the different system levels and dimensions (Banathy, 1991).

The stakeholders valued the recognition, even the celebration, of individual differences for a variety of reasons, including learning styles and the demonstration of learning achievement. They believed learning is a process that makes sense of the world around a learner.

The stakeholders recognized the relationship between education and the larger society. They sought the rationale of restructuring in terms of the gap between education's current status and change in the larger society. In this context, they emphasized challenging obsolete assumptions through a continuous learning and change process. To them, the fundamental focus of restructuring should be 'each learner' and her or his learning achievement. To achieve this goal, they believed restructuring should produce changes in peoples' mindsets and attitudes toward the nature of learners as well as change in structure.

Regarding strategies, the stakeholders emphasized the 'readiness of people' in the school. Professional development and staff self-efficacy were outstanding values. Collective wisdom and support available through divergent stakeholder groups was considered to be mandatory. They believed streamlined communication to be critical for effective communication within and among these groups. Moreover, they believed restructuring works well when there is a value-laden change process allowing the people to have choices and eventually develop ownership. They were fully aware of the importance of resources from comprehensive areas--both internal and external --to help restructuring happen.

The stakeholders valued 'a whole person,' who achieves excellence in the entire learning arena; 'a life-long learner' who challenges her or his own standards. They shared their ideas of th learning process under the overarching value, "The learning process should be consistent with findings about the nature of a learner and learning." Based on the belief in assessment consistent with the processes of learning used and learning outcomes expected at CC, they focused on students' continuous progress and comprehensive and collaborative assessment tools. They valued a learning environment that promotes the richest opportunities for a child's success in school. This environment was expanded to include areas outside classroom walls.

They valued their school as an organization in which there was a value-laden decision making structure and streamlined communication among and between stakeholders. They perceived that an educational system should be a center for life-long learning; to this end, it should coordinate with other systems in the larger society.

Again, the values identified in this research share commonalties with core ideas that Banathy (1991) proposed, in light of their challenges to the dominant traditional values and practices in the educational establishment. Nevertheless, those shared values in the research site tended to represent its unique context, more or less reflecting the constraints experienced by informants.

VII. Discussions and Implications

This research represents an effort to provide systemic guidance that emerged from the synthesis of ideal elements identified from the study's research site. Through examining a real world school's restructuring practices, I intended to advance theoretical understanding in articulating values with regard to systemic school restructuring, as well as provide a systemic model of values categories which can help stakeholders to start and continue dialogue to identify their own values. By doing so, eventually the findings of this research may bridge the gap between the real world, which lacks theoretical guidance in identifying values, and the academic arena, which needs greater understanding of practice.

The categories that emerged from the research site show numerous similarities with the value categories suggested by Banathy(1992) in terms of their features, as well as comprehensively reflecting multiple levels and dimensions relevant to educational system design. Banathy has presented two different schemes of value categories at different times. In 1991, he (p. 126-128) presented three categories of values including (1) educational functions and purposes, (2) learner and learning, and (3) systems design that will guide change. In 1992, Banathy (p. 32-33) suggested that in designing a new educational system, we need to explore essential values related to the followings: (1) education's relationship with and relevance to society, (2) the designation of its societal functions, (3) the kind of learning to be offered in an information and knowledge age, (4) the way such learning should be offered, and (5) the design of its organizational forms and arrangements. All the elements of the value categories discovered in my study are represented in either one of Banathy's value schemes.

Even though my study was conducted in an inductive way without having any specific propositions to examine, the similarity between Banathy's non-data-based research and my empirical research indicates two things. First, Banathy's value categories are reliable and applicable even with no supporting data. Second, my research resuls appear to be more generalizable since being confirmed by another researcher.

In using these values categories meaningfully and effectively in a design process, several factors need to be considered, mainly rooted in the nature of values.

Articulating values is simply ***one*** of the important elements in a design process. Accordingly, values or values identification does not have a value in and of itself. Rather it is meaningful when considered within the context of a design process. As Goulet and Dolbec (1991) state, the systems design process is purposive and deliberate so that, in order to give direction to human actions, values should be explicated through statements of mission, goals, and specific or concrete objectives.

Values are ***dynamic and emergent*** so that values clarification should be an on-going process. Values, by nature, shape, change, and reconstruct throughout time. Due to the functional interaction of each part in a system, the parts are designed with respect to harmony, which is concerned with "the effect of the interactions of the parts on the whole", "the effects of the functioning of the whole and the interactions of the parts on the parts themselves", as well as "the effects of the functioning of the parts and the whole on the containing system and other systems in its environment" (Ackoff, 1981, p. 17).

Human beings, as one part in a system, ***change their values and beliefs*** based on their experiences. Besides, as things evolve, more stakeholders and new stakeholders are engaged in the design process. Then perhaps different values evolve because of the presence of new people. As a result, values clarification is not a "one-shot" activity or a step in the design process, but is inevitably a continuous reflection and reconstruction process while stakeholders and organizations proceed toward change.

There is a possibility of espoused advocated values in organizations so that ***values are not consistent with individual and organizational actions.*** With this in mind, we should be aware of the importance of a "designing culture" which promotes thorough dialogue about personal values. An organization--the individuals in the organization- should gain the ability to surface individual values and share them publicly and clearly through meaningful dialogue throughout an organization.

All of the issues discussed above lead to numerous questions to be examined further, which can not be separated from using the value categories above. Some examples might include: When should stakeholders publicly clarify values, so as to be sources for creating a new educational system, not for maintaining the current one? How should facilitators or change agents help stakeholders dialogue on those values areas and arrive at consensus? What would be the best way to translate values into missions, visions, or specific goals? What does a continuous process of value clarification mean? How can we make continuous values clarification happen?

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Appendix A: Interview Questionnaires.

√Background information

- In which year did your school begin its current restructuring effort?
- What were the forces driving or stimulating to these change initiatives?
- Who were the individuals or groups initiating the change? Do you think they were the best ones? Why? Why not?
- Who are the groups or individuals driving the continuous change process? Do you think they are the best ones? Were there any missing groups or individuals? Why? Why not?
- What was your role in the early change process?
- How do you define your current role in redesigning your school program? Why?
- What were the previous main focuses and what are the current ones? Why should it/these have been prioritized more than any others in a specific period?
- In which category is your school? --urban, suburban, and rural? And what are the determiners?

√

- How did your school examine the beliefs/values and develop this statement? Please tell me who was involved in it, when it was written, and how it proceeded? Do you think your school chose the best way to do it? Why? Why not?
- What is the role of a value statement in redesigning your school? Do you think the current belief statements have responded well to your purpose? Why? Why not?
- In which ways, if any, do you think your school can clarify its values better and develop better value statement? What will be the contents of your different(revised) value statement?

- What are the values/beliefs behind each of these "Exit Outcomes"? That is, why have these outcomes been considered to be important ?
- What are the values/beliefs behind each of the "Long-Term Goals"? That is, why did you choose these as long-term goals?
- What are the values/beliefs behind each of the "Intermediate Goals 1991-92"? Why do you believe each of these goals are important?

• Why are these achievements during school year 1991-92 considered significant?
• What are the values/belief behind the plans/immediate goals, programs, strategies for 1992-93? Why did you decide on th[illegible] goals?

• What do you envision the ideal image of your school to be? -- learning activities, instructional strategies, programs, assessment, or learning environment.

• How do you define 'learning'? And why do you think so?
• What do you believe about how a student learns and thinks? Why?
• What types of learning and instruction does your school have? How do you feel about these? What other learning and instruction do you want your school to have? Why?
• What do you expect the students to learn or be able to do when they leave the school? Why?
• What are the programs and learning activities to support students in achieving these outcomes or capabilities? How do you feel about these? Why?
• What are the teaching techniques and resources? How do you feel about these? Why? Why not?
• How does your school evaluate student achievement? How do you feel about this? Why?
• What is the learning environment supporting these learning activities and programs? How do you feel about these? Why?
• If any, what else do you want to see at your school in terms of learning and instruction? Why?

• What is the ideal role and responsibility of each stakeholder you want to see implemented at your school? Why?
• What are the governing structures that you want to see implemented at your school? Why do you want to have/develop these features of governance?
• What are the informal or social structures, relationships, or communication channels between and among all stakeholders: teaching staff, administrative staff, students, their parents, and the community. Why do you highlight this feature of relationship?
• What do you think is education functioning for learners and your school community? Why should this aspect be pursued?
• What are the resources you think to be important to achieve learning? Why are they important?

• What are the ideal relationships between your school and other schools in the County? Why do you think these relationships should be pursued?
• What are ideal relationships that your school envisions with other communities (e.g., business, governmental groups, etc.)? Why do you think there should be this sort of relationship?
• What about the ideal relationship with universities? Why should this be pursued?
• What should be the relationships with schools in other states and countries? Why do you think this relationship is important?
• What about the relationship with governmental or policy making groups? Why should it be pursued?

• What are the main decisions and implementations your school has effected since restructuring ideas were initiated?
• If you were asked to summarize the core attributes of your school's change process, what would you put in this list of attributes? Why do you think your school buys into each of these change approaches?
• Who has been involved in each of the school's restructuring processes? How have they been involved in the change process? What is the main role of each of the stakeholders?
• What do you think about each stakeholder group's (differential) role in the change or decision-making process? Are they appropriate? If so, why? If not, why?

If any, how do you think your school could do better in terms of obtaining people's opinions about education? Why?

• What committees or organized groups does your school have in order to develop. Do you think it is important for your school to have formal committees or groups? How important is it? Why or why not?

• Is there any informal group helping in redesigning? What are these groups? Who are involved in these groups? Why do you think these groups are useful in redesigning your school? Or why not?

• Does your school have an outside facilitator or consultant in order to get help? If so, who are they and what do they do? How important is it for your school to get outside (expert) help? Why or why not?

• Does your school have an outside experts' help in redesigning learning or instruction? If so, who are they and what have they done? How important was it for your school to obtain their services? Why?

• What do you think school restructuring is?
• What should school restructuring focus on?
• What do you think are the most difficult obstacles to restructuring ?
• What do you think are key factors in successful restructuring?

Appendix B: The Summary of Contact Form:

CONTACT SUMMARY FORM

Type of Contact:	Site CC
Inf. Interview: VR	Contact date 4/20/93
Phone: _____	Date coded 5/19/93
Observation: _____	Written by ISL

1. Pick out the most salient points in the contact. Number in order on this sheet and note page number on which point appears. Number point in text of write-up. Attach themes or codes or aspects in CAPITALS. Invent themes/codes where no existing ones apply and asterisk those. Comments may also be included in double parentheses.

PAGE
7. 1. Students at CC are expected to learn to respect self, others, and the environment. I believe that a feeling of self respect and appreciation of others and peaceful environment around is basic for "survival" as a human being. PD-LD-OUT/SELF-RESPECT

7. 2. Students at CC are expected to learn to communicate effectively. Here the idea of communication is very broad, including verbal and nonverbal. Through the understanding of others' viewpoints, you can grow and change yourself. The ability to communicate effectively gives that power. PD-LD-OUT/COMMUNICATION

7. 3. Students at CC are expected to learn to apply problem solving processes. Life is full of problems. Here is the issue of empowerment. I can handle these things(problems) and then I'm an empowered person and feel empowered. PD-LD-OUT/PROBLEM SOLVING, EMPOWERMENT

7. 4. Students at CC are expected to learn to set and meet high standards. When they set ideal standards and try to arrive there, these standards are helping them stretch and grow. Accepting

the challenge is important for growing. The idea of setting goals for yourself and pulling yourself up to higher level is important for growing. PD-LD-OUT/HIGH STANDARDS, CHALLENGE, GROWING

7. 5. Students at CC are expected to learn to participate as a lifelong learner productively and responsibly in a rapidly changing world. Ideas here again involve growing. You'll never know everything. You'll never be done learning. You are not static and you are better off being an informed person. In a democracy, you are contributing by being knowledgeable. PD-LD-OUT/LIFELONG LEARNER, GROWING

7. 6. The most appropriate level for the parents to be involved is at the instructional level. PD-ORG STRUC/ROLES OF PARENTS

7. 7. We have a responsibility to educate parents: set up the meeting and explain to them the aspects of programs. PD-ORG-STRUC/ROLES OF SCHOOL FOR PARENTS

7. 8. Developing trust between teachers and parents is also important. PD-ORG CUL/TRUST, OPENNESS, PR-GUID/TRUST BUILDING

9. 9. The quality of teaching is enhanced by implementing a staff development plan that has focus and continuing emphasis. The undergirding belief here is the idea of continuous learning from each other. Share is one aspect. It is a ridiculous idea that teachers are educated and get out of college and are done learning. Learning has to be continuous. PR-GUID/STAFF DEVELOPMENT, CONTINUOUS LEARNING, SHARING. PD-ORG-CUL/CONTINUOUS LEARNING

9. 10. Program effectiveness is improved by increased opportunities for communication between staff: Just sharing ideas can charge people up. If not, we can be very isolated. Through communication with others we can take the best ideas and use them. Also you can iron things out, like misunderstandings. There's like a little community. PD-ORG-CUL/COMMUNICATION

9. 11. Getting reward from colleagues and others is important since this is a human need and professional need. PD-ORG-CUL/RECOGNITION

9. 12. Authentic/alternative assessment of student achievement and their program is essential to an instructional program. It is essential because not everyone fits the same mold. Kids learn in a lot of different ways and are able to show you in a lot of different ways what they learn. It's a real discrimination just to use only standardized tests to make judgment about kids. PD-LD-ASS/ALTERNATIVE, MULTIPLE WAYS, PD-LD-LEARNER

11. 13. Reading is the basis for achieving any kind of significant learning. When they are secure in reading, they love to read. Students need these kinds of fundamentals in developing self-esteem: For the kid who can't read, it is very hard for them. PD-LD-PRO/READING, PD-LD-OUT/SELF-ESTEEM

11. 14. Math is connected with daily life. But, then thinking in mathematical way is really problem solving. PD-LD-PRO/MATH, PD-LD-OUT/PROBLEM SOLVING

11. 15. We need to maximize the effectiveness of available technology as an instructional tool: Children need to feel comfortable with any tool which is available. I see technology as a broader way of interacting with the world: a tool to connect my classroom to the outside world and to

different cultures. We are relatively homogeneous. Here is the idea of global community. Also we need to teach them to understand and use technology since it will be a part of their future careers. PD-LD-PRO/RESOURCES-TECHNOLOGY

13. 16. Designation as Indiana 2000 gave us a step of approval from the state. So politically good. And it gave us money so we could do staff development. It also brought us network with other people in Indiana 2000. Through the network, we can support each other. I think recognition is the main thing. PR-GUID/LEGITIMIZE, RECOGNITION, MONETARY RESOURCE, NETWORK.

13. 17. We moved forward in development of outcome-based goals for instructional programs: An outcome-based program is the thinking of what we want a child to be able to do. It is also that CC can do better for them when they leave the E county schools. It allows us a cumulative instruction and learning and the same direction. PD-LD-PRO/OUTCOME-BASED INSTRUCTION, CONSTANCY AND CLARITY.

13. 18. We implemented performance assessment for student progress: It seems a much less artificial way of assessing given tasks. If I see there's value to something I understand and where I'm going, and if I get proof of what I can do, then there is a lot of satisfaction. PD-LD-LEARN, PD-LD-ASS

14. 19. We implemented continuous-progress instructional program at the primary level: Children don't learn exactly in nine months and nine months. There is no limit to how far they ought to go or they can go in that period of time and so get the child moving along their path. And if they really satisfy the requirements at their grade level, then why not let them go on and explore more. That's what the continuous program is about. They should go where they need to go and it is not determined by the grade level. PD-LD-PRO/CONTINUOUS PROGRESS, PD-LD-LEARN/CONTINUOUS LEARNING

14. 20. I think it is really important that individuals are allowed to grow at their speed whatever their speeds are. But we're tied together through thematic instruction so we are all studying the same things but the levels of what is dealt with are different. I think thematic instruction is a good balance since we need to share the experiences. Community in a classroom is very important because we are looking at the same theme. What teachers and students do with these themes could be more individualized. PD-PD-PRO/THEMATIC INSTRUCTION, SHARING EXPERIENCES

14. 21. What will be the best way to restructure ?
> You have to bring people along and have to have support but you can't make any change into the next century through step by step. PR-GUID/???

14. 22. In which way is your school restructuring?
> I think we have one-three-five year plans. Some of the changes are rapid, such as the ungraded classroom structure, but it wasn't for everyone. So you could do some rapid things as long as there are some choices people can be involved in. You don't make anybody to do it. It is always voluntary here. Maybe we reassess what we thought we were doing. So I think we should do step by step planning but at the same time something should be brought along relatively quickly if you have support. Then people who feel uncomfortable with change will have a place to be rather than just complain. It was always either or or. I think more and more teachers are involved in multi-age grouping. PR-GUID/CHOICE, SCHOOLS WITHIN SCHOOL

15. 23. It seemed very logical to outreach since we have a lot of strength in faculty. Around 75 % of the faculty feel comfortable and are willing to present their expertise at conferences. We have huge numbers of volunteers. We had organizational ability and we could take it. We are willing to go beyond and share. Also it is here the issue of pride in what are doing and opportunity show up. PR-GUID/SHARING, USING STRENGTH, RECOGNITION, PRIDE, FEELING OF EFFICACY, VOLUNTEERS

15. 24. We continued as National Reading Styles Institute Model School Site: NRS is a kind of organized way of connecting learning styles (individual differences and preferences) to reading. This is one way to remove some of the roadblocks. PD-LD-PRO, PD-LD-LEARN/INDIVIDUAL DIFFERENCES IN LEARNING STYLES AND PREFERENCES

16. 25. As faculty, we thought it would be good that student teachers are involved in multi-aged groups but nobody was interested in it. We're trying to find connections with an university in some other ways. I know we can support each other. What we've been doing here is based on whole language and literature based methods. I hope for a professional relationship with AN UNIVERSITY.
PR-GUID/RELATIONSHIP WITH SOCIETY

17. 26. We created opportunities for children in grades K-6 to participate in life skills-based economies education project: It gives kids a chance to do something having a sense of real life. We need to connect more and more with children's real life. Unless kids feel that is important, saying that this is important does not work. Technology should be a tool for exploring the real world. PD-LD-PRO/REAL LIFE, PD-LEARNING ENV/TECHNOLOGY AS TOOL

17. 27. We actively promoted and established after-hours use of the building as a community-based resource for children: Parents were really interested in the school as more of a community center. By having social services in the building and also using the building in the evening, it gives people a place to belong to and a feeling of place for the community. I personally like more and more moving toward that direction. PD-SOCIAL-ED/SCHOOL AS COMMUNITY CENTER

17. 28. We developed building-wide awareness for a thematic approach to instruction: We've been reading a lot about brain research and about the ways people think. Based on what we know about how kids are learning, they do not learn in separate subjects, but within a context. PD-LD-PRO/THEMATIC APPROACH, PD-LD-LEARN *VALUES/CONSTANCY BETWEEN VALUES.

18. 29. The immediate goal (92-93) is the development of an instructional program which has clarity and consistency throughout the age levels of school: When programs have clarity and consistency, students do a better job because they are comfortable with it. Even maybe teachers' personalities are very different. Maybe or maybe not this new teacher will use the thematic approach. But the program at different levels shouldn't be totally different from the last year, shouldn't cost last year's experiences. Clarity and consistency in an instructional program help kids feel comfortable with the learning process. PD-LD-PRO/CLARITY AND CONSTANCY, PD-LD-LEARN/SELF-COMFORT

18. 30. We offer the Up-Lift program as an option. Changing is uncomfortable for a lot of people, but I think it's good. I think some of the parents still might be uncomfortable. For school, still to some extent there is a need to push people; that is DF's job. He keeps the

whole picture. He has a kind of balance -- supporting people trying innovation but also not loosing people who feel uncomfortable. PR-GUID/CHOICE, VOLUNTARY PARTICIPATION

Appendix C: A START LIST OF CODES

PRODUCT OF RESTRUCTURING		**PD**	**1**
LEARNING DIMENSION		PD-LD	1.1.
PD-LD	Nature of Learners & Learning	PD-LD-LEARN	1.1.1.
PD-LD	Outcome of Learning	PD-LD-OUT	1.1.2.
PD-LD	Process of Learning	PD-LD-PRO	1.1.3.
PD-LD	Assessment	PD-LD-ASS	1.1.4.
PD-LD	Learning Environment	PD-LD-ENV	1.1.5.
ORGANIZATIONAL DIMENSION		PD-ORG	1.2.
PD-ORG	Organizational Structure	PD-ORG-STRUC	1.2.1.
PD-ORG	Organizational Culture	PD-ORG-CUL	1.2.2.
SOCIAL DIMENSION		PD-SOCIAL	1.3.
PD-SOCIAL	Role/function of education		
PD-SOCIAL-ED		1.3.1.	
PD-SOCIAL	Role/function of society		
PD-SOCIAL-SO		1.3.2.	
PROCESS OF RESTRUCTURING		**PR**	**2**
PR	General Principles	PR-GEN	2.1
PR	Guiding Principles	PR-GUID	2.2
SITE INFORMATION		**INF**	**3**
INF	DEMOGRAPHICS	INF-DEMO	3.1
INF	EVENT CHRONOLOGY	INF-CHRON	3.2
INF	STRUCTURE	INF-STRUC	3.3
INF	CULTURE	INF-CUL	3.4

Appendix D: DEFINITIONS OF CODES

1. PRODUCT OF RESTRUCTURING

415

1.1. Learning Dimension

1.1.1. Nature of Learner/Learning:
Basic assumptions or values which affect the articulation of the other values or ideas, especially, relevant to process of learning and assessment

> Nature of Learner: values or ideas about the ways that a learner learns the best; values or ideas about the natures of a learner including intellectual, social, emotional, and physical

>Nature of Learning: definition of learning, focus of learning, climate for learning

1.1.2. Outcomes of Learning/Learning Outcomes: what the learner will be able to know and do after the process of learning.

1.1.3. Process of Learning/Learning Process: values and ideas regarding how to achieve learning outcomes. That is, the ways of learning including the types of learning arrangement or strategies and learning situations. They should be consistent with the values concerning the nature of learning and learner; and they should promote the learner to achieve the expected learning outcomes.

1.1.4. Assessment: values or ideas in regard to the purpose of evaluation (why), the content of evaluation (what), the way of evaluation (how), time of evaluation (when), and party (ties) of evaluation (who). They should be consistent with the values concerning the learning outcomes as well as the nature of learning and learner.

1.1.5. Learning environment: values about the ideal environments which might support the process of learning that is designed to ensure learners to achieve the expected learning outcome: physical and human resources; social, cultural, and disciplinary atmosphere.

1.2. Organizational Dimension

1.2.1. Organizational structure: Formal organizational arrangement (Nadler, Gerstein, & Shaw, 1992, p. 133): a governance structure, formalized roles and responsibilities of stakeholders, and organizational communication channels/bodies.

1.2.2. Organizational culture: I mean 'organizational culture' in this definition only the highest level of Schein's model (Nadler, Gerstein, & Shaw, 1992, p. 134): visible behaviors, or 'artifacts', in a daily life. These include manner of speaking among stakeholders, standardized patterns of behavior, expression, gesture, events, and rituals.

1.3. Social Dimension

1.3.1. Role/function/purpose of education: values and ideas about the function of education, the relationship of an educational system with other social organizations.

1.3.2. Role/function of society: an educational system's expectations toward other social organizations; fundamental relationships of the larger society with an educational system.

416

2. PROCESS OF RESTRUCTURING

2.1. General Principles
General/fundamental principle of restructuring: reasons for why restructuring is needed, the definition/nature of restructuring, and the main focus(es) of restructuring.

2.2. Guiding Principles
Strategic or tactical values or ideas which include internal factors and external key factors to success: people (who should be involved); process (how should restructuring be processed; governance/organizational structure; organizational culture/working relationships, internal and external resources (time, technology, people, monetary....)

Appendix E: Interview Summary Report
C. MM.

First Interview.

1. 1. The biggest thing to me and many of my peers is collaborative staff. We feel very comfortable about asking to be taught by others that have expertise. We also feel comfortable with offering to share over the course of time.

1. 2. No one individual knows or can lead the change. Depending upon their expertise, people are concentrated on certain areas based on collaboration.

2. 3. I feel comfortable that any parent of my students calling or talking with DF. Since I think she might need to know what he knows better than I do or needs something he can provide better than I do.

2. 4. We are interested in students seeing computers as tools: utilize computers as another tool in their learning process.

3. 5. We need to provide what they think is important. Also, We need to provide education in, not just a competitive, but a cooperative and social context.

3. 6. We try to teach students to actually demonstrate what they learn at CC, we do not want them to leave with just report cards with happy faces and pluses and checks. We want the children to be able to go out to the real world and demonstrate the ability they learn to communicate by reading, writing, speaking, and listening.

3. 7. We don't do the same things better, we do not do completely different things either, by throwing away old things. But we borrow from effective school programs, effective leadership models.

7. 8. In our culture, we don't respect others because we were not truly taught to respect our own individual uniqueness. Respecting the environment is becoming a more and more obvious issue. So we need to teach our kids to respect self, others, and the environment.

7. 9. If families and others can't provide these kinds of things: respect self, others and the environment, there is a need that we (schools) have to provide this.

7. 10. Communicate effectively. Preparing the students for the adult world--jobs. That is one issue of communication. Children as well as staff need to learn all of those critical communication skills.

7. 11. Reeding is a way of gleaning information. Reading allows us to understand what the author of that material wants to communicate.

7. 12. Students need to learn in context.

8. 13. The world is always rapidly changing because we're in the information age in which there is a dramatic impact of technology. We need to teach the children to recognize problems and use their own resources as a "lifelong learner".

8. 14. Student should know to set and meet high standards. Each student's high expectation is unique to each student. We as a teachers should help them to constantly assess and reset new goals.

8. 15. Students learn to participate as a lifelong learner productively and responsibly in a rapidly changing world.

9. 16. Because the world is dramatically changing, the population is changing, group dynamics are changing in the classrooms, strategies can't be the same. We are open to that change and open to that communication which will take place.

9. 17. Our society is less than functional because we have such a competitive bend, not cooperative and, thus, we are not served to a useful end.

10. 18. The quality of teaching is enhanced by implementing a staff development plan that has focus and continuing emphasis.

10. 19. Program effectiveness is improved by increased opportunities for communication between staff.

11. 20. Alternative assessment of student achievement and programs is essential to an instructional program. For students, it allows them to analyze themselves and allows the class to review. How they feel about themselves is far more important and how their peers feel about them is far more important than what I feel about them.

12. 21. For students, reading can be seen as one of the easiest and clearest manifestations of communication events. Also, it's a tool for respecting yourself. If you feel you can't do something, you never attempt to do it.

12. 22. Our life depends upon mathematical concepts.

12. 23. In our society, computer assists our life in many ways. Computers and technology is in all aspects of our life whether we want it or not, whether we realize it or not. We need to maximize the effectiveness of available technology as an instructional tool.

14. 24. Our designation as an Indiana 2,000 school site: It gave us credence. We are not anymore seen as risk takers out on the edge. That's recognition for what you have done. It (officially) opened the opportunity to invite people in our building and share. One of the most important ways you learn something is to teach someone else. Moneta-y rewards allowed us to do more. Usually we as teachers have to do more with less. This allowed us to do more with more.

14. 25. Without continuous progress types of thought within classroom teachers' strategy and instruction plans, a student will not have the ability to progress at his continuum, not according to the school continuum. If we don't teach the way the children learn, we will teach the ways they learn.

15. 26. We hosted our own conference in which we invited people to see specific elements of what we're doing at CC, what we think is unique about CC and maybe unique for E County. We did not want to be seen as blowing our horns. We wanted to take pride in what we are doing and communicate it with other learning environments. We believe what we're doing can be transferred to other environments.

15. 27. We developed an extra-curricular instrumental band for ten and eleven year old children. Some students can excel in academics and others in sports. We should give them the opportunities: in which they feel self actualization, in which to feel comfortable, in which to feel growth, in which they feel regard for their own abilities.

16. 28. We created opportunities for children in grades K-6 to participate in a life skills-based economies education project. Why is that important to the children to learn these things? Part of it goes back to communication. What we do in CC goes to the idea of life long learning.

16. 29. We actively promoted and established after-hours use of building as a community-based resource for children. There is a great need in our community for children after school to practice sports, to be engaged. It also gives positive ways for adults to interact with their kids as well as others. Because we are a building with public money it should be open to the public for their use.

16. 30. We developed a building-wide awareness for the thematic approach to instruction. That's because the thematic approach gives children a framework on which to learn content and insights into the others' schema. Without it, everything we learn is just an isolated bit of information. Without some kind of connection or integration, we can't be as effective in school as we should or could be. Content is not divorced from process, process of understanding the content is not divorced from the product of the process. They are not necessarily ends and means of one another.

16. 31. We've focused on the development of an instructional program which has clarity and consistency throughout the age levels of school. If not, there might be gaps in our curriculum within this building.

17. 32. We've been implementing a performance-based curriculum model in which multi-dimensional assessment tools are used to measure student progress and program effectiveness. Why? I, as an assessor, might be not good at certain aspects of evaluation. We need multi perspectives and insights in order to have e balance in evaluating the students' achievement. Traditionally, we have focused on summative evaluation. But formative evaluation should be more focused because it allows us to evaluate children's continuous progress. These assessment tools allow us to evaluate how they grow in multiple ways.

17. 33. Environment element: We are planning to build the outdoor stage and sitting in the woods outside the building. The belief behind this is an extended concept of classrooms: Learning places are not confined within the classroom's wall.

Appendix F: Matrix

1.1.1. PD-LD-LEAR **Nature of Learners and Learning**	Interviews DP 1st	DP 2nd	VR 1st	VR 2nd	MM 1st	MM 2nd	CT 1st	CT 2nd	KW 1st	KW 2nd	MMc 1st	2
Nature of Learner												
• Differences as a cause for celebration. 1-a				3.1.								
• Recognition of individual differences.1-a					15.17.		4.7.					
• Kids learn in a lot of different ways: they have different modality, strength, and preference. 1-a	2.2.		9.12		15.17.	4.5.	4.7.		4.8.		7.12	
• Kids are able to show in a lot of different ways what they learn. 1-b			9.12		17.32.							
• Children don't learn exactly in a determined period. Each child developmentally reaches a certain point with different rates of time. 1-b	3.3.		14.19								7.12.	
• Kids do not learn in separate subjects, but within a context. 2			17.23.		16.30.		4.6.					
• Students do a better job what they are comfortable with. 2			18.29.		15.17.				6.17			
• In the long term, investment to younger children has greater impact.	6.20											
• A child learns something is important rather than when they learn.	11.29.											
• Kids need a sense of ownership/responsibility about what they are doing; internal motivation. 2				3.1.		7.9.						
• Self-esteem is basis for accomplishment. 2					11.20.						7.11	
Nature of Learning												
• Learning is a 'process'; it takes time. 1	3.6.			10.14	16.30.							
• Learning is 'making sense of the world.' 2	3.6.					14.20.						
• Learning does not stop. 3	5.17			7.5.								

Appendix G: Appendix J: Primary vs. secondary value categories inventory

Stakeholders' view of primary and secondary value categories

Listed below are 11 value categories identified from interviews, document analysis, and observation at your school. Indicate how you feel about the importance of each value category (definitions of value categories attached) by circling the appropriate number on a scale of 1 to 5.
A higher number indicates primary, so that is more important. A lower number indicates secondary, so that is less important.

1. Nature of Learner	1	2	3	4	5
2. Nature of Learning	1	2	3	4	5
3. General Principle of Restructuring	1	2	3	4	5
4. Procedural Principles of Restructuring	1	2	3	4	5
5. Outcomes of Learning	1	2	3	4	5
6. Process of Learning	1	2	3	4	5
7. Assessment	1	2	3	4	5
8. Learning Environment	1	2	3	4	5
9. Organizational Structure	1	2	3	4	5
10. Organizational Culture	1	2	3	4	5
11. Function of Education Within a Larger Society	1	2	3	4	5

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Appendix H: Definitions of Value Categories

Definitions of Value Categories

Dear ,

Listed below are the definitions of the value categories which are provided in order to enable you to have a clearer idea about each term presented on the opinion sheet. Please read these descriptions before you answer the opinion sheet, ***Stakeholders' view of primary and secondary value categories.***

1. Nature of a Learner:
values or ideas about the ways in which a learner learns the best; values or ideas about the nature of a learner including intellectual, social, emotional, and physical.
2. Nature of Learning:
values or ideas reflecting the fundamental attributes and functions of learning.
3. General Principles of Restructuring:
values reflecting the reasons for restructuring, the nature of restructuring, and the

main focus(es) of restructuring.
4. Procedural Principles of Restructuring:
strategic or tactical values or ideas which are perceived to be key factors to successful restructuring. These factors include both internal and external factors.
5. Outcomes of Learning:
values or ideas relevant to the expectations of what a learner will attain after completing the process of learning.
6. Process of Learning:
values and ideas regarding how students should achieve the expected learning outcomes.
7. Assessment:
values or ideas reflecting the purpose of evaluation (why), the content of evaluation (what), the way of evaluation (how), time of evaluation (when), and party(ties) of evaluation (who).
8. Learning Environment:
values about the ideal environments which might support the process of learning that is designed to ensure that learners achieve the expected learning outcome.
9. Organizational Structure:
values and ideas describing formal organizational arrangement which includes a governance structure, formalized roles and responsibilities of stakeholders, and organizational communication channels/bodies.
10. Organizational Culture:
values and ideas relevant to visible behaviors, or 'artifacts', in daily life.
11. Function of education within a larger society:
values and ideas reflecting the goals, functions, and responsibilities of an educational system within a larger society and relationships of the larger society with an educational system.

422

Title:

Key Elements in Successful Educational System Redesign: learning from Theory and Case Studies

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Introduction

There has been an increasing perception of the need for fundamental redesign in the American educational system. This restructuring movement has received its primary impetus from the realization that the current system fails to satisfy individual learners' and societal needs as society continues to change (Banathy, 1991; Reigeluth, 1987; National Commission on Excellence in Education,1983; Walberg, 1984; Walberg & Fowler, 1987; Branson, 1987). Not only on the national level but also on the state and local levels, countless numbers of people have put their time, energies, and resources into redesigning efforts.

Despite these attempts, however, evaluation of earlier restructuring indicates little difference in practice or achievement as compared to previous years. The more we realize efforts at redesigning have not worked well, the more we come to seek factors that would more likely ensure successful educational systems redesign. Recognizing the demand for a knowledgebase to enhance redesign, the current study aimed to add to that base by identifying factors that are likely to lead to successful redesigning of educational systems.

Research Objectives

1. To synthesize the key elements involved in the successful redesign of educational systems through literature review.
2. To uncover the key elements in enhancing success in educational systems design by synthesizing data from two research sites.
3. To provide a synthesis of the key elements gleaned from existing theory and the present case study.

1. Key Elements: Learning from Theoretical Perspectives

I reviewed theoretical and empirical research relevant to the factors affecting successful school redesigning so as to present a broad picture of these various elements. The review includes the following:

1. A study of the 'institutionalization' of new educational systems, based on a comprehensive analysis of institutionalization in various organizational sectors and of case studies in school restructuring (Miles and Ekholm, 1991; Miles, 1993).
2. A theoretical framework including the key elements in educational systems redesign, based on conceptions of the needs for concomitant consideration of the appropriate key elements within educational systems and their contextual relationship with societal systems (Lee, 1992).
3. A study focused on the major reasons of why most previous restructuring efforts have failed (Keefe, 1993).
4. A study of educational system elements particularly important to schools, districts, and states when moving through the systems design process (Anderson, 1993).
5. A study of the key dimensions involved in successful implementation, especially in light of teachers' view. Put differently, this study revealed those conditions under which teachers tend to be more willing and able to engage in the change process (Evans, 1993).
6. A study regarding the primary features of strategies for achieving systemic redesign of education (O'Neil, 1993).
7. A study of the support and implementation strategies identified at the Center for Educational Technology (Florida State University), based on the view that "Design requires that we are not constrained in our thinking by current practice or by limitations which may not be relevant in a redesigned system" (Salisbury, 1993, p. 135).

8. A case study of a major metropolitan public school district undergoing a fundamental restructuring process, which identifies the main factors contributing to this district's successful redesign process (Breidenbach, 1989).

9. A nationwide case study involving diverse information about the systemic restructuring process as well as its products, including the key factors related to a successful change process (Reigeluth, Norris, & Ryan, 1991).

Findings from Literature Review

From the above literature review, the following key elements in a successful redesigning process can be drawn.

Visions

Given the large-scale changes accompanying the re-examination of people's mindsets and values, it seems critical for stakeholders to clarify and share their *visions*, that is, their views of what schools should be like. These visions should be future-oriented, not limited to current conditions. Visions provide a foundation for ongoing design efforts, by supplying direction, generating new activities, and providing criteria for trouble-shooting (Miles & Ekholem, 1991, p. 15).

Visions articulated from stakeholders' core values are those most likely to be accepted. In addition, those visions should be translated into communicated and measurable goals.

Comprehensive Plan

The literature review showed the importance of formulating visions into a clear, consistent, comprehensive strategic plan. Such a plan represents "the incorporation of major and visionary recommendations into the more specific goals or blueprint" (Salisbury, 1993)

Change Management

Comprehensive educational systems redesign requires long-term effort and commitment. Therefore, the change process should be managed with willful and intelligent design strategies and skills. The literature review specifically addressed a knowledgebase relevant to the following factors: planned coordination between and among all stakeholders (internal and external), management of the pain that accompanies a long-term change process, needs analysis of individuals and groups involved in the redesigning process, change eventually to be embedded into stable organizational routines, transition management, personal and organizational learning, and avoiding staleness.

Resources

Human and physical resources, both internal and external, should be fundamental to any systemic change. Intellectual (instructional and organizational strategies/knowledge), financial, and technological resources are required to initiate as well as maintain change. In order to decrease risks and enhance the quality of redesigning efforts, multiple sponsorship is recommend (Salisbury, 1993).

Networking

Networking is essential in collaborative redesigning efforts and eventually is more likely to lead to establishment of lasting systemic change. Through a network, local schools can outreach to collaborate in studying, piloting, and supporting a new vision of the educational system.

Support

Success in redesigning a system is more likely if a school has strong external support. A significant aspect of systemic school redesigning is the environment that supports and is complementary to the values, functions, and services of new educational systems. This is due to the fact that, viewed as open systems, educational systems are interdependent with their external environment.

State and local policy support, which includes commitment, legitimation and endorsement, alignment, and facilitation should be obtained. Without policy support and accommodation, we can hardly expect to implement envisioned changes in educational systems and instructional management in the schools and classrooms. A broad base of support and advocacy from the business community, parents, and other educational organizations also provide the support and energy necessary for the long journey to systems redesign.

Commitment and Ownership

Comprehensive redesign in a system takes a long time to accomplish, demanding energy, openness, flexibility, and continuous and intensive work on the change process. Stakeholders participating in the redesign process should consider themselves as 'long-distance runners (Miles & Ekholm, 1991, p. 14). Staff ownership and collaboration seem especially crucial to maintaining the momentum for change.

Internal Structures and Culture

Redesigning is more likely if a school develops its own internal capacities through the redesign process. A school should re-conceptualize peoples' roles, relationships, and responsibilities. In addition, it should created an innovative culture that nurtures competencies, morale, and initiatives; distortion-free communication patterns, shared decisionmaking, and democratic and professional management styles.

Learning/Instructional System

A coherent learning and instructional system should be designed based on the reflection of shared values, visions, and goals. Without changes in learning and instruction, all other changes have little meaning. Key learning and instructional elements to be considered include learning programs, learning strategies, the learning process, the learning environment, and assessment.

Leadership

Leadership is the most important source of momentum in educational restructuring (Blase, 1986; Barth, 1990; Liberman & Miller, 1990; Goodlad, 1983; Liberman, 1988; Cohen, 1989). This is due to the fact that purposively induced change processes require skillful and highly committed management. Especially, the primacy of authenticity and motivation in leadership have been stressed in the literature.

2. Key Elements: Learning from Case Studies

Two public schools, Indiana Creek Elementary School (ICS) and Sunshine Elementary School(SES), were selected through a purposive sampling strategy (Kidder, Judd, and Smith, 1986; Merriam, 1988). These schools were researched at an earlier time for different purposes. However, They were selected for the current study since they had similarities as well as differences. Both schools were elementary schools located within a 25 miles distance from one another and were designated as Indiana 2000 --an Indiana state' restructuring initiative project -- school sites. They were different, however, in terms of organizational and community environment. The following sections describe the methodologies used and the research findings from each site.

Indiana Creek Elementary School (ICS)

A qualitative case study approach was employed for four months to gather data about the school setting. The methods of data collection included participant observation, interviews, document analysis, and VAXnotes (an electronic conference). All the data were recorded by means of a personal journal.

Data collection

The primary data collection technique was observation. I visited and observed each classroom once each week from January through April of 1992. Whenever possible, I helped individual teachers as a teachers' assistant in the classroom. I also observed the general atmosphere of the school, which included students' activities outside the classroom, the classroom structure, and the school's architecture. Secondary data sources included interviews and document analysis.

The informants interviewed included the staff, students, and parents. Interviews provided information about informants' activities, feelings, and lives (Eisner, 1991). It also was necessary to analyze past events that could not be directly observed (Merriam, 1988, p. 72). The interviews with the principal were mainly formal, conducted at her office, and relatively open-ended. I took notes during the interviews, which were tape-recorded. Informal conversations were conducted with teachers, other staff, students, and parents in the interviews, in classes or at lunch time.

Documents and programs also were useful sources of information (Lincoln & Guba, 1985) for this study. These were comprised of proposals, reports or articles prepared by the staff, the school newspaper, class schedules, the monthly school calendar, activities designed by the teachers, students' progress reports, and students' work, projects, and portfolios.

Data Analysis

I employed triangulation by using different data gathering methods and different informants or sources as described above. Triangulation allowed me to detect distortion and exaggeration of information by checking the plausibility of the accounts and the reliability of informants (Whyte, 1982). I also detected and corrected distortion by comparing an informant's account with accounts given by other informants (Whyte, 1982). A regular group meeting with other university members in the evaluation project, averaging every two weeks kept me probing possible biases, exploring meanings, and clarifying interpretations and findings (Schnorr, 1990). Moreover, VAXnotes (an electronic conference) among the evaluation team[1] members helped me to compare multiple points of view to detect and avoid bias.

Geographical and demographic Information (ICS reports, July, 1991)

Indiana Creek Elementary School (ICS) is a K-5 school that serves over 180 students. The staff defined the socio-economic level of the local area as low; fully one-third of the students are on the federal free/reduced lunch program. In fact, over 43 percent of the adult population has not achieved a high school diploma. Consequently, a large number of students' potential was not considered to be met. The self-esteem and confidence levels of both parents and children were very low.

While ICS has only one elementary school in its school corporation, the staff still believes that the elementary school can have a dramatic effect in increasing the high school graduation rate of ICS students.

[1] I worked with this school as one of the 12 evaluation team members. ICS invited us to evaluate their redesigning process.

ICS students, while all Caucasian, still represent a broad range of cultural backgrounds. While twenty-five years ago the area was predominantly an agricultural community, it is now becoming a bedroom community.

Process of Restructuring

The ICS principal said, "The ideas for the restructuring of ICS were spawned at least five years ago during informal conversations of staff members at lunch, in the hallways, and at other gatherings." .

In the spring of 1990, school personnel were invited to participate in the "Restructuring to Promote Learning in America's School" teleconference series sponsored by the North Central Regional Education Laboratory (NCREL) and the State Department of Education.

During the summer of 1990, the staff and several parents attended conferences, workshops, and meetings to learn more about restructuring.

As school was beginning for the 1990-91 year, these individuals participated in the redesigning efforts unanimously decided to continue pursuing their shared vision. The Design Team, composed of a broad stakeholder group and outside facilitators, sent surveys to the school community. A survey was conducted to determine what the community wanted schools to be like for their children. Based upon the input received, the Design Team developed a mission statement and supporting principles.

They used this statement to decide what issues they would address first. Then, based on the input received from meetings open to the community, they developed a plan for their first year of redesigning implementation. The major working areas, as of the fall, of 1992, were ***continuous progress, multi-age grouping, alternative assessment, thematic instruction, cooperative learning, and integration of technology.***

Findings

Professional development was critical in ICS, which was attempting to be a professional development school through collaboration with a higher education institution, active invitation of outside help, research, and training.

> "We will spend most of the Indiana 2000 project grant money for staff development. We will use it for teachers to visit other schools, to go to conferences, and to invite workshops to come into school during the summer." (the principal)

Teachers and the principal at ICS seemed to believe in ***systemic change*** in which they should consider all possible elements simultaneously and balance them within the system. However, it might extremely aggravate the uncertainty and pressure on them.

> "Once teachers understood what it was and why we do it, they'd better develop their own skill themselves." (the principal)

Yet, she admitted that it is almost too overwhelming for them and the teachers are emotionally very exhausted.

> "We almost have to do everything all at once. There's so much to learn and we don't have ***time.*** Instead of focusing on portfolio, alternative evaluation, etc., I'm trying to put them all on the floor. That's because everything has to go together."

is another main element, and at the same the least available resource, in ICS's redesigning process. Recently staff members have cooperated in order to redesign curriculum that fits their own needs, but have suffered from lack of time.

> "We don't have enough time to talk with colleagues to share ideas and co-work." (a teacher)

"I don't have time to figure out what's going on and whether any of it's working." (a teacher)

Management of uncertainty also seemed to be a critical element in ICS's redesigning process. The staff at ICS needed to manage outside complaints as well as cope with business as usual. However, they seemed not to have a clear picture of what they wanted to achieve after the "disaster, confusion, and grief" involved in school redesign.

"I went to one workshop and read some articles but it is not enough to help me. I want to see them being used. I don't think I have enough references." (a teacher)

"...there is a lot of enthusiasm, but too many things are going on in class. The teachers also worry about failure. They've heard about successful 'individualized' learning. But one of the teachers said that she doesn't know how to apply it to her class. And they worry that they can't handle that situation." (an outside evaluator)

"We don't know the parameters of the Community Council yet......Nobody can give us the answer. Because our school is different from others, we need the way that fits our school." (the principal)

" We do not have a well-structured portfolio yet. We still don't know what kind of portfolio it should be."(a teacher).

ICS did not have much time to demonstrate success. In the summer of 1991, the School Board gave the school a one-year trial period in which to implement changes. Also, not all of the parents were supportive of the school's efforts. Some parents worried that the changes would be disadvantageous for higher achievers. Some parents worried that the redesign efforts may not last long.

"These teachers are very, very dedicated. They love kids, or they wouldn't be doing this. But we all know that people can burn out."(a parent)

The staff clearly saw the need for more ***communication*** and ***collaboration*** among teachers and with the community. They tried to individualize students' learning by inviting more adults into the classrooms. ***Parents and community volunteers*** regularly helped teachers inside and outside each classroom. Teachers were not isolated within their classrooms anymore, but opened them to other classes and the community. They invited each other to get involved in collaborative learning activities and exchange ***rewards*** and wishes. In this process, they respected different perspectives and learning styles. Also, they cooperated in order to design a curriculum that fits their needs.

"The answer is time and ***communication***.... What we found is we were using the wrong kinds of communication with parents -written form. Parents in general don't read written documents" (the principal).

Individual and organizational learning appeared to be a critical element in their redesign process. The staff and community members, as individuals and as a group tried to learn more about how to redesign their school system in various ways. A teacher referred to her ***networking*** and affiliation with Phi Delta Kappa, a state education computer group, the school's design team, the Illinois Renewal Institute, Technology 2000, the 21st Century Schools grant, and the 3 R's grant, as well as a small support group of colleagues who were dedicated to the formation of an ideal school.

Technology, *especially computers,* was considered prominent in successful redesign, especially at the level of learning and instruction. Computer activity was one of the requirements in the Choice programs. However, there was not enough systematic guidance in students' computer work, nor did the teachers seem to have much preparation for teaching students to use computers.

"We would like to utilize computers more and get training for more efficient computer utilization." (teachers)

Sunshine Elementary School (SES)

A qualitative case study approach was used to gather data from February in 1993 through August of 1993. The methods of data collection included mainly interviews, document analysis, and observation.

Data Collection

Prior to the first site-visit, I analyzed available documents, including an annual report, local newspaper clips, and some promotional pamphlets which were already available. This provided me with preparatory information about the site. Upon visiting the school, I discussed my research plan with the principal. At this pre-research meeting, I obtained more documents, which included an Indiana 2000 application and PBA(Performance Based Accreditation) documents.

The primary data collection technique involved interviews with the stakeholders most involved in the redesigning of their school system. These included an administrator, two teachers, two parents, and one community member. I mainly conducted semi-structured interviews. These interviews were guided by a list of questions or issues to be explored, but neither the exact wording nor the original order of the questions was used during the interviews. In addition, structured interviews were added to obtain some standardized information (Merriam, 1988, p. 74). Information was collected about the past, present and future by asking: What has the school done, how, and why? What have they been doing, how, and why? What are they doing, how, and why?

Key informants were interviewed individually at least twice. Follow-up interviews were made either through a meeting or phone call. I took notes during the interviews, which were audio tape-recorded. Verbatim transcriptions were made from the recorded interviews. As a non-participant observer, I observed classroom activities. After I left the room, I summarized my observations as soon as possible either on- or off-site. Then I took time to remember more substance and elaborated the scenes and dynamics at the site. Data from documents and observations were recorded for the purpose of verification.

Data Analysis

The techniques of *'unitizing'* and *'categorizing'* (Lincoln & Guba, 1985, p. 344) were used to analyze data. All data from interview transcripts, documents, and observation notes were read through several times from beginning to end. While reading, I jotted down notes, comments, and observations in the margins (Goetz and LeCompte, 1984, p. 190-191). Through this process, I identified *units* of information as the basis for defining categories. Then, selected information was summarized and categorized through the use of *codes*.

Developing categories involves seeking recurring regularities in data by comparing one unit of information with the next. Once the relevant sets of categories are derived from the data, they can be filled out and made more vigorous by searching through the data for more and better units of information. An alternative display, a *matrix*, was utilized for better analysis.

Interview data analysis. The data consisted of verbal accounts, derived from 3-4 hours of interview interactions. Upon completion of all interviews, the contact summaries were edited and sent to informants. Each informant was called after they received the summarized interviews -- interview summary reports --for initial verification of content. Minor editing was done through phone calls or personal contacts, according to participants' preferences. Upon conducting these verification contacts, there was one follow-up interview.

Document Analysis. Documents also were summarized and coded on the summary sheet. Primarily, the content analysis focused on measuring the frequency and variety of information, confirming the emergent hypotheses, and advancing new categories and hypotheses (Merriam, 1988, p. 108).

Observation analysis. Data collected through observation was summarized and coded on observation summary sheets. The main focus in the observation was to answer the question, "Are they really practicing what they said they value?" The main purpose of the observation was for *triangulation*.

Demographics of school building

Sunshine Elementary School (SES) was a relatively large elementary school of 530 students. The faculty describe their school as being somewhere between rural and suburban. However, they think they are close to being a suburban school.

There were drastic changes and growth in the school community between 1989 and 1991 with the construction of a large new school building in 1990. 50% of the families and 75% of the faculty are new. In 1989, the school had 11 staff members but by 1992 it had 52. Most parents were employed in light manufacturing or service sector jobs. Four to five percent of the students were ethnic minorities, and some used English as a second language. One of the faculty members said that most of the families were non-conventional, that is two-parent and two-income, or single parent and single income families. 10% of the school population was enrolled in the before- and after-school custodial program.

Process of Restructuring

The current restructuring effort was initiated by the faculty, who saw that what they were doing was not successful and thus wanted to make changes. "Many of the faculty felt that much of the business we were doing did not meet the needs of the kids. We were seeing that many kids were not successful with what we were doing (the principal). "The driving forces are collaborative staff" (a teacher), "having leadership skills and professional excellence, having broader pictures. . . sharing knowledge." (a teacher).

The starting point of the current restructuring effort was differently defined by each informant. It was clear, however, that they began to think about and prepare for redesigning their school before the new building was open. They have been involved in the National Reading Styles Institute as a model school site since 1988.

In 1989, they doubled staff size and took time to get to know each other's expertise. "It was an active reorganization and data collection time for us." (a teacher).

In 1990, a new building was opened and a PBA (Performance-Based Accreditation) document was produced through the group work of faculty members, which consisted of background information on the school community, parent survey results, a mission and belief statement, goals for SES , analysis of strengths and weaknesses, and goals and strategies to improve these areas.

In 1991, SES began an ungraded primary multi-age grouping program, UP-LIFT(Ungraded Primary - Learning Is Fun together). In the same year, they started to talk about a strategic way of looking at outcome-based instruction.

In 1992, they clarified 'Exit Outcome' which is what they expect students to know and to do when they leave school. In 1992-93, they expanded multi-ungraded grouping by starting an intermediate multi-age grouping, called Project LaUnched. At the end of 1992, they developed outcome-based instruction as a faculty.

In 1993, they tried to more fully implement OBE(Outcome-based education), with each faculty member being required to develop his/her own education plan. They currently put a lot of effort into making connections among various groups within the building.

Findings

Continuous and focused ***professional development*** was one of the most commonly discussed elements among informants, which was defined in terms of "collaboration" and "collegiality" among staff, as well as "self-efficacy."

> "In order to achieve the learning consistent with our beliefs support from people, and staff development is really important." (a teachers)
>
> "at SES, the successful factors for restructuring is collaborative staff, people who are collegial and are not threatened by the opportunity." (a teacher)

Collective wisdom emerged as another key shared element among the informants. They believed that they needed to listen to new and different ideas and perspectives from more people both within and outside the building.

> "I believe the community should be involved in their [SES'S] restructuring process for fresh perspectives. Somebody outside the system has some new and fresh ideas, not always the same old people are talking to the same old people about the same old thing. It is valuable to bring in new ideas because new ideas are the stimulus for change and there's also a result of change. That is new ideas to keep a process evolving so it wont' be stagnant. (a community member)

Administrative leadership also was discussed as one of the primary elements in restructuring: "Leadership is critical." Administrative leadership at SES was perceived as a successful factor in their redesigning process.

> "At SES, the principal allows to be collegial and is collegial himself. He does not see me inferior and I do not see him superior. We see that each other has specific roles and we have expectations for each others for our role." (a teacher)
>
> "The approach I've used in terms of bringing people along is collaboration and encouragement, and direction without dictation." (the principal)

Parent involvement in the redesigning process appeared to be critical. Parents themselves were convinced about the importance of their support and involvement more than any other informants.

> "If you're not willing to come and talk at the meeting and express your opinion, you don't have a right to complain." (a parent)

The staff members also believed that parent involvement was one of the 'should-be' factors in successful redesigning:

> "Parents should be part of the change process from the beginning. . . . They are not necessarily academic educators, but they should be understanding and motivated as parents so that they should definitely be a major part of the change process." (a teacher)

Community involvement. As indicated by their documents, the people at SES were mainly interested in 'community' as 'resources' which allowed them to have 'a school-wide planning time.' In the community member's part, community also perceived as an outside helper of SES's restructuring process.

> "The other element of my role would have been to create a climate for acceptance of change within the overall school administration. So it would be a kind of paving the way for the principal at the upper level and further try to reinforce what he was doing" (a community member).

Communication. No matter what or who is involved in the change process, communication appears to be a critical factor. Streamlined communication within the school was emphasized as "the heart of what has to happen whenever people have to work together with understanding" (the principal).

> "Just sharing ideas can charge people up. If not, we can be very isolated. Through communication with others we can take the best ideas and use them. Also you can iron things out, like misunderstandings." (a teacher)

Choice. Choice appeared to be almost a norm at SES. Staff and parents understood that changing can be uncomfortable for many people and thus people should have the final say regarding their own practice. By practicing the change strategy of 'school within a school', they attempted to "shape people's perception, not force them to be a part of change" (the principal). They also believed that change can not happen overnight.

> "You don't make anybody do it. It is always voluntary here. Then people who feel uncomfortable with change will have a place to be rather than just complain." (a teacher)

Ownership. "Ownership" of stakeholders was assumed to be an element fostering the restructuring process. The principal defined their restructuring process as a 'bottom-up' approach where the impetus for change comes from the 'grassroots', not from the administration.

> "We worked as a whole in order to discuss what we stand for and what we believe about kids.... The model works because of its belief driven and self-driven nature. It is a grassroots kind of thing so it works." (a teacher)

> "SES's approach toward the community is very good. If you need community help you need to bring the community into it at the early stages. You can't just make a change and then ask everybody to support your change. I think THE PRINCIPAL understood that and involved community from the first. So people are part of the change, not just recipients." (a community member)

Resources were prominent, especially in the staff members' discourse as well in their main documents. The informants' assertions about their accomplishments provided good examples of the most appreciated resources: ***legitimacy*** of change, ***money***, and ***networking*** with other organizations.

> "The designation as an Indiana 2000 school site was significantly important since it legitimized what we were doing throughout the state and the school district. Also, those teachers that participated in the development of the grants had a chance to be recognized and increase their feeling of self-efficacy. It also gave us monetary resources that we primarily spent on staff development" (the principal).

> "Designation as Indiana 2000 gave us a step of approval from the state. So politically good. And it gave us money so we could do staff development. It also brought us network with other people in Indiana 2000. Through the network, we can support each other. I think recognition is the main thing" (a teacher).

SES' belief about networking was well exhibited through its 'outreach' effort. The school hosted its own 'professional development conference' in which it invited people to see specific elements of what was being done at SES, what they thought was unique about SES, and perhaps unique for their county.

> "We wanted to take pride in what we are doing and communicate it with other learning environments. We believe what we're doing can be transferred to other environments." (a teacher)

Time was another resource that is considered to be a critical factor in redesigning, yet not provided enough:

> "If we are going to change the ways we do the business, we need to have time to collaborate" (the principal), "communicate" and "coordinate" a school-wide planning (PBA); "during the school day." (MM)

Conclusion and discussion

The literature review allowed for considering the key elements to success in comprehensive ways, revealing internal and external factors as well as human, structural, cultural, and procedural factors. The findings of the case study mainly confirmed or elaborated on existing theory.

From these two research approaches; literature review and the case study, four elements were identified as being the most critical for a successful redesigning process: ***resources, change management, an appropriate internal structure and culture, support from the environment*** *and* ***clearly shared visions.*** Yet, we should understand that those elements work within the context of the change process and that other elements might be more critical in different cases.

Interestingly, however, the findings from the case study of the two research sites did not provide information indicating the schools held a 'clearly shared vision' was a critical element enhancing their redesigning process, unlike the literature review. Thus, it seems important to answer the question, what does this difference between other researchers' conclusions and my own results mean?

Since change is assured by "a favorable configuration of key aspects" (Miles and Ekholm, 1991), when certain elements are seriously considered, other elements also should be emphasized in order to produce the effect as planned. In addition, different schools or school districts might have their own conditions. Then, different sites need to consider different elements in order to respond to their own need in change process. As redesign emerges, key elements to be considered may shift since different design phases might demand different elements. But this is not fixed, being a contextual and relative matter depending on what happened before, what has been going on recently, and what should happen in the course of redesign process.

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435

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Title:

Closed-Captioned Educational Video: Implications for Post-Secondary Students

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437

Over 40% of freshmen entering public technical schools, colleges and universities are seriously deficient in reading, English skills, and mathematics skills. Many students are unable to improve and eventually drop-out of college, despite remedial efforts. This study used closed-captioned videotape as a technological approach to improving learning and retention skills in college students with deficiencies in reading. An experimental group of 168 Developmental Studies College students, along with 168 comparison academic core education students, were exposed to one of six treatments (i.e., closed-captioned video with sound, regular video with no captioning, closed-captioned video with no sound, audio tape with print, audio tape without print, and print only). Data gathered were pretest, posttest, and retention test scores.

Even though gains were made in posttest and retention test scores for Developmental Studies students in all treatments, they never achieved to the level of their academic peers. When examining individual treatments, the use of closed-captioned video was significantly better than other treatments for academic core students; however, for Developmental Studies students, this treatment produced the poorest scores for the posttest and second poorest for the retention test.

This study suggests learning through multi-sensory instructional media, such as that commonly employed in academic core college classrooms, is more difficult for the Developmental Studies student.

INTRODUCTION

A substantial portion of college students' academic competency is reflected in reading and English skills. Deficits in reading and English usage result in poor academic achievement, which leads to academic probation and subsequent withdrawal. There are no winners when a college student struggles in reading and writing. Students who drop out of college because of reading and writing deficits will find employment in lower-paying positions (Johnson, 1987; Kerachsky & Thornton, 1987; Rusch & Phelps, 1987).

Developmental studies and student support programs are designed to provide academic support to students who are underprepared in the basic fundamentals of reading, writing, mathematics, and study skills. Many enter college lacking appropriate secondary school coursework, but some of these students have disabilities. The majority of post-secondary students with a disability are learning disabled; however, many never inform the college of their disability, fearing a stigma will be placed on them (Henderson, 1992). Additionally, college programs have no standard definition of learning disabilities (Wallace & McLoughlin, 1988).Thus, it is common for students to be inappropriately served, underserved, or to receive no support services at all.

Despite efforts by most colleges and universities, traditional student support programs that require specialized classes are not highly successful. Numbers of students "exiting" these programs can be misleading, for many simply drop out of college (Whinnery, 1992). There are indications numbers of students needing remediation are increasing. Since the end of 1970, the percent of freshmen who report having a disability has tripled. Additionally, the disabling conditions that are most prevalent today are more likely to be invisible (e.g., learning disabilities, health impairments, communication deficits, low vision, or hearing impairments) than obvious disabilities (e.g., deafness, blindness, physical) (Henderson,1992) . New provisions for appropriate student access and support under the 1990 Americans with Disabilities Act challenge colleges and universities to examine more efficient and effective ways to deliver appropriate learning environments, methods, and materials to students who desire a higher education.

Reading skills for college students are essential forsuccess. English and reading programs should: (a) emphasize critical thinking, (b) build students' elaboration skills, (c) advance readers' abilities to interpret, and (d) afford opportunities to form opinions with reasoned support (Applebee, Langer, & Mullis, 1988). In order to achieve these goals, students must develop fluency in reading as well as comprehension skills. Carver and Darby (1972) believe these two skills are inseparable. They define reading comprehension as:

> ...a thorough communication process which involves two primary components -- the rate at which the thoughts are received and the accuracy with which the thoughts are understood. The end product of these two components is the efficiency with which the thoughts are communicated (p.292).

Poor reading comprehension is usually the first academic identifier that a student may have a specific learning disability. (Smith & Luckasson, 1992, p. 217). For these students who stay in school until their senior year, their average academic achievement in reading is at the fifth grade level (Schumaker, Deshler, Alley, & Warner, 1983). Therefore, students who have learning disabilities are reading at approximately this level when they enter college. To ensure success at the college level, new methods and materials must be developed to address learner diversity through media, such as instructional video (Hofmeister, 1992). Closed-captioned educational videotape used to instruct college students who are underprepared or have disabilities may prove to be a powerful alternative or addition to traditional support methods.

Much of the current research with closed-captioned video has been done with hearing impaired populations (Koskinen, Wilson, & Jensema, 1985; Montandon, 1982; Sherman & Sherman, 1989) and with persons who use English as a Second Language (ESL) (Markham, 1989; Spanos & Smith, 1990). Results are encouraging that closed-captioning is effective in enhancing learning and improving literacy skills.

The majority of reading studies that examined closed-captioned materials was conducted with students in elementary grades (Brashier-Spath, 1989; Koskinen, Wilson, Gambrell, & Neuman, 1993; Beentjes & Van Der Voort, 1988; Goldman & Goldman, 1988). Improvement in vocabulary, reading comprehension, writing skills, and reading rates was reported. Based on these studies, effects of closed-captioned materials for reading deficient post-secondary students are examined. Can post-secondary students who have intense reading task demands do better using closed-captioned video media?

The purpose of this study was to examine the effects of closed-captioned educational video as an instructional tool to improve reading comprehension and retention of learning.

METHOD

Subjects

This study included 168 students enrolled in Developmental Studies curriculum (English and Reading classes) and 168 students from Regular academic core courses (School of Education classes). All subjects were first year students at a regional university in the Southeast.

Subject selection for the Developmental Studies students was based on criteria from the Freshmen Evaluation for Developmental Studies, an evaluation tool comprised of writing samples and test scores. Students scoring below 400 on the Scholastic Aptitude Test (SAT) Verbal and below 75 on the Collegiate Placement Exam reading and English subtests were included in the subject pool. All students who participated in the study volunteered.

The Regular academic core course students met college admission standards and had SAT Verbal scores at 400 or above and scored 75 or above on the Collegiate Placement Exam in reading and English subtests.

There were significantly more African-American Developmental Studies students than Regular academic core students who volunteered for the study. Additionally, there were significantly more females in the Regular academic core group than males. These differences also reflect numbers of students in the subject pool.

Insert Table 1: Demographic Data here

Materials

A thirty minute edited closed-captioned video from *The Civil War: Episode One, The Cause -- 1861* (Burns, 1990) was the treatment material. Narration of the video was recorded on audio cassette as well as transcribed in printed form. Materials needed to administer treatments were: 2 TeleCaption 4000 closed-captioned decoders, 2 audio cassette players, 3 Panasonic BT-S1300N color video monitors, and 3 Sharp XA-305 video cassette players. Text was double spaced and administered in bound booklets.

Measures

Based on the edited video, a 33-item multiple choice test was constructed and used as a pretest, posttest, and retention test. The items tested subjects' ability in decoding single words, understanding vocabulary, interpretation of sentences (including appreciation of morphology and syntax), identifying main ideas, identifying supporting details, rejecting irrelevant or distracting information, retelling a passage, identifying the author's intention and/or point of view, and summarizing. These are considered relevant parameters of reading comprehension necessary for reading success (Levine, 1987, p. 298).

Experimental Design

The experiment was a 2 x 6 x 3 (Group x Treatment x Test Scores) within factor design using treatment and test scores as factors. Two groups were Developmental Studies students and Regular academic core curriculum students. Three tests were pretest, posttest, and retention test. Six treatments and their descriptions were:

CC Closed-Captioned Video.
Students receiving this treatment viewed a video with sound having closed-captioned text shown at the bottom of the video monitor.

V Sound Video.
Students receiving this treatment viewed a regular video with no captioning.

CM Muted Closed-Captioned Video.
Students viewed a video with captioned text but the audio portion was muted. The purpose of this treatment was to test subjects' visual sensory adapting capability when the situation required them to process complex information (video and captioned text) when audio sensory mode was artificially disabled.

A Audio Media.
Video narration was recorded on an audio cassette tape format.

AP Audio and Printed Media.
Students receiving this treatment listened to audio tape narration as well as read the printed narration at the same time.

P Printed Media.
Students read a printed text transcribed from the video narration. (This treatment served as control.)

Based on the grouping and treatment assignment described above, a grouping chart is depicted as follows:

Insert Figure 1: Grouping Chart here

This study examined the following questions:

1. Between groups, do Developmental Studies students perform differently from Regular academic core curriculum students in their mean pretest scores, mean posttest scores, and mean retention test scores? (DS vs RA)

2. Between groups, do Developmental Studies students and Regular academic core curriculum students receiving the same treatment perform differently in their mean pretest scores, posttest scores, and retention test scores? (1 vs 7, 2 vs 8, 3 vs 9, 4 vs 10, 5 vs 11, and 6 vs 12)

3. Within groups, are there differences among groups of subjects who received different treatments in their mean pretest scores, mean posttest scores, and mean retention test scores? (1 vs 2 vs 3 vs 4 vs 5 vs 6, and 7 vs 8 vs 9 vs 10 vs 11 vs 12).

4. Within groups, are there differences among groups of subjects who received closed-captioned video, regular video, and printed media in their mean pretest scores, mean posttest scores, and mean retention test scores? (1 vs 2 vs 3, and 7 vs 8 vs 9)

5. Within groups, are there differences among subjects who received the closed-captioned with sound video treatment from subjects who viewed the sound video treatment in their mean pretest scores, mean posttest scores, and mean retention test scores? (1 vs 2, and 7 vs 8).

Procedures

All subjects were given a 33-item pretest on the topic *The Civil War: Episode One, The Cause — 1861* (Burns, 1990) containing information presented in the treatment session. Those scoring 80% correct and higher on the test were eliminated from the study because they had mastered the instructional materials. After the subject pool was identified, a Pilot Study was conducted with 36 students to correct any errors and modify treatment materials.

In the Experimental Study volunteer students in Developmental Studies curriculum and students in Regular academic core courses were randomly assigned to one of the six types of treatment listed above. For both groups, each cell contained 25 students. Immediately after treatment, subjects were given a posttest with the same 33-item multiple choice test items used in the pretest. Four weeks after the posttest, the subjects were given the same 33-item multiple choice test as a retention measure. All data was analyzed and interpreted to answer the experimental questions stated above.

RESULTS

The dependent variables for the study are mean pretest scores, mean posttest scores, and mean retention test scores. Test items of the pretest, posttest and retention test were constructed in a multiple choice format.

Based on the experimental questions stated in Design section under Method, all data were analyzed using the following statistical analysis procedures with a significance level set at a = .05. Statistical analyses of all data in this investigation were performed through the use of SAS statistical software.

Question 1: Multivariate analysis of variances (MANOVA) was used to test group differences.

Question 2: Profile analysis was conducted to test group by treatment interaction effect. If significant differences were found, treatment analysis was performed using oneway ANOVA and contrast analysis.

Question 3: Profile analysis was conducted. If significant differences were found, a oneway ANOVA for each group was performed, with post hoc comparisons of means via the Tukey-B test.

Orthogonal contrast analyses were conducted on both Question 4 and Question 5.

Analysis of Covariance (ANCOVA) procedures were conducted on the after-treatment measures of mean posttest scores and mean retention test scores. The covariate for the mean posttest scores was the mean pretest scores. Both mean pretest scores and mean posttest scores were used as covariates for the analysis of mean retention test scores differences.

Mean scores of students' performances on pretest, posttest, and retention tests are listed in Table 2.

Insert Table 2: Means Table here

Question #1

A multivariate analysis was performed. Group differences were found on all measures (i.e., pretest, posttest, retention test). Developmental Studies students scored statistically below their Regular Enrolled peers before and after treatment. See Figure 2.

MANOVA for Question 1

Dependent Variable: Pretest.

Source	DF	SS	MS	F	p
GROUP	1	1172.16	1172.16	87.08	<.001
ERROR	298	4011.23	13.46		
TOTAL	299	5183.40			

Dependent Variable: Posttest.

Source	DF	SS	MS	F	p
GROUP	1	2670.08	2670.08	132.91	<.001
ERROR	298	5986.75	20.09		
TOTAL	299	8656.84			

Dependent Variable: Retention Test.

Source	DF	SS	MS	F	p
GROUP	1	2144.01	2144.01	119.90	<.001
ERROR	298	5328.93	17.88		
TOTAL	299	7472.95			

Insert Figure 2: Group Comparison of Three Measures here

Question #2

The following measures were performed: For the pretest measure, group by treatment ANOVA; posttest, group by treatment ANCOVA using pretest as the covariate; retention test, group by treatment ANCOVA using pretest and posttest scores as covariates.

The results of the analyses on the three measurements show group differences but no treatment or group by treatment interaction effects. Developmental Studies students' scores were significantly lower than Regular Enrolled students scores for all measures.

Question #3

(For Questions #3, #4, #5, the analyses were performed to determine treatment effects within groups.)

The following measures were performed: For the pretest measure, one-way ANOVA; posttest, one-way ANCOVA using pretest as the covariate; retention test, one-way ANCOVA using pretest and posttest as covariates.

For Developmental Studies students, no treatment differences were found in pretest and posttest scores. There was a significant difference in retention test scores. Tukey's Studentized Range Test indicated students who received muted video and those who received printed media scored better than those who received closed-captioned video and audio only. See Figure 3.

Insert Figure 3: Selected Treatment Comparison of Developmental Studies Students' Measures here

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For Regular Enrolled students, no treatment differences were found in pretest scores. There was a significant difference in posttest scores. Tukey's Studentized Range Test indicated students who received audio print scored higher than those students who received print only and audio only treatments. There was a significant difference in retention scores. Tukey's Studentized Range Test indicated students who received audio print and closed captioned treatments scored significantly higher than those students who received print only treatment.

ANOVAs & ANCOVAs for Question 3

Dependent Variable: Retention Test (Developmental Studies Students).

Source	DF	SS	MS	F	p
TREAT	5	178.37	35.67	5.57	<.001
Pretest	1	408.29	408.29	63.72	<.001
Posttest	1	620.95	620.95	96.91	<.001
ERROR	142	909.88	6.41		
TOTAL	149	2117.49			

Dependent Variable: Posttest (Regular Enrolled Students).

Source	DF	SS	MS	F	p
TREAT	5	231.60	46.32	3.67	<.01
Pretest	1	1205.69	1205.69	95.44	<.001
ERROR	143	1806.47	12.63		
TOTAL	149	3243.76			

Dependent Variable: Retention Test (Regular Enrolled Students).

Source	DF	SS	MS	F	p
TREAT	5	115.20	23.04	3.71	<.01
Pretest	1	1373.01	1373.01	221.10	<.001
Posttest	1	841.42	841.42	135.50	<.001
ERROR	142	881.80	6.21		
TOTAL	149	3211.44			

Question #4

The following measures were performed: For the pretest measure, one-way ANOVA; posttest, one-way ANCOVA using pretest as the covariate; retention test, one-way ANCOVA using pretest and posttest as covariates.

For Developmental Studies students, no treatment differences were found in pretest and posttest scores. There was a significant difference in retention test scores. Tukey's Studentized Range Test indicated students who received print only scored better than those who received closed-captioned video.

For Regular Enrolled students, no treatment differences were found in pretest and posttest scores. There was a significant difference in retention scores. Tukey's Studentized Range Test indicated students who received closed-captioned treatments scored significantly higher than those students who received print only treatment.

443

ANOVAs & ANCOVAs for Question 4

Dependent Variable: Retention Test (Developmental Studies Students).

Source	DF	SS	MS	F	p
TREAT	2	68.59	34.29	4.94	<.01
Pretest	1	148.08	148.08	21.35	<.001
Posttest	1	313.20	313.20	45.16	<.001
ERROR	70	485.52	6.94		
TOTAL	74	1015.39			

Dependent Variable: Retention Test (Regular Enrolled Students).

Source	DF	SS	MS	F	p
TREAT	2	60.03	30.01	5.20	<.01
Pretest	1	597.81	597.81	103.51	<.001
Posttest	1	346.88	346.88	60.06	<.001
ERROR	70	404.27	5.78		
TOTAL	74	1408.99			

Question #5

The following measures were performed: For the pretest measure, one-way ANOVA; posttest, one-way ANCOVA using pretest as the covariate; retention test, one-way ANCOVA using pretest and posttest as covariates. No treatment differences were found in pretest, posttest, and retention test scores for both Developmental Studies and Regular Enrolled students.

DISCUSSION

Examination of data from baseline measures to determine differences between Developmental Studies college students and Regular academic core students revealed Developmental Studies students knew less about Civil War history than their peers. These students would appear to have less command of information expected of students who enter college.

This study suggests that using different instructional media may not be effective in bringing Developmental Studies students to the level of their peers. Even though gains were made in posttest and retention test scores in these students, they never caught up in level of achievement with their academic core peers. None of the six uses of instructional media (i.e., closed-captioned video, sound video, muted closed-captioned video, audio media, audio and printed media, and printed media) was successful in raising posttest and retention test scores of reading deficient students equivalent of their peers. A body of research in learning disabilities suggest these children never catch up to their nondisabled peers, no matter what interventions are given. This research with students having reading deficts appears to support those findings with learning disabled children. However, after examining differences within groups, results do not give a clear picture explaining why Developmental Studies students do not learn or retain as much information as their Regular college peers. These results might suggest students who have reading deficits prefer instructional strategies that require one sensory mode when using cognitive skills required in reading, while those who do not have deficits can more easily utilize both visual and auditory senses to more efficiently process and retain information.

Other explanations for these differences can be derived from looking at the data for retaining information using closed-captioned video, sound video, and printed media. Developmental Studies students retained more information when given printed text. They performed worse when learning through closed-captioned video. However, the opposite happened for Regular academic core college students. They retained more learning through closed-captioned video than print media.

These results suggest more is involved than sensory overload. If that were the case, Developmental Studies students would not be significantly different from their peers in their posttest and retention test scores for those treatments involving only visual or auditory learning. This was not the case. Perhaps Developmental Studies students are deficient in metacognitive skills of "knowing how to learn." Research supports that children with learning disabilities lack metacognitve skills essential in reading; yet, the majority of the Developmental Studies students in this study were not identified as having a learning disability. These findings suggest Developmental Studies students may share some of the same deficits as students with learning disabilities and may be better served by colleges and universities with methods and materials designed for students with learning disabilities.

This study suggests learning through multi-sensory instructional media, such as that commonly employed in academic core college classrooms, is more difficult for the Developmental Studies students. However, the finding that Developmental Studies students who received muted closed-captioned treatment retained information more than their same peers who received other treatments suggests that two learning modalities (i.e., printed word and visual) are effective and that the addition of the third modality (i.e., sound) may interfere with learning and retention.

More research should be conducted to determine why closed-captioned video appears to be the most effective instructional media for learning retention with students who do not have reading deficits. The results of this study seem to have identified another factor that can make closed-captioned video highly successful for one group and not effective for another. Of particular importance may be the speed of the prompt rate. These prompt rates are designed for hearing impaired persons who are considered to be competent readers. Therefore, a person deficient in reading skills may not be able to keep up with a fast prompt rate, could become easily frustrated, and, therefore, not learn. This research needs to be replicated with prompt rates modified to more closely match reading level and comprehension rate assessed in students with deficient reading skills.

The use of technology in the classroom is being promoted in education at all levels; however, this study clearly points out that introduction of technology can have detrimental effects when not closely examined. Using closed-captioned video is supported through this research as being an effective instructional method for students without reading deficits. With more research, this could also prove true for those who struggle to learn through reading, such as students in Developmental Studies, in special education programs, and in Chapter I reading programs.

At this time we do not know why all students did not respond positively to closed-captioned videotape. Therefore, the results of this study should be interpreted cautiously. More research is needed with a larger number of students with reading deficits. Additionally, closed-captioned video technology needs to be responsive to allow for more manipulation in order to more clearly examine its power.

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Table 1: Demographic Data

		Developmental Studies	Regular
Gender			
	Female	97	128
	Male	63	22
Race			
	Black	67	17
	White	81	130
	Other	2	3
Age			
	Mean	21.73	24.59
	Standard Deviation	5.78	6.27

TABLE 2: Group, Treatment, and Group by Treatment Means

		Pretest	Posttest	Retention Test
GROUP				
	Dev. Studies	11.22[a]	16.99	15.17
		3.22[b]	4.29	3.77
	Regular	15.73	22.96	20.52
		4.07	4.67	4.64
TREATMENT				
	CC	12.70	20.00	17.72
		4.40	5.67	5.70
	V	13.18	19.86	17.78
		3.95	4.63	4.69
	CM	13.24	20.00	18.22
		3.94	5.03	4.00
	A	12.94	19.04	17.14
		4.21	5.54	5.96
	AP	14.20	20.74	18.42
		4.53	6.43	5.49
	P	12.92	20.22	17.80
		3.96	4.92	3.92
GROUP by TREATMENT (Developmental Studies)				
	CC	10.28	16.24	14.12
		3.16	4.66	4.17
	V	11.08	16.92	15.00
		2.56	3.62	3.32
	CM	11.64	16.96	16.68
		2.69	3.49	2.98
	A	10.56	16.72	13.72
		3.58	3.84	3.79
	AP	11.84	16.40	15.08
		3.52	5.34	4.25
	P	11.92	18.72	16.44
		3.58	4.47	3.33
GROUP by TREATMENT (Regular)				
	CC	15.12	23.76	21.32
		4.18	3.82	4.68
	V	15.28	22.80	20.56
		4.02	3.56	4.22
	CM	14.84	23.04	19.76
		4.37	4.49	4.33
	A	15.32	21.36	20.56
		3.39	6.06	5.82
	AP	16.56	25.08	21.76
		4.22	4.07	4.49
	P	13.92	21.72	19.16
		4.13	4.98	4.06

a Mean Score; b Standard Deviation
CC Closed Captioned; V Video Only; CM Muted Closed Captioned
A Audio; AP Audio & Printed Text; P Printed Text

		Treatment					
		CC	V	AP	CM	A	P (control)
Group	DS	1	2	3	4	5	6
	R	7	8	9	10	11	12

Figure 1: Grouping Chart

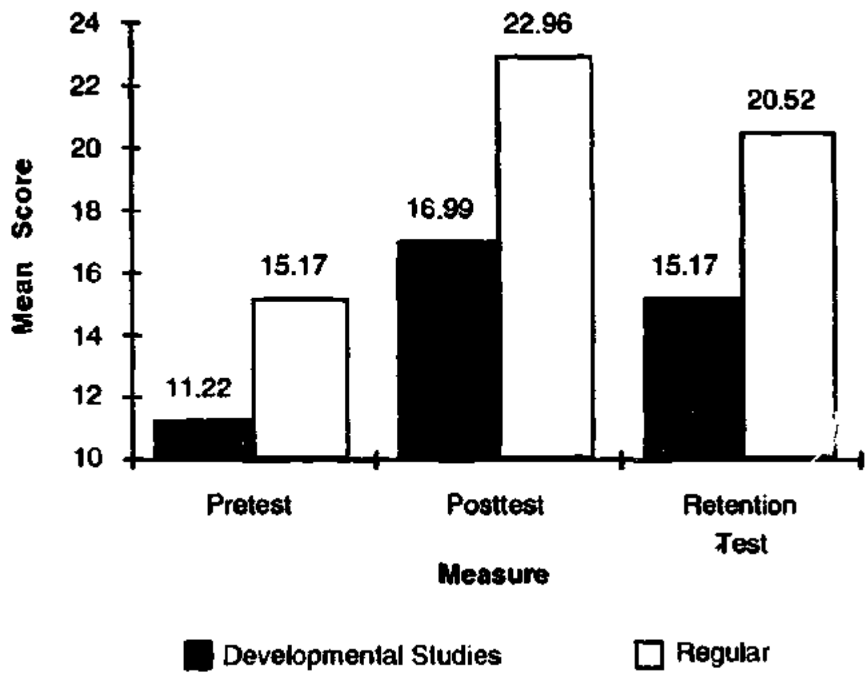

Figure 2: Group Comparison of Three Measures

449

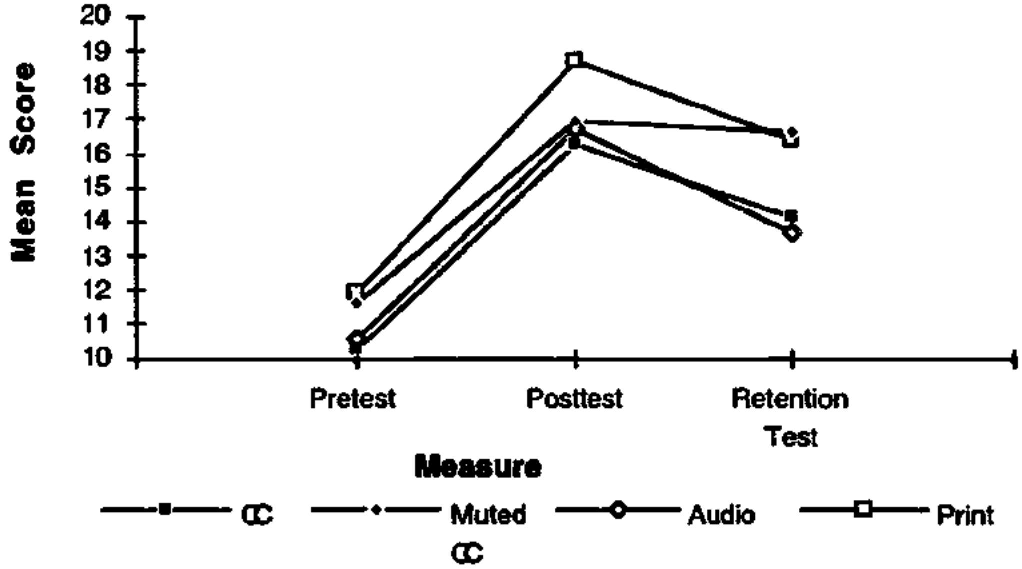

Figure 3: Treatment Comparison of Developmental Studies Students' Measures

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Title:

Effects of Linking Structure and Cognitive Style on Students' Performance and Attitude in a Computer-Based Hypertext Environment

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451

Introduction

Hypertext is a way of organizing information using nonlinear text. Hypertext provides different ways from traditional text to access and manipulate information. The nonlinear characteristics of hypertext seem to change the ways people interact with information and knowledge. This may cause learning problems. However, little empirical research has examined the results of hypertext and human interaction.

One question that researchers are currently exploring is "How can we structure hypertext for maximum learning?" Based on theories of cognitive style and research in aptitude-treatment interaction, Witkin et al. (1977) suggested that educators might be able to adapt instructional treatment to the learning needs of field-dependent and field-independent learners. Therefore, there is reason to examine whether different linking structures within hypertext environments will have differential effects on learners with different cognitive styles. Such examination may indicate that it may be necessary to provide access constraints to serve as learning guidance in order to make hypertext effective for learners with different cognitive styles.

The purpose of this study was to determine the implications of content organization and cognitive style with regard to the design of hypertext. Specifically, the study examined the effects of linking structure and field-dependency and -independence on performance, as well as attitudes.

Linking Structures in Hypertext Environment

The five linking structures used in this study are based on Jonassen's (1986) three levels of hypertext structure (node-link hypertext, structured hypertext, hierarchical hypertext) and include linear linking structures, hierarchical linking structures, hierarchical-associative linking structures, associative linking structures, and random linking structures. Hierarchical linking and associative linking are most frequently advocated in the literature (Gaines, B. R. & Vickers, J. N., 1988; Smith, Weiss & Ferguson, 1988).

The five levels of hypertext structure used in this study will be: Linear (in which the nodes are linked linearly); Hierarchical (in which the linking emphasizes the relationship of type and part and the representation of hierarchies); Hierarchical-Associative (in which each node set is structured hierarchically and in which random access and direct access to any node set is provided); Associative (in which the linking provides random access and direct access to any node in the hypertext); and Random (in which any node can be linked to any other node directly). Study of different linking structures could be of benefit to instructional designers who develop materials for a variety of learners with different cognitive styles, e.g., field-dependence and field-independence.

Individual Differences and Field Dependence and Independence

According to Goodenough (1976), field-independent (FI) individuals adopt an active approach toward learning while field-dependent (FD) individuals adopt a passive approach toward learning. In classroom learning situations, FD learners appear to demonstrate poorer structuring abilities than FI learners (Goodenough, 1976). The FD learners display certain distinctive characteristics. For instance, FD students tend to depend on and be highly influenced by "authority figures" and are less able than FI students to generate alternative functions for elements or items used in a familiar way (Witkin 1977, 1979, 1981).

In this study, it is hypothesized that more structured hypertext instruction provides an organizational aid to learning, especially for FD learners. In contrast, when the text is less structured, organization must be provided by each learner, and would therefore be less facilitative for field-dependent learners. Furthermore, because FD individuals tend not to provide organization internally, FD subjects should have particular difficulty with less structured sequences that contain, for example, associative and random hypertext links. Thus, it is expected that FD learners will recall fewer concepts than FI learners in learning from a hypertext-based lesson with associative and random links.

The Study

The purpose of this study was to examine the interactions and effects of hypertext linking strategies and field-dependence and field-independence (FDI) on recall performance and attitudes toward learning in a nonlinear hypertextual environment.

Research Questions

The research questions were as follows:

1. Is subjects' performance/attitudes significantly predicted by linking structure, FDI, and their interaction?
2. Is the interaction of linking structure and FDI significant?
3. Do the five linking structures/attitudes differ in subjects' average performance scores with FDI held constant?
4. Does FDI relate to subjects' performancev with linking structures held constant?

Independent Variable

The two independent variables in this study were linking structure type and cognitive style. The independent variable of linking structure type had five levels: linear linking, hierarchical linking, hierarchical-associative linking, associative linking, and random linking. The second independent variable was field-dependence/independence, as determined by results of the Group Embedded Figures Test (GEFT) (Witkin, et al., 1971).

Dependent Variable

The primary dependent variables included in this study were the learners' performance and attitudes. Performance was measured by a posttest that elicited recall of verbal information. Attitude was measured by an attitude survey. Both the performance posttest and attitude questionnaire were created by the researcher and reviewed by a content expert and two instructional design specialists.

Instructional Materials

Five treatments were administered to learners through a self-paced, computer-based lesson in a hypertext environment. The contents of instructional materials for the five treatment groups were based upon "Chinese Politics" which was developed by Kenneth C. Wedding (1991). The content was about the people, organizations, places and events involved in the Tiananmen Square Event of June 4, 1989, in Beijing. The content units for the five treatments were identical, but each employed a different linking strategy using linear linking structures, hierarchical linking structures, hierarchical-associative linking structures, associative linking structures, or random linking structures.

Hypertext with Linear Linking Structures

In linear hypertext, nodes are linked linearly, allowing the student to move to the next or to the previous node only (see Figure 1). This linear structure is similar to most traditional computer-assisted instruction, and thus serves as the control structure for this study. An example would be: a user selects one "Event" from the main menu and reads the information under the category of "Events". When the user finishes reading the "Event" or decides not to read anymore in "Events," he must go back to the main menu and select another category.

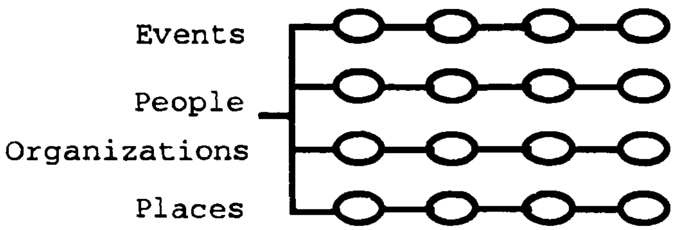

Figure 1. Hypertext with linear linking

Hypertext with Hierarchical Linking Structure

In hierarchical hypertext, a node at one level can only access nodes directly below or above it (see Figure 2). An example would be: A user moves along the hierarchical structure and reads the information in the node of "Cultural Revolution". When the user finishes reading "Cultural Revolution", he may go back to the node of the "Early History" which is the parent node of the "Cultural Revolution". Or, the user may go to "Great Leap Forward", the other child node of "Early History", which is next to the "Cultural Revolution".

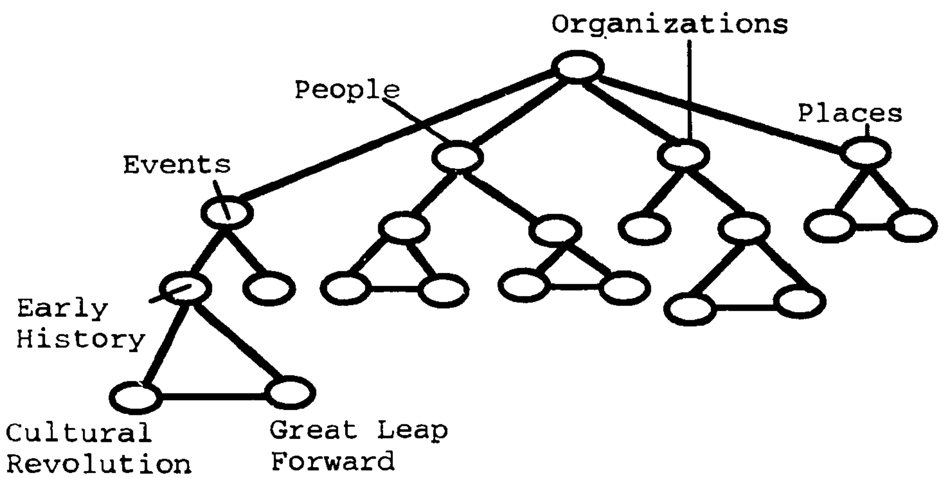

Figure 2. Hypertext with hierarchical linking

Hypertext with Hierarchical-Associative Linking Structures

In hierarchical-associative hypertext, nodes are basically linked in a hierarchical way. The associative links in this structure are provided from some nodes to other nodes that are referential to them. That is, in hierarchical-associative hypertext, a node at one level can access nodes that are directly below or above it or a node associated with it (see Figure 3). This type of linking combines associative and hierarchical linking. For example, a user moves along the hierarchical structure and reads the information in the node "Cultural Revolution." He does not know the name "Mao Zedong" which appears in this node. He may click on the name "Mao Zedong" to go to the node "Mao Zedong" to learn about him. However, when the user finishes reading "Mao Zedong", he must go back to the node "Cultural Revolution."

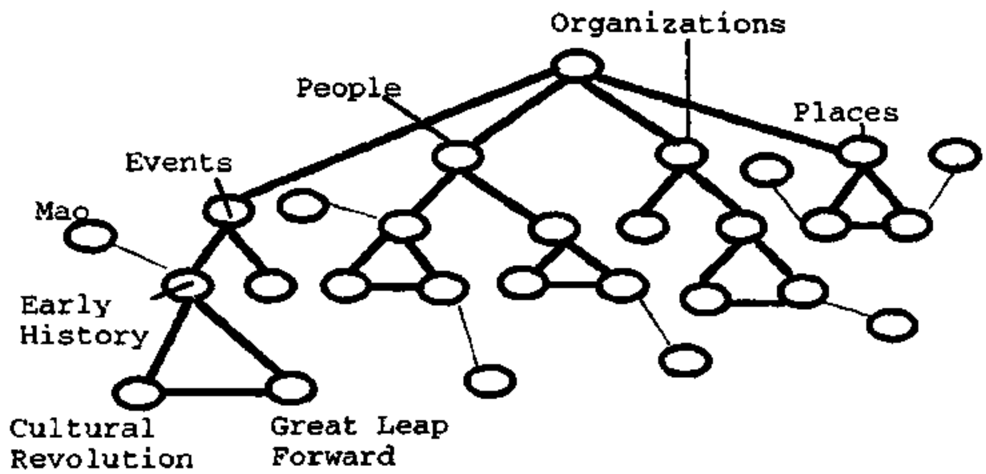

Figure 3. Hypertext with hierarchical-associative linking

Hypertext with Associative Linking Structures

Similar to hierarchical-associative linking, associative linking is based upon a global hierarchical structure. Unlike hierarchical-associative linking, which requires the user to return to the original hierarchical node from the referential node, associative linking allows the user to link to the referential node and stay in the node set to which the referential node belongs. For example, a user moves along the hierarchical structure and reads the information in the "Cultural Revolution" node. He does not know the name "Mao Zedong" which appears in this node. He may click on the name "Mao Zedong" to go to the node "Mao Zedong" to learn about him. While reading in the node "Mao Zedong," he does not understand the term "Chinese Communist Party." He may then click on the term "Chinese Communist Party" to go to the node containing information on the "Chinese Communist Party" to learn about the organization. Alternately, he could want to stay in the node set of "Mao Zedong" (People) to learn about other people in this node set. (See Figure 4.)

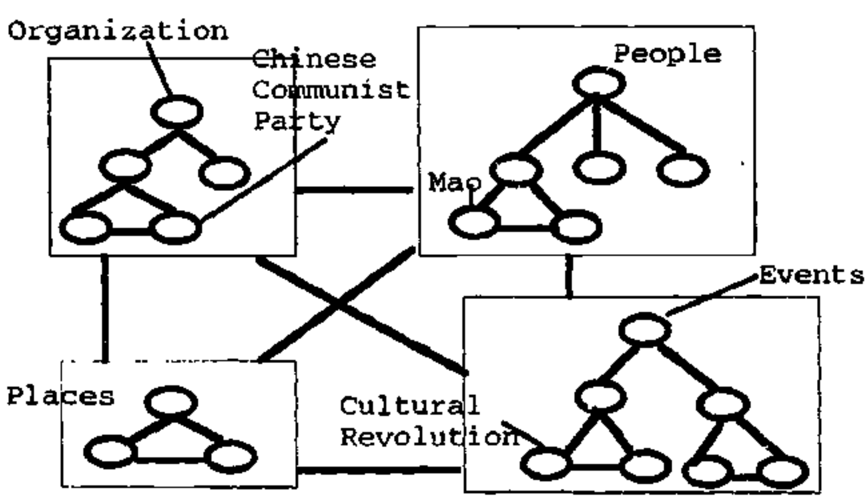

Figure 4. Hypertext with associative linking

Hypertext with Random Linking Structures

Random hypertext allows any node to be linked to any other, regardless of whether the nodes are referential to each other or not. For example, a user can jump from the node about Beijing (Places) to the node about the Chinese Communist Party (Organizations) or jump from the Cultural Revolution (Events) node to the node about Deng Xiaoping (People) directly. (See Figure 5.)

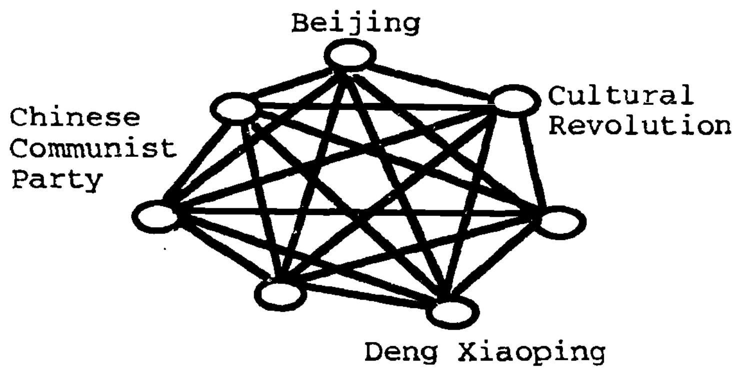

Figure 5. Hypertext with random linking

Subjects

The subjects were 139 undergraduate students enrolled in the College of Education at The University of Texas at Austin. Participation in the study was on a voluntary basis. Subjects were randomly assigned to one of the five condition groups.

Procedures

A brief introduction to the research study was presented to students. The GEFT was administered by the researcher during the class immediately after the students signed up for the experiment. Field-dependence scores were recorded. Subjects were then assigned randomly to the computer running their group treatment on it. The researcher introduced the subject of the lesson and the actual software. Subjects were informed of the grading policy and time was also provided for any questions on operating the program that the subjects had.

At the end of the instructional time, the performance posttest was administered. Upon completion of the test, an attitude questionnaire was distributed.

Data Analysis

A regression analysis test was chosen to detect the presence of any aptitude-treatment interaction. According to Pedhazur (1973), the advantage of using regression analysis is that:

> MR, Multiple Regression, is applicable to designs in which the variables are continuous, categorical, or combinations of both, thereby eschewing the inappropriate or undesirable practice of categorizing continuous variables (such as designating individuals above the mean as high and those below the mean as low) in order to fit them in what is considered, often erroneously, an ANOVA design (p.7).

In this regression analysis, a continuous value of cognitive style was to describe as many different types of subjects as there were observed. The purpose of the regression analysis is to reveal whether or not the group regressions (e.g., posttest scores on GEFT scores) are homogeneous.

Discussion of Results

This section will discuss the specific results of this study as they related to the research questions and hypotheses posed at the beginning of this research document. Since there were some significant findings as a result of data analysis, conclusions based upon the results will be suggested.

Performance

Research Question 1: Was subjects' performance significantly predicted by linking structure types, FDI, and their interaction?

Discussion. The results of this study show that 14.5% of the variance of performance can be explained by linking structure type, FDI, and their interaction. Since research on hypertext is rich in theory and poor in actual study results (Jonassen, 1986), some scholars have called for research on the structure of hypertext, proposing different types of linking structure models. Little research has investigated the effects of linking structure type and cognitive style on performance in hypertext environments. The findings of this study provide initial evidence on this issue. Linking structure types and cognitive style and their interaction have significant effects on students' performance.

Research Question 2: Was the interaction of linking structure type and FDI significant?

Discussion. Research on cognitive style suggests that consideration of style may be related to improved performance (Salmon, 1984; Keller, 1983). It was the expectation of this study that consideration of these two variables together would produce significant positive effects on performance.

It was expected that subjects with less field dependency would perform better in more structured instructional environments whereas subjects who were more field independent would perform similarly, regardless of the linking structures employed. The observations do not support these expectations. Rather, findings are more similar to those reported by Canino & Cicchelli (1988) and MacNeil (1980). These researchers found no interaction of treatments and cognitive styles upon subjects' performance.

Research Question 3: Did the five linking structures differ in average subject performance, with FDI held constant?

Discussion. Research has shown that subjects who are more field-dependent will perform better when receiving more structured instruction (Mandler, 1967; Meshorer, 1969; Clark, 1982, 1984, 1987). The results of this study, however, do not support these findings. There was no significant difference found in performance between subjects working in a more structured environment and a less structured environment.

Research Question 4: Was FDI related to subjects' performance with linking structures held constant?

Discussion. The results of this study reveal that the subjects with higher scores on the GEFT outperform those who score lower on the GEFT regardless of instructional treatment. The results prove consistent with the studies of Carrier, Davidson, Higdon, and Williams (1984), Carrier, Joseph, Krey, and LaCroix (1933), and Frank (1983). These researchers claimed that cognitive style influences performance in general.

Attitude

Research Question 1: Was subjects' performance significantly predicted by linking structure types, FDI, and their interaction?

Discussion. The significant results of the full model regression analysis show that subjects' attitudes could be predicted by linking structure type, cognitive style, and their interaction. Some researchers have called for research on the structure of hypertext and different proposed types of linking structures (Jonessen, 1986). Little research has investigated the relationship between linking structures and cognitive styles upon attitude in hypertext. The findings of this study provide initial evidence on this issue that linking structure types and cognitive style and their interaction have significant effects on students' attitude when learning in a hypertext environment.

Research Question 2: Was the interaction of linking structure and FDI significant?

Discussion. Research on cognitive style suggests that instruction designed with consideration of cognitive style may be related to improved attitude (Clark, 1982. Salomon, 1984, Keller, 1983). It was the expectation of this study that consideration of these two variables together would produce significant positive results upon attitude.

It was expected that subjects with lower field dependency would have more positive attitudes when using less structured instruction, while subjects who are more field independent would prefer more structured instruction. The results of this study support the findings from Salomon (1984), Keller (1983) and Clark (1982). Clark (1982) indicated that field independent individuals tend to be more self-motivated and have greater expectations of achievement. Although they may learn effectively from both structured and unstructured methods, they may believe that more structured methods are more efficient in facilitating learning, so they may prefer more structured instruction. However, field-dependent individuals' motives for achievement tend to be low. They may perceive more demanding methods as providing more freedom for students to control learning time and effort level. With structured methods they can invest less effort, and their failures are less visible. Therefore, they like less structured methods, which seem to make their lives easier. The results of the calculations support the expectation that field-independent individuals prefer structured instruction.

Research Question 3: Did the five linking structures differ in average attitude score with FDI held constant?

Discussion. The findings for this question indicated that subjects tended to prefer the hierarchical structures and the hierarchical-associative structures more than linear structures.

Research Question 4: Was FDI related to subjects' attitudes with linking structures held constant?

Discussion. The results indicate that students who tend toward field-independence have more positive attitudes about learning about "Chinese Politics" from the hypertext system used for this study than those who tend toward field-dependence.

Support Data

Although no formal hypotheses were formulated for the following analyses, there were areas related to the previously stated hypotheses that served to support or elaborate upon the findings associated with them.

Prior Knowledge of Hypertext Systems

When the effect of prior knowledge of hypertext systems was taken into consideration in reviewing subjects' performance and attitudes, results showed that prior knowledge had no main effect on either performance or attitudes. Regression analysis also showed that prior knowledge cannot significantly predict subjects' performance or attitudes.

Prior Knowledge of Chinese Politics

When the effect of prior knowledge of subject content was taken into consideration in reviewing subjects performance and attitude, the results showed that prior knowledge had a main effect on both performance and attitude. The more the students knew about the subject, the better they performed on recall of the content ($p < .01$). The more the students knew about the subject, the better attitudes they had toward the instructional materials ($p < .05$).

Conclusion

To summarize, the results of this study indicate:

1. The performance of these subjects can be predicted by linking structures, cognitive style, and their interaction.
2. The performance of these subjects cannot be predicted by the interaction of linking structure types and cognitive style.
3. There is no difference in subjects' performance when learning from hypertext systems with different linking structures.
4. Field-independent subjects outperform field-dependent subjects overall.
5. The attitudes of the subjects can be predicted by linking structure types, cognitive styles, and their interaction.
6. The attitudes of the subjects can be predicted by interaction of the linking structures and cognitive styles.
7. Students like hierarchical structures and hierarchical-associative structures more than linear structures in hypertext environments.
8. Field-independent subjects tend to have better attitudes than field-dependent subjects.

To summarize, the results of this study failed to support the hypotheses for interaction between linking structure types and cognitive styles for both performance and attitude, including a main effect of linking structure upon performance. The lack of support for these hypotheses may have been due to methodological rather than conceptual causes. It is possible that specific details of this study may have contributed to the significant findings in this research.

Recommendations for Future Research on Hypertext

1. Information seeking strategies in hypertext should be investigated. In this study, five linking structures were investigated. All the subjects were taught by the researcher about how to navigate through the program. However, important questions remain. How do users learn information navigating strategies, and how do they apply them in a non-instructional situation? What can search systems do to assist in the selection and application of strategies? The use of index menus in this study is only one representation of browse strategies. Other manifestations of these strategies could be examined, such as embedded menus or navigation maps.

2. Qualitative methods can be adopted by hypertext researchers. In situations such as these where complex interactions are likely to occur, a qualitative approach with which researchers can look for patterns may be useful in building hypotheses for qualitative studies. One approach to such a study is to examine individual pathways in a hypertext lesson. By focusing on paths that are taken, a hypertext instructional system might be improved.

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Title:

Embedding Metacognitive Cues Into Hypermedia Systems To Promote Far Transfer Problem Solving

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ABSTRACT

A pretest-posttest control group design with random assignment, together with qualitative data collection and analysis, was used to investigate whether metacognitive, cognitive and affective-awareness cues embedded in a hypermedia program could facilitate college students' near and far transfer of problem solving in biology learning. It was assumed that when subjects are asked to explain reasons for their own actions during the problem solving, they must engage in self-reflective intermediate processes comparable to metacognitive processes of monitoring, evaluating, and regulating ongoing problem solving. Four treatment groups were used: one received metacognitive cues; one received cognitive cues, one received affective-awareness cues, and the control group received no cues. Results showed that subjects in the metacognitive group performed better on far transfer tasks than all other groups. The qualitative analysis indicated that metacognitive-oriented questions encouraged students to "stop, think and reflect" on their problem solving processes which in turn helped students understand the process of how the problems were solved. The understanding of processes students went through to solve problems helped them transfer what they learned to novel situations.

Introduction

One of the primary goals of education is to enable individuals to develop skills which allow them to continue self-education throughout their lives. In the past 15 years, helping students develop self-regulated learning skills has been commonly known as helping students develop skills of learning how to learn. Self-regulated learning is defined as the extent to which the students are metacognitively, motivationally, and behaviorally active participants in their own learning processes (Zimmerman, 1986).

The heart of self-regulation is developing the awareness and capacity for effective planning, monitoring, reflecting, and modifying one's own learning processes (Corno & Mandinach, 1983; Brown, Bransford, Ferrara, & Campione, 1983). Corno and Mandinach (1983) further suggest that long-term exercising of self-regulated learning activities will help students at all levels learn how to learn and develop school aptitude and motivation. It is important to note that the definition of self-regulated learning encompasses metacognitive, cognitive, and affective processes. Flavell (1976) defines metacognition as the awareness and active monitoring of one's cognitive processes. In problem solving, the metacognitive processes monitor the selection and application of solution processes as well as ongoing feelings about self and task. A metacognitively aware learner is able to "apply, adapt and/or modify what they have learned to new tasks and across different situations" (Rowe, 1988, p. 228). It is the understanding and regulating of their own cognitive processes that enable students to tackle new tasks, solve new problems, and transfer learning across domains (Pintrich, Cross, Kozma, & McKeachie, 1986; Glaser, 1984; Rowe, 1988; Berardi-Colette, 1990; Dominowski, 1990).

Transfer is defined as the process in which students use previously learned knowledge and skills to successfully solve problems in new situations (Gagné & Berliner, 1988). It can be divided into two levels: near and far transfer. Near transfer refers to situations in which training situations and problem tasks are almost identical (Butterfield & Nelson, 1991; Salomon & Perkins, 1989). Far transfer occurs when knowledge and skills are successfully applied to a highly novel problem, and it requires creative use of knowledge and strategies learned (Clark, 1992).

A growing body of literature supports the notion that optimal academic performance is strongly tied to the degree of self-regulation the learner is capable of exercising (Zimmerman, 1990; Borkowski, et. al., 1990; Pintrich & DeGroot, 1990; Corno, 1986). As a result, considerable attention has been focused on the phenomenon of self-regulated learning. There has been much progress made in (1) identifying knowledge structures and processes that underlie self-regulated learning and (2) recognizing the importance of a motivational component in addition to metacognitive and cognitive components (McCombs & Marzano, 1990). The integrative nature of the concept may lead to increased theoretical complexity of the construct and a greater understanding of learning processes. However, to use the concept of self-regulation as a realistic guide for everyday classroom situations, there is a continued need for theoretical and empirical research which shows how each component of self-regulation impact learning and problem solving. Further research is also needed to learn more about the role affective-awareness plays in contributing a better problem solving performance. These needs provided the theoretical basis for this study.

Computer technology is thought to hold great potential for more effective teaching of self-regulated learning skills (Henderson, 1986). It has been suggested that technology-based instruction is likely to result in citizens who know how to learn and will continue to learn in the future if the program used emphasizes self-discovery of new ideas, helps learners gain feedback about their ideas, and encourages them to assess their own ideas (Linn, 1983). Hypermedia systems, a fairly recent advance in technology, provide more potential and advantages to learning over conventionally programmed CAI due to their greater degrees of flexibility and capacity for individualized instruction (Bourne, 1990). The term "hypermedia" is defined as an advanced technology that combines film, video, computer graphics, sound, music, and text in a unified information-delivery system centered upon the personal computer (Paske, 1990). It is a mixture of technologies controlled by hypertext. Hypertext is the term that is used to describe non-sequential writing, text that branches and allows choices to be made by the learners (Paske, 1990). In a hypermedia system, the information can be organized in a non-linear manner and a topic can be explored in multiple ways (Spiro & Jehng, 1990).

In addition to the theoretical problem posed earlier, two practical problems were also addressed in this study that involve the role of hypermedia in students' learning. They were: (a) how each component of self-regulated learning processes (metacognitive, cognitive and affective processes) influenced positive near and far transfer of problem solving skills; and (b) how hypermedia should be used to promote self-regulated learning which might lead to positive transfer.

Although previous research has shown that positive problem transfer is difficult to obtain (Thomas, 1974; Gick & Holyoak, 1980), studies requiring subjects to explain reasons for actions while solving problems have consistently shown positive transfer effects (Gagné and Smith, 1962; Berry & Broadbent, 1987; Berardi-Coletta, 1990; Stinessen, 1985). These studies typically required subjects to "state reasons" for their actions during the problem solving. Most of these studies dealt with college students in solving the types of problems involving puzzles. They all found successful near and far transfer effects. Most of their explanations for the positive effect on solution transfer have been limited to speculations that verbalization induced more planning and forced subjects to think (Gagné and Smith, 1962), and verbalization provided the metacognitive experience needed for successful transfer. However, it was not clear what was responsible for the positive transfer, verbalization or metacognitive processes.

Berardi-Coletta's (1990) study answered these questions. She concluded that it was not verbalization which produced the positive transfer effect. Rather, metacognitive processes enabled subjects to understand the process of how the problem was solved, which led to positive transfer (Berardi-Coletta, 1990). Giving reasons for one's own actions involved learners in metacognitive process (Berardi-Coletta, 1990). She also found in her study that negative self-evaluation distracted learners from focusing on the task, and thus produced negative effects on transfer performance. However, she did not explain how affective-awareness influences near and far transfer of problem solving. Further, it was not demonstrated in these studies if the use of self-explanation cues to induce metacognitive processes which were effective for puzzle problem transfer remain effective for content-rich problem transfer.

It is also important to investigate whether embedding question cues in hypermedia system to encourage learners to self-explain their own problem-solving processes is effective for content-rich problem transfer because technology is likely to become an increasingly common component of learning in both education in schools and business training. With the advent of technology, especially hypertext and hypermedia which provide high levels of flexibility and autonomy for learners to explore and construct their own learning, it should be possible to assist learners to acquire self-regulatory processes that are essential for effective transfer of learning.

In summary, the theoretical needs to explore how each individual component of self-regulated learning theory impacts learning and problem solving, together with the practical needs to investigate how hypermedia systems should be used to promote self-regulated learning and positive transfer of problem solving, provide the rationale for this study.

The purpose of this study was to investigate 1) whether metacognitive, cognitive, and affective awareness processes provoked by self-explanation cues embedded in a hypermedia simulation system improves immediate near and far transfer problem solving in biology learning; 2) how subjects respond to metacognitive, cognitive, and affective cues; and 3) how metacognitive, cognitive and affective cues influence students' task design in the hypermedia system during the training.

It was hypothesized that there would be no differences among groups in near transfer. However, subjects who received metacognitive cues were expected to perform better than subjects who received cognitive or affective cues and students who received no cues in immediate far transfer problem solving. Subjects who received cognitive and affective cues were expected to perform equally well on immediate far transfer of biology problem solving. However, subjects in cognitive and affective groups were expected to perform better than subjects in control groups (no cues).

Methodology

Experimental Design

This study involved pretest-posttest control group design with random assignment, together with qualitative data collection and analysis. There were three treatment groups and one control group. The three treatment groups were: (1) a metacognitive group which responded to question cues from the computer program which asked subjects to plan ahead of time, monitor the process, evaluate the results and modify task design; (2) a cognitive group which responded to question cues that asked subjects to explain specific rules, goals, strategies which were related to the content of specific problems); and (3) an affective-awareness group which responded to question cues that asked subjects to explain their concurrent feelings, or to compare feelings at the beginning to those at the end. Subjects in the control group did not receive any cues. All of the groups received the same level of training, which differed only in the types of cues on which training focused. The locations of the cues were the same for all of the three treatment groups. The program was identical for all treatment groups except for the specific cues. Appendix 1 lists the content and locations of the cues for all three groups.

The independent variable was the type of cues: metacognitive cues, cognitive cues, · fective-awareness cues and no cues. The dependent variables were near and far transfer of problem solving.

Subjects

Eighty-eight pre-service elementary education majors enrolled in an introductory course in biology at Purdue University volunteered to participate in this study. The total enrollment of the class was 205, with 195 females and 10 males. The distribution of the class was approximately one-third juniors, one-third sophomores, with the rest a mixture of freshman and seniors. The study was an extra credit project option provided by the instructor. Originally one hundred forty students signed up for the project. But only eighty-eight were included in the data analysis due to several technical difficulties, which included program bugs and system compatibility problems. Among eighty-eight subjects, eighty-four of them were females and four of them were males. All of them passed content tests so that content knowledge would not be a factor that influenced the performance. Only 5% of the subjects were familiar with Macintosh computers. However, experience with computers was not considered a concern to the project.

Materials

This research project was part of a laboratory experiment which had been found to be problematic for students enrolled in the class in the past. The content selected for the hypermedia-based training task was a series of experiments designed by the students to test the effects of light and moisture on isopod behavior. We will refer to these as the "student tasks", to avoid confusion between this experiment and the experiments which the students were designing. To solve these problems, subjects had to recognize the need to control variables and understand random behavior to verify their derived solutions, identify experiments which did not produce useful data, and repair them. It has been suggested by several researchers that the lack of metacognitive reasoning abilities might be the major factor inhibiting subjects from solving this type of problem successfully (Lawson, Blake, & Nordland, 1975; Lawson, 1979; Piaget, 1962; Lawson & Nordland, 1976).

Training tasks were built into a hypermedia simulation program running on Apple Macintosh™ personal computers that linked Authorware™ (Macromedia Inc) and HyperCard™(Claris, Inc.). There were six options in the program menu, and subjects were given the freedom to select their own content, pace and paths. The program was developed by the authors of this paper.

Another commercial program, Screen Recorder™(Farallon, Inc.), was also running at the same time when a randomly selected sample of subjects were using the simulation program. This program created a "record" of everything that happened on the screen, including the selected subjects' time on task, sequence of their selections, design of the tasks, learning paths, and frequency of selection of each option. The purpose of this program was to collect qualitative data on how the different cues influenced subjects' responses and design of the experiments.

The test of near transfer measures required subjects to work with a preset experimental design to test the effect of moisture on isopod behavior. The far transfer, however, asked subjects to design an experiment to determine which of three possible causes (peer influence, diet, or family environment) were responsible for an increase in hyperactivity in a hypothetical elementary school class. Both near and far transfer tests were developed by the instructor of the course. Refer to Appendix 2 for the copy of the test.

Procedures

All of the students met for the lecture once per week for 50 minutes. There were also nine hands-on laboratory classes with about 25 students per classes. When registering for the lecture, subjects signed up for the lab classes based on their schedules for the semester. There was one instructor for the lecture and nine teaching assistants (TAs) for the lab divisions. Each hands-on lab division met for two 90 minutes sessions/week, and there were always two teaching assistants present.

The project was divided into three phases, pre-treatment (four weeks), treatment (two weeks) and post-treatment (one week). The pre-training was conducted because it has been suggested by Berry and Broadbent (1984) that concurrent verbalization or self-explanation may only have a significant effect when accompanied by pre-task training on how to respond to the questions.

During the first week of the pre-treatment phase, TAs were introduced to the project by the researchers. The purposes of the project, time required of TAs for help, and overall plan and scope of the project were all explained. They were also asked to go through the computer program as well. The researchers went to the lecture to explain the project to all of the students. The policy for extra credit was explained as well as the learning benefits students might obtain by participating in the project. They were told that this experience could help them to learn to solve problems better, which could be applied to other course projects they would be assigned. They were also told that training would be provided by the researchers and TAs so that they would know how to use the program when they came to the computer lab. This was done to alleviate possibilities of student unfamiliarity and/or anxiety about the use of computers.

During the second and third week of the pre-training phase, subjects completed a hands-on isopod lab experiment during their regularly scheduled lab divisions. At the same time, the sign-up sheets for the computer lab schedules were posted so that subjects would have 3 weeks to sign up for the computer labs. Each subject was required to sign up for two computer sessions with 2 hours each session. TAs were instructed by the researchers on how to train subjects from different treatment groups to respond to different cues. The instructions for the training were given to all of the TAs. Students were randomly assigned within divisions to each treatment group by the researchers, and the TAs were also informed of the names within each treatment group.

During the fourth week of the pre-training phase, student training on how to work with the programs and how to answer cue questions were conducted by the researchers and TAs in their regular lab sessions. The random assignment within divisions gave approximately 7 subjects per treatment group within each division.

During the treatment phase, eighteen Mac IIcx computers in a computer lab were used. Each computer was equipped with the four versions of the program corresponding to the three treatment groups and one control group. Each version required subjects to enter their own passwords to access a specific treatment. The password was given to the subjects during the pre-training session. By assigning the passwords to each student, the treatments were effectively isolated, preventing any opportunities for mixing the treatments. The researchers supervised the lab across all sessions to make sure that everything ran smoothly.

During the post-treatment phase, subjects were informed about the real nature of the project and were told that treatment was manipulated. They were encouraged to practice with different versions of the program so that everyone was exposed to the same versions of the program to reduce the possible effects caused by the manipulation in their performance on the course final exams.

Data Collections and Analysis

The data collection was divided into three stages, pretest data collection, on-line data collection and posttest data collection. Three weeks before the treatment, all of the subjects who signed up for the project were given pretests on near and far transfer problem solving. The on-line data was collected by Screen Recorder™(Farallon, Inc.) running at the same time when selected subjects were working in the program, as well as information which the program itself recorded to disk
(student responses to the cues and time on task). Three subjects from each treatment group and the control group were selected randomly. No subjects were interviewed during the treatment time.

As soon as the subjects finished two computer lab sessions, they were given the posttests on near and far transfer. The content was exactly the same for pre and posttests except that the orders of the questions had been changed. Eight subjects from each of the treatment and control groups for a total of 16 were selected for interviews right after they finished the near and far posttests. Five questions were used to direct the interview, and the same questions were asked across groups. They were 1) how subjects responded to the different cues; 2) how the cues affected the process of on-line task problem solving, 3) why some subjects did not respond to the cues; 4) whether the subjects asked themselves the same questions during the transfer problem solving; and 5) how the experience affected subjects' confidence and task interests. Refer to Appendix 4 for the sample protocols from each group.

The data was analyzed both quantitatively and qualitatively. One-way ANOVA and post-hoc Newman-Keuls were used to measure posttest differences among groups. Paired sample t-tests were used to measure the pre and posttests differences within groups. A random sample of 6 protocols from each group were coded for the cue response content by two independent raters. Interrater reliability was checked to be sure that subjects in the different treatment groups were in fact responding to the type of information that was requested in the question cues. The qualitative data were analyzed within each group to find the patterns of subjects' responses and learning processes based on their responses to the interviewer, and the student task designs were analyzed through a constant comparison process for any subgroupings.

Results

Quantitative Findings

To test the main hypothesis that all of the groups would perform equally well on immediate near transfer test, and that the metacognitive group would outperform all of the other groups in immediate far transfer test, analysis of variance (ANOVA) was used to compare performance across the groups on near and far transfer measures. Refer to Table 1 for the means and standard deviations for the pre and post measures on dependent variables among groups. There was no significant mean score differences among groups on the pretest of near or far transfer. Neither were significant mean score differences found among groups on posttest near transfer and the average time spent on the training task. However, the ANOVA for post far transfer tests indicated there was a statistically significant main effect among groups: $F(3, 84) = 5{,}95$, $p < .001$. Student-Newman-Keuls (SNK) was chosen for post hoc paired comparisons contrasting group means. Results of a post hoc SNK showed the order of the group means (in descending magnitude) in post far transfer (Refer to Table 2). Means which were not underlined by the same line were significantly different from each other. The finding suggests that the metacognitive group outperformed all of the other groups in posttest far transfer. The cognitive, affective-awareness, and control groups were not significantly different from each other. The main hypotheses were supported.

Table 1: Individual group means and standard deviations for dependent variables of pre and posttests on near and far transfer:

Variable	Group	N	Mean	Std Dev
Pre-Near	Affective	21	15.619	2.706
	Cognitive	20	15.550	1.8129
	Control	23	16.239	2.1313
	Metacog.	20	15.925	2.7012
Pre-Far	Affective	21	2.380	1.5961
	Cognitive	20	1.950	1.5035
	Control	23	2.043	1.637
	Metacog.	20	2.150	1.785
Post-Near	Affective	22	16.59	2.333
	Cognitive	21	16.69	2.337
	Control	24	16.39	3.65
	Metacog.	21	18.09	1.505
Post-Far	Affective	22	2.318	1.728
	Cognitive	21	2.523	1.364
	Control	24	1.708	1.366
	Metacog.	21	3.476	1.123
Time	Affective	15	77.46	24.12
	Cognitive	15	70.00	18.40
	Control	17	80.29	33.79
	Metacog.	17	67.58	18.12

Table 2: Results of the Post Hoc SNK contrasting group means on post far transfer test:

	Meta	Cognitive	Affective	Control
M	3.476	2.524	2.318	1.708

The differences between pre-post mean scores, standard deviations, T scores, and p values on near and far transfer within groups are listed in Table 3. The results indicate that metacognitive group was the only group which had significant differences between pre and posttests on both near ($p < .01$) and far transfer ($p < .05$). The closest to significance in pre and posttests on far transfer was found within cognitive group ($p = .07$). Affective and control groups did not have significant differences between pre and posttests on both near and far transfer.

Table 3: **The differences between post-pre mean scores, standard deviations, T scores, and p values on near and far transfer within groups**

Groups	Means (post-pre)	Std Dev.	T Score	P-values
Affective-awareness				
Near	.928	3.15	1.35	.192
Far	-.095	1.94	-.0224	.824
Cognitive				
Near	1.025	3.53	1.29	.210
Far	.65	1.56	1.85	.07
Control				
Near	.260	4.77	.262	.79
Far	-.260	1.91	-.654	.51
Metacog.				
Near	2.125	3.30	2.87	.0096
Far	1.4	2.32	2.69	.0144

Qualitative Findings

Immediate post task interviews, on-line data collection, and student task design analysis were used to answer the two qualitative research questions: 1) how subjects responded to metacognitive, cognitive and affective cues, and 2) how metacognitive, cognitive and affective cues influenced the students' task designs in the hypermedia system during the training.

To answer the first question, coding consisted of classifying students' responses to each question cue into one of the 3 levels of focus. The following is a list of the categories used in the coding of students' responses to the different question cues embedded in the hypermedia-based simulation program:

A. Process-Oriented Responses:
1. Planning (one step ahead, two steps ahead, etc.)
2. Monitoring (recognize right/wrong choices and why)
3. Subgoaling ("I decided to test that after I finished this because...")
4. Evaluative ("This experiment seems to be working because...")
5. Modifying ("I realize that I need to replicate what I have got in the first trial to draw more reliable conclusions.")

B: Cognitive-Oriented:
1. Stating specific rules for the problem ("the experiment needs to control variables, etc.")
2. Stating goals of the problem ("test how light and moisture affect isopod behaviors")
3. Recognizing the current state of the problem solving (" I got this answer right"; "my second experiment yielded right answer")

C: Personal Feeling-Oriented:
1. Positive ("I feel OK, fine, confident, etc.")
2. Negative ("I feel frustrated"; "It was too confusing")

To look at how subjects in the different treatment groups were responding to the questions that were asked in the program, a random sample of 6 protocols from each of the treatment groups was coded for the content by two independent raters according to the categories classified above. The summary consisted of the number of responses judged to be a member of each category for each question cue by each subject. A grand summary for each treatment was then calculated by each rater. The interrater reliability indicated 90% agreement. The differences were resolved by discussing the responses in question and deciding upon agreed-on judgments.

The total percentage of the responses made in each major category by each group was then calculated and compared to find out whether any of the groups differed in terms of the content of their responses. It appears that each group focused on the appropriate level of information requested by the questions (see Table 4). The affective subjects gave 96.5% feeling-oriented statements, 3.5% process -oriented statements and almost no cognitive-oriented statements. Among feeling-oriented statements, 65% were rated as positive and 35% of them were negative statements. Cognitive subjects gave responses that fell into the problem-oriented category (rules, goals, and problem state) 85.7% of the time. 14.3% of the time they made process-oriented responses and they almost made no feelings-oriented statements. The metacognitive subjects gave 72% of the responses that fell into the process category, 21% of the responses fell into problem or cognitive level and 7% fell into feeling levels.

Table 4: Category percentages for each group

	Affective	Cognitive	Metacognitive
Process	3.5%	14.3%	72%
Cognitive	0	85.7%	21%
Personal	95.5%	0	7%
Total	100%	100%	100%

In further analysis of the interview data, it was found that metacognitive subjects were involved more in the reflective processes. When they reached the solution, they were not just satisfied with it, but went further to find out why it was right or wrong. For example, when asked to summarize how the questions affected the whole process , one student responded "I think that they really made me go back and look at it and check myself to see that I was doing them right and really looked at my experiments to see how the results were turned out *.Otherwise, I might just finish and not go over it"* (emphasis is the authors'). Another student said that these questions helped her to " question further about [her] conclusions, like why. They made [her] make sure that they were valid enough". When this same student was asked if she would do anything differently if she were not asked the questions, she responded " Not really. I probably would not understand the processes I went through this well. I would just be satisfied that I got them right" In fact, most people from the other 3 groups were just happy to get the right answers and stopped there. One student in the cognitive group summed this up well . She said: " I did not really ask myself anything at the end. I was just glad. I knew I was correct."

Additionally, it appeared that while solving far transfer problems, metacognitive subjects continued to ask themselves questions similar to those presented in the computer program. This was not indicated by other groups of subjects. One student in the metacognitive group stated "Yes. I did go through the similar processes. I asked myself at the first place why I knew my results and setting up the experiments are right, why was I confident that I got a certain part right because I remembered my computer experiences". This response is characteristic of 11 of the 14 metacognitive students interviewed.

Affective subjects reported that awareness of on-task feelings helped them realize how they were doing in the problem solving process. If they were aware that they were frustrated or nervous, they felt that there must be something wrong with their performance. But many of them reported that they did not know what was wrong or how to fix it. ("It made me think about how I was solving the problem by realizing how I was feeling at that moment. But the question did not help me solve the problem better. Because they did not help me find out where is my problem and how to solve it.") Their responses told us that the awareness of emotion state is not sufficient to enhance the problem solving performance.

During the interview of control subjects, most of them indicated that they were very confused all the time and they needed more help. They felt that decision-making was the toughest part in the whole process. They were glad that feedback was given at the end to help them realize that they got right answers. "I feel very confused the whole way through. I wish I had more help. I was not sure if I was right or wrong. The decision-making part was very hard on me." Overall, subjects across groups reported increased interest and confidence in using computers. Many of them said "I like computer experiments. It saves time and mess.(metacognitive group)..."; "I like computers and I would feel more confident if I have to use it again..(Cognitive group)."; "I think that it was very neat that I could visually see what was happening in my experiments. I become more confident in using computers after this hard (control group)"; and "I like computers and wish to have more experience with it. (affective group)".

To answer the question of how metacognitive, cognitive and affective cues influence students' task design in the hypermedia system during the training, a constant comparison analysis was performed . The students were asked to diagram their designs on paper immediately after finishing the computer program. Figure 1 shows a visual representation of the process of forming the groups. In the end, the designs fell into one of four (4) large groups: designs exactly like those on the program; designs which did not show any separation of variables; designs which showed a separation of variables, but did not test the two variables against each other; and designs which tested the variables against each other. The group which showed separation of variables was subdivided by number of variables tested (1, 2 or 3) and whether or not those in the 2 variable category ran replications or not. This resulted in four subcategories in this group. The group which showed some testing of the variables against each other was also subdivided into those who only compared the two variables, and those who both isolated the variables and compared them. This last group was subdivided further as to whether the testing of the variables against each other was correctly designed or not, and if the correctly designed one ran replications or not. This gave a total of four subgroups in this category, making a total of ten possible groups of designs

In each of these ten groups, the students were clumped as to which of the four experimental groups they participated in. Numbers of students in each group were converted to the percentage of the total number of students from their treatment group, so comparisons could be made across treatment groups. See Table 5 for these results.

The ideal task design would be to both isolate variables and correctly tested them against each other(group 10) . If we do not consider whether the student carried out replications, then 19% of the cognitive students are seen in this group, 6.60% of the affective students, 4.7% of the control students and 4.5 % of the metacognitive students.

FIGURE1:
A Visual Representation of the Resulting Groups for Analysis of Student-reported Designs

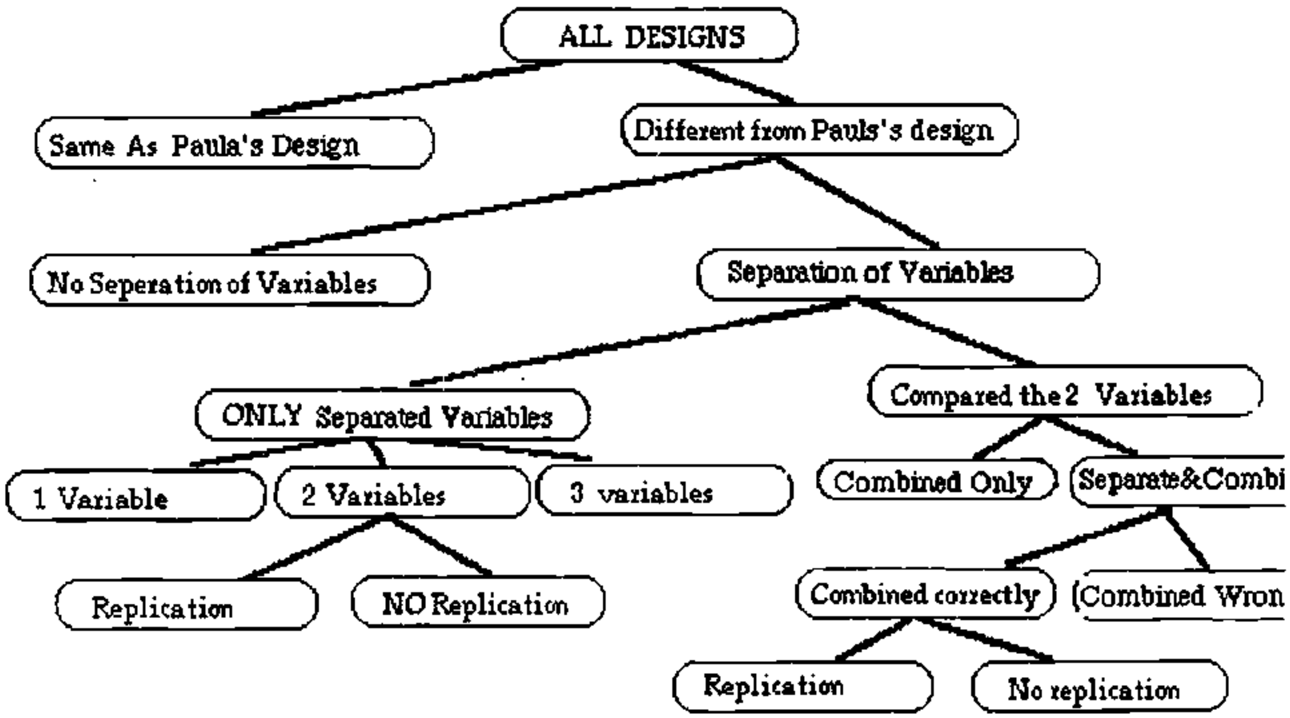

Table 5: Comparison of Group Compositions for Design Analysis:

group	1	2	3	4	5	6	7	8	9	10
control	4.70	4.70	9.50	9.50	47.00	0.00	9.50	4.70	4.70	0.00
affective	0.00	13.30	13.30	6.60	33.0	13.30	13.00	0.00	6.60	0.00
cognitive	4.70	4.70	19.04	19.04	28.50	0.00	0.00	0.00	9.50	9.50
metacog	9.00	4.50	4.50	27.00	32.00	4.50	0.00	4.50	4.50	0.00

Note: group numbers in this table refer to group numbers designated in Figure 1

Conclusions

On the posttest of far transfer, the metacognitive group scored significantly better ($p < .001$) than any of the other groups. In the within-group t test analysis, the metacognitive group was the only group which showed statistically significant increases from the pretest to the posttest on both near and far transfer tests. This shows that the metacognitive question cues can positively affect the way in which students approach problems, and that this effect continues afterward for problems which are only distantly related to the training problem.

More evidence for this carryover of thought processes is revealed in the student interviews. When asked about the transfer tasks, students in the metacognitive group replied that they continued to ask themselves questions similar to the ones in the computer program, while the other cued groups did not. One control student, when asked about the post test answered " For the most part I knew I was right, so I did not question myself." Another student in the affective group, when asked if she asked herself anything similar to what she was asked on the computer program, replied "No. Not really. I did not really ask myself anything like that." During the interviews, the metacognitive students also spoke of the fact that if the cues had not been there, they would not have stopped to plan as well as they did, nor would they have stopped to contemplate why they got correct or incorrect answers. For example, one student when asked if she would do the same thing if she had not been cued replied "No. I wouldn't. I may just be satisfied with the fact that I got it." The same student, when asked if the questions affected her confidence, interest or motivations, said "Yes. They made me feel good because I got them all right and I did the experiments right and understand the whole process better..." She stated that if she had not been asked the questions by the computer, she would not have felt the same way, "because those questions helped [her] to understand."

There was variation within the groups, however, and some students replied that even though they were forced to give some reply to the cues, they did not give much thought to the cues. One student commented, "basically I just used pre-knowledge from the lab we originally did, the hands-on experiment. I used prior knowledge to decide what I was going to do next as I had originally done." One student's answers indicated that although she said she ignored the cues, she may have been using them. When asked if she had ignored the questions, this student replied, "Exactly. Those questions did not help me. *But they did provoke me to think what I would do next.* But I could not find the direct relationship between what I have thought and my understanding of the whole process" (emphasis is authors'). All of the preceding quotes were from the students in the metacognitive group. Although the responses varied among these students, the majority of them (11/14) interviewed indicated that these cues caused them to stop, reflect and do something different than they would have without them.

Although the qualitative analysis of students' task designs seems to contradict this "good news" by showing that, on average, the metacognitive group did worse on their task designs, we are reluctant to give these data heavy weight for several reasons. First, the designs were self reported by the students after they completed the computer activity. Within the "recorded" subset of students, when we compared their self-reports of their task designs with what actually happened while they were on the computers, 50% of the students either under or over represented the training task designs which they had actually completed. Second, after watching the screen recordings, we found that many of those students who were recorded also designed tasks which were not actually run, or changed the design of the task before they ran it. The students' self-reported data were not complete. The data tended to show only a segment of the task designs and did not accurately show the changes that students made during the process of designing the task. In analyzing these data, it is often not possible to tell if the students' diagrams represent an initial plan or the end result of the entire process of computer task design. It can be concluded from this experiment that retrospective qualitative data are not as accurate as on-line process data, and are not appropriate for collecting process data, especially when the data can not show the progress or changes made during the process.

Therefore, even if the metacognitive group task designs were less comprehensive than those of the cognitive and control groups, we feel that this is not an indication that all of the cues failed (since the metacognitive group went on to outperform the other groups in the transfer test), but may mean that some of the cues failed. One cue that may not have been successful for the metacognitive students' task design was the first cue ("What's your plan for solving the problem?"). This cue asked the students to detail their plans for the experiment.

All of the students came to the experiment with strong preconceptions carried over from the experiences in the hands-on lab. Unless an event occurred during the process of the computer simulation to jar them out of this preconception, they continued to solve this problem as they did in the lab. For some students, reaching wrong answers or unexpected cues made them confront their preconceptions. Since almost 60% of the metacognitive group ended up in one of the two groups which only tested two variables independently (see Table 5: 5&6), it may be that the cue which asked them "What's your plan for solving the problem?" was not different enough from what students were thinking at that moment to elicit a strong response and thus break them out of their preconceptions.

This hypothesis is further supported by the interview data. When asked how they reacted to the first cue, most of the metacognitive students indicated that the main effect this cue had was to cause them to stop and think, or to slow down. For example, one student responded, "it made me think about it for a second before I took any actions. During that second it reminded me of what I did in class." However, while doing the hands-on lab experiment, the students were never required to test variables against each other. The problem-solving process they went through in the hands-on lab could not be applied to the problems posed in the computer program. Thus, the student's response was not appropriate. When asked if they would have done anything differently if they had not been given this cue, most of the metacognitive students answered that the only difference was that they would not have written down their plan, or that their plan might not have been so detailed. Another student responded "I put 'plan to test variable individually'. I did not make a very detailed plan." In all of these cases, we see that the first cue did not succeed in breaking these students' preconceptions, but allowed them to continue their task designs with their preconceptions intact. This might explain why so many of the metacognitive group had task designs which only tested the two variables (light and moisture) independently, and why they did not go on to test the two variables against each other.

Contrasted to the metacognitive students' responses to the first cues, the cognitive students' interviews showed that in order to answer their first cue ("What variable(s) are you testing for?") they had to do a lot of metacognitive thought. For example, one student said, "They really made me think. They really did. They helped me along to see what I need to do in an experiment. They kind of making me think about exactly what variables I need to test and how many I am supposed to have in the experiment." Another student said, " They really made me think how to set up certain things. And it just made me think more consciously about what I was doing." This tells us that although the responses to this cue were cognitive
(light,moisture, etc...), students had to go through a metacognitive process in order to respond to this cue appropriately. In fact, within the cognitive group, 9 of the 12 interviews indicated that the cognitive students went through such metacognitive-oriented processes when responding to the first cue.

We can conclude that a cue which induces a metacognitive process can have a significant positive impact on students' problem solving processes. In the case of the first cue, the metacognitive response was actually found in the cognitive group. Consequently, their task designs were also much better than all the other groups. However, this single cue was not strong enough to guarantee that the rest of their thought processes continued to be metacognitively oriented, and the cognitive students failed to show far transfer.

Even though the first cue in the metacognitive group failed to induce metacognitive processes, the metacognitive students subsequently received many more cues which actually induced metacognitive processes (refer to Table 4 for the category percentages for each group). The high percentage of process responses generated by the metacognitive subjects suggest that the majority of the metacognitive cues successfully engaged students in metacognitive processing. This allowed the students to continue a process of "self-questioning" during the posttest, which may have helped them score significantly higher on the posttest of far transfer. Therefore, what students actually transferred were the metacognitive processes rather then the content-specific information. These processes made students focus on and become consciously aware of the solution components. By focusing on a process level, subjects were able to attend to information regarding the way in which they solved a problem. This finding is consistent with what Berardi-Colleta (1990) found in her study. She concluded that the process-focused groups are not only transferring knowledge to the new task, but that they are also transferring an approach to the new problem.

Since all groups claimed to have planned, regardless of the type of cues, we propose that metacognitive planning needs to be carefully interpreted by the researcher. Mere planning was not sufficient to insure correct and complete task design. In order for task design to be correct and complete, these "plans" had to be coupled with active metacognitive processes such as monitoring, reflecting and evaluating.

The issue of how these cues affect the students' task design process needs to be further explored. Given our experiences here, we would recommend that the process data be collected concurrently and be as detailed as possible. We would also caution that researchers and teachers need to be careful about their choices of cues, ensuring that the cues are attention focusing,and strong enough to break previously held preconceptions, as well as inducing metacognitive processes. Finally, the emphasis in problem solving research has placed on needs to shift to focus on human problem solvers as "memory banks" to humans as dynamic,active processors of their own learning experiences that are continually acquiring information in the learning process.

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APPENDIX 1:Cues Embedded Within the Computer Program

Affective Group	Cognitive Group	Metacognitive Group
Location One: after reviewing Paula's experiment and problem statements, and before any selections have been made		
Rationale: check feelings and mood before task	**Rationale**: review the goals and rules of solving the problem	**Rationale:** make plans for solving the problem
(1) How are you feeling right now in dealing with this problem?	(1) What variables are you testing?	(1) What is your plan for solving the problem?
Location Two: after selecting all of the materials and supplies, and before conducting the experiments		
Rationale: check on-task feelings	**Rationale:** check actions against goals and rules of solving the problem	**Rationale:**reflect on the actions have been taken and plan for the next step
(2) How are you feeling right now?	(2) What materials and supplies have you selected? (3) What are you going to test?	(2) Why did you select those materials and supplies? (3) How are you deciding what to do next?
Location Three: after finishing all of the experiments and drawing conclusions, and before the feedback was given		
Rationale:check post-task feelings	**Rationale:**encourage self-discovery of the current sate of the problem solving	**Rationale**: monitor and evaluate the effectiveness of the process of the problem solving
(3) How you feeling right now?	(4) What conclusions can you draw about the variable(s)?	(4) How did you decide that you have had enough data to make conclusions?
Location Four: after providing the feedback		
Rationale:check the processes of the feeling change	**Rationale:**check the final performance by knowing the number of the experiments that are useful or not useful	**Rationale:**do not be satisfied with right or wrong answers, find out why they are right or wrong, build up a repertoire of strategies for further modifications of the processes
(4) How are you feeling right now comparing to when you just got started?	(5) How many of your experimental designs gave useful data? or How many of your experimental designs did not give useful data?	(5) What part of your experiments led you to the right or wrong conclusions? *How are you going to fix it?(ask only if the conclusions are wrong.)

Appendix 2: Teacher-Made Near and Far Test of Problem Solving

NAME____________________________________ **DIVISION**________________

BIOLOGY 205 LAB QUIZ FALL 1992

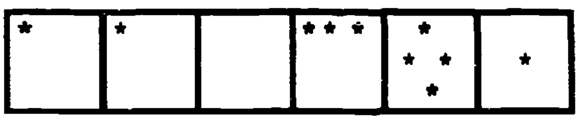
INDIVIDUAL QUIZ - ISOPOD LAB

1. What environmental conditions do isopods "prefer?" (4 pts.)

2. Explain the basis for your conclusions about isopods' "preferred" environmental conditions. (6 pts.)

3. Suppose you had the following information for the isopod lab:
Ten isopods were placed in a trough in section 3, and after ten minutes, the following results were noted as diagrammed below:

WET **DRY**



1 2 3 4 5 6

Based on the information given above, answer the following questions:

a. What is the variable in this experiment? (1 pt.)

b. How would you describe the response of these organisms to this variable (based on the diagram above)? (2 pts.)

c. What is random behavior? (1 pt.)
d. Do you see random behavior in the diagram above? Explain your answer. (3 pts.)
e. What could you do to validate your results? (3 pts.)

4. **QUESTION (6 POINTS TOTAL) (FAR TRANSFER PROBLEM)**
The elementary school in which you teach seems to have an unusually high number of hyperactive students. In fact, of the 100 students in second grade, 50 of them are hyperactive. Different groups of adults have proposed various ideas to explain this. The parents say that the **peer influence** causes them to be hyperactive. The principal thinks that the **family environment** is the cause of their hyperactivity. The teachers, on the other hand, say that **diet** is the source of the condition. You have been asked to design an experiment that would determine which one or more than one of these explanations is correct. Explain how you would set up this experiment to determine the cause or causes of the students' hyperactivity. (Use the back of this sheet if you need more space.)

Title:

Metacognition: Implications for Research In Hypermedia-Based Learning Environment

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ABSTRACT

In learning environments which provide little structure (e.g., hypermedia systems), students have an especially strong need to regulate and control their own learning. Such learning environments should be ideal for enhanced learning. However, a review of the literature indicates that merely providing learners with flexible learning environments does not necessarily mean that they will effectively explore and learn meaningfully from the resources provided. It has been suggested from previous research that poor metacognitive skills, that is the inability to accurately monitor, reflect, evaluate and adjust learning, hinders learning in this free environment. Metacognitive theory and research are reviewed and recommendations are made for future research in hypermedia-based instruction and learning.

Metacognition: Implications for Research In Hypermedia-Based Learning Environment

Hypermedia is an advanced technology that combines film, video, computer graphics, sound, music, and text in a unified information-delivery system centered upon the personal computer (Paske, 1990). The authoring capability of popular products used to develop hypermedia-based instruction makes the development and production processes relatively easy and rapid. Many advantages make hypermedia systems attractive delivery alternatives for both school education and industrial training purposes.

The use of hypertext and hypermedia systems as an effective instructional aid "is premised on a belief in learner control" (Jonassen, 1989; p. 49). For example, the nonlinear nature of hypermedia systems requires users to decide when and where to enter and exit the system, how much information is needed, what kind of information should be selected, where to find it, and what approach is the best. It is apparent that independent decision making, as well as understanding and effectively regulating one's own learning process, is crucial for an individual to successfully exercise the control required by hypermedia-based environments.

For the learner, the advantages of using hyper-based text and media include the ability to augment learning by providing a means to: (a) immediately make connections among a variety of knowledge sources; (b) derive potential relationships among topics of information; and (c) interlock webs of information (Balajthy, 1990). Additionally, from a motivational viewpoint, this mode of presentation can greatly increase the learner's control, allowing for an emphasis on personally relevant topics and/or the elimination of unwanted topics from review. Increased learner control may also lead to learning achievements being more readily attributable to the individual, thus increasing positive perceptions of self-efficacy (Schunk, 1991).

As Jonassen (1989) points out, learner control is an instructional strategy that is grounded on the belief that the learner knows what is best for him or herself and will be more motivated toward learning if given control of learning decisions. However, "the research on learner control has not been supportive" of this premise (Jonassen, 1989; pp. 49). It has repeatedly been shown that learners do not make the best decisions when given control over instruction and in many cases actually learn less than those not given such control (Jonassen, 1989; Williams, 1993).

Several potential explanations may help clarify the gap between the potential learning benefits and the empirical findings. One such alternative is simply that learner control is not an effective approach to learning new material. Given this alternative, it would be hypothesized that reduction in learner control with a reciprocal increase in program control would lead to increased learning. Findings from studies designed to test this hypotheses, however, have also been inconsistent. Moreover, imposing control essentially negates the flexibility and potential motivational value of hypertext and hypermedia technology.

A second explanation focuses on the possibility that learner control does make a positive difference in learning, but traditional tests of this hypothesis have been inadequate. Both Marchionini (1988) and Jonassen (1988) indicated that new evaluation criteria are needed to assess knowledge structures and student learning in learner controlled hypertext/hypermedia environments. Gleim and Harvey (1992) reviewed and discussed several methodologies that may permit a better view of what actually is occurring within these environments.

A third alternative suggested by several researchers, and the one that is the focus of this paper, is that learners" lack of metacognitive knowledge and skills of the users may hinder their learning in situations of increased learner control (e.g., Balajthy; 1990; Park, 1992; Steinberg, 1989; Williams, 1993).

Metacognition is usually defined as the awareness and active monitoring of one's cognitive processes (Brown, 1987; Flavell, 1987). Individuals with higher levels (or more developed) metacognitive skills tend to plan cognitive actions, recognize personal capabilities, monitor their progress, and reflect upon their own mental processes, as well as regulate those processes (Brown, Bransford, Ferrara & Campione, 1983). Metacognitive skills thus help individuals learn independently, guide their own learning processes, control the selection and sequence of both content and process, and transfer what has been learned to other situations (Rowe, 1988; Lin, 1993). These skills enhance the individual's independent thinking and learning-how-to-learn abilities. Because hypermedia systems rely heavily on learners to make decisions, appropriate inferences, and adjustments to the changing learning environment, it seems plausible that a fairly high degree of metacognitive knowledge and skills would be important for successful learning within such environments.

As hypertext/hypermedia becomes increasingly popular in education and training, there is a greater need for instructional technologists to understand the construct of metacognition and its role in comprehension and learning. Metacognitive skills appear critical to effective use and learning from hypermedia systems and, reciprocally, hypermedia formats may provide a fertile environment for the learning of such metacognitive skills. If effective metacognitive instructional strategies can be incorporated into hypermedia-based learning environments, they may in fact foster the development of good thinkers who are successful problem-solvers and lifelong learners.

The purpose of this paper is to examine research on metacognitive theory and examine its implications for hypermedia-based instruction. The paper (1) discusses the promises and limitations for learning in hypermedia systems; (2) reviews research findings from the field of metacognition; (3) discusses implications of the findings for research in hypermedia learning environments; and (4) suggests areas for future research.

Learning In Hypermedia Environment

The most frequently cited hypertext system capability is the provision of high levels of flexibility and freedom for learners to explore, construct meaning and generate their own learning models (McGrath, 1992). For example, hypermedia systems provide the freedom to navigate through the system in whatever manner the user desires (Kozma, 1991). Such systems also provide means whereby the user can add his or her own information and construct their own relationships (Kozma & Van Roekel, 1986).

Learner control is a basic premise within hypertext/hypermedia environments (Jonasson, 1989). It is left up to the learner, based on his or her goals and previous experiences, to decide what to explore, how, and when to explore it (Roselli, 1991). Because of a wide variety in those past experiences, and in the manner in which individuals learn, it has been hypothesized that "...instruction generally increases in effectiveness, efficiency, and appeal to the extent that it permits informed learner-control by motivated learners" (Reigeluth & Stein, 1983).

Why should the effectiveness, efficiency, and appeal of instructional materials be enhanced through informed learner control? According to Williams' (1993) recent comprehensive review of the learner control literature, instructional effectiveness (i.e., the degree to which the material is learned), may in part be dependent upon the levels of invested mental effort required of the learner. "One might expect a learner-controlled instructional treatment to induce more elaborate mental processing from the students as a result of their pondering the choices with which they are faced" (p. 6). Several theorists argue that greater mental effort increases the probability of meaningful elaboration resulting in deeper comprehension (Salomon,1983; Stein & Bransford, 1979). Additionally, from a constructivist point of view, providing a learning context in which the learner participates in the construction of mental structures, in place of having those structures predetermined, facilitates learning (Ertmer & Newby, 1993; Hartley, 1985).

From an efficiency standpoint, increased levels of learner control allow instruction to be tailored by the individual learner so that it is relevant to his or her own goals and capacities (Roselli, 1991), thus limiting or eliminating redundant or undesirable learning materials and experiences.

Finally, the appeal of instruction and its motivational value should also be affected by the degree of learner control. Steinberg (1989) pointed out that in learner-controlled computer environments, a learner's boredom, frustration, and anxiety should be reduced. Within such environments, when faced with a boring task the learner has the ability to choose to alter and add variety to what is presented. This variety may increase the level of appeal of the instruction (Keller, 1987). Similarly, when unfamiliarity increases feelings of frustration or anxiety, users have the opportunity to postpone exploration of the system to select other materials. Additional motivational benefits of learner control include possible elevated levels of confidence being acquired by the learner (Keller, 1987), increased levels of self-efficacy (Schunk, 1991), and increased levels of continuing motivation (Kinzie & Sullivan, 1989). In each of these cases, the benefits are based on the learner's ability to attribute success more readily to him or herself because of the control over the learning experience.

Although many potential benefits from learner control have been suggested for several years, to date, the research does not support its unconditional use (Williams, 1993). In reviewing the literature on learner control in computer-based instruction, it has been shown that when students are given control over sequence, path, content, pace, etc., their performances are mixed in terms of effectiveness, efficiency and appeal. Frequently, results of learner control studies indicate performance at levels similar to or significantly <u>less</u> than students who are not given controls (Rubincam & Oliver, 1985; Steinberg, Baskin, & Matthews, 1985; Williams, 1993). Rubincam and Oliver (1985), for example, surveyed eleven studies to compare students' achievements in learner-controlled versus computer-controlled situations. Five of the studies showed superior performance under non-learner controlled conditions and only two under learner-controlled conditions. The rest of the studies indicated no differences between the two conditions. Researchers in the area have found that users often exit lessons too soon, view too few examples, and complete the lesson too quickly (Tennyson, Tennyson, & Rothen, 1980; Ross & Rakow, 1980).

Rubincam and Oliver (1985) conducted a study involving a high school CAI algebra lesson. Students controlled the sequence of objectives within each topic and decided whether to take instruction before the test or go to the test immediately. It was found that students who had a consistent selection strategy and a reason for selecting their strategies performed better than those who did not. However, being able to select strategies consistently required learners to know what was best for themselves concerning the task at hand and the environments in which they were studying. Learners had to be able to select effective learning strategies, and to understand when and why those strategies should be used..

In hypermedia-based learning environments, users are given even more control over the instruction than in traditional CAI. Moreover, easy access to the vast quantities of information (Marchionini, 1988), the increased number of learning options available in the systems (Jonassen, 1989), and the richness of the non-linear representation of information (Dede, 1988) can make learning in hypermedia systems extremely challenging and difficult. It is likely to be especially difficult for those users who lack skills in planning, monitoring, reflecting, and regulating their personal learning strategies. The increased complexity and lack of structure of such environments automatically impose increased responsibilities and cognitive processing requirements on users. In these circumstances, it is important for individuals to be able to select and generate strategies to guide their own learning processes and explore thought itself. They should be able to identify (to oneself or others) how a particular strategy came into being, why particular options were chosen, and how particular conclusions were reached. These metacognitive skills enable users to control their own cognitive processing internally. Lacking these abilities, users may become confused and "get lost" in hypermedia systems. They may not be able to discern what they want, where they are in the network, or how to reach any specific point. These problems are known as learner cognitive overload and disorientation (Marchionini, 1988; Roselli, 1991).

Despite the importance of possessing metacognitive skills, they often are not clearly demonstrated by young children or even college students (Wong, 1989). In addition, the overall quality of users' metacognitive skills is relatively poor (Schoenfeld, 1985). It seems that the problems in attaining the potential benefits of learner-controlled learning environments may be attributable, at least in part, to the lack of the learner's use of metacognitive knowledge and skills. In our view, such environments require users to engage in a variety of metacognitive activities, including being aware of the nature of personal learning styles and deficiencies and planning, monitoring, and decision making during learning.

Providing External Support

To fulfill the learning potential in hypermedia-based learning environments, the creation of external supports as a supplement to users' abilities has been advocated. One external support that is frequently used is adaptive advisement, a technique in which the computer is used to diagnose the learner's understanding, prescribe the instructional procedures, explain underlying principles and processes, etc. Another common support is to use graphics, maps, charts, etc., that show students the structure of the knowledge in the system. Designers of hypermedia systems have also used metacognitive aids (on-line ability to save self-generated explanations, highlighting of unfamiliar terms, etc.). Overall, students provided with external supports perform significantly better in immediate tasks, but they do not maintain or transfer their knowledge very well (Steinberg, Baskin, & Matthews, 1985; Steinberg, Baskin, & Hofer, 1986; Tennyson & Rothen, 1979; Tennyson, 1980). In fact, these external supports may themselves be burdens. The so-called metacognitive aids provided within some hypermedia systems (e.g. program-provided explanations of the process one has gone through) are frequently ignored by users and are viewed as additional cognitive load (Recur & Pirolli, 1992). Marchionini (1988) pointed out that novices use external help to avoid cognitive overload rather than as a way of dealing with it.

These findings support Bernard-Colleta's (1990) contention that, unless learners are directed to be involved in the metacognitive process themselves, many will not automatically engage in metacognitive processes (Brown, Bransford, Ferrara & Campione, 1983). These results suggest that, although external supports can help students solve problems initially, they do not necessarily help learners develop their own strategies and other required metacognitive skills (Steinberg, 1989). Too many external supports may lead students to ascribe the success or failure of their learning to external factors and subsequently take less responsibility for their own learning. Their motivations to develop strategies may even be severely impaired if too many external supports are provided (Steinberg, 1989). Thus, the mere provision of an external support is not necessarily beneficial, at least for long-term retention and transfer, if learners do not understand how it can help, and when, where and why to use it.

Most of the external support discussed above may have lacked the support needed to help learners develop appropriate internal learning-how-to-learn abilities. Learning may not be optimal in hypermedia systems because users have used inappropriate learning strategies

(Steinberg, 1977), because they lack the knowledge and skills or metacognitive skills (Merrill, 1980; Rigney, 1978) needed to make meaningful decisions (Steinberg, 1989; Tennyson & Rothen, 1979) for a combination of these reasons. In reviewing the literature on hypermedia and metacognition for disabled readers, Balajthy (1990) came to similar conclusions. He suggested that poor metacognitive functioning, defined as students' inability to monitor accurately their own success or failure, hindered learning in situations in which students were given control, as opposed to situations in which control was exerted by the computer. Therefore, it is important to look at the construct of metacognition and research findings arising from metacognitive training to suggest how to enhance the effectiveness of hypermedia-based learning environments.

The Need for Learner-Generated Metacognitive Processes

Research related to cognition focuses on how thoughts and internal mental processes influence learning and behavior as well as how these processes take place successfully or unsuccessfully. In the process of acquiring knowledge, a learner applies various "cognitive strategies." For example, a person who must learn to discriminate among several sets of numbers might apply a categorizing strategy to help distinguish one set from the others. An instructor might employ an association strategy at the beginning of a new class in order to memorize the names of students.. Cognitive abilities can thus be regarded as "enabling variables" in that they facilitate performance of specific tasks (Rowe, 1988, p. 228).

Theorists who distinguish between cognitive and metacognitive processes use the term metacognition to refer to those aspects of cognition that require learners to understand their own cognitive processes and to monitor, direct and control them. Flavell, who pioneered the field of metacognition with his exploration of metamemory, describes it this way:

> Metacognition is usually defined as knowledge and cognition about cognitive objects, that is, about anything cognitive. However, the concept could reasonably be broadened to include anything psychological, rather than just anything cognitive. For instance, if one has knowledge or metacognitive. (Flavell, 1987, p.21)

Brown (1987) defines the concept of metacognition as the understanding of knowledge that can be reflected in either effective use or overt description of the knowledge in question. Within the psychological literature, the term has been used to refer to two distinct areas of research knowledge about cognition and the regulation of cognition (Brown, 1987).

Knowledge About Cognition

For Flavell (1987), metacognitive knowledge consists of three major variables: person variables, task variables and strategy variables. Knowledge of the three variables may influence a person's performance.

Person varibles involve knowing about oneself as a learner, e.g., one's cognitive strengths, weaknesses, abilities, motivation, attitudes, etc. In hypermedia-based learning environments, this knowledge will include one's beliefs concerning one's own ability to interact with the environment as well as one's understanding of personal affective states, such as motivation, interests, curiosity and anxiety. Personal knowledge can also include one's awareness of preferred personal learning styles and searching patterns. Realizing that one is frustrated and confused by attempts to solve certain kinds of problems is another example of this aspect of knowledge.

Task variables refer to knowledge about the nature of the tasks, for example, knowing that one task is easier or more difficult than another. Knowledge of task variables implies that the individual knows the type of cognitive demands required in certain instructional settings and how the nature of the task affects the manner in which one should deal with it. For example, a person with an awareness of task variables may know that it is generally more difficult to synthesize information than simply to remember it.

Strategy variables include knowledge of how to use a strategy, or what strategies are available, or how well a strategy works. When an individual knows what strategies are most effective to obtain the best learning results, then he/she is said to possess knowledge about strategy variables. For example, in most learning environments, including hypermedia-based ones, strategically aware individuals might plan ahead of time, monitor their processes, ask themselves why certain steps are taken, and evaluate their performance.

Flavell (1987) suggested that these three metacognitive knowledge variables interact in important ways. For example, individuals might realize or believe that certain types of tasks are very easy or difficult for them and create appropriate strategies that work especially well for them and the task in a certain environment.

Regulation of Cognition

Regulation of cognition is a metacognitive process defined by Flavell (1979) as conscious monitoring that controls and regulates both cognitive and affective processes. Brown (1987) argues that the concept of metacognition consists of activities used to regulate and oversee learning. According to Brown, metacognitive experiences include planning, monitoring, evaluating and revising.

Planning involves determining an overall approach to completing a task or solving a problem, e.g., selecting appropriate strategies, determining what sequence should be taken, and deciding how to evaluate progress while reaching the goals. Monitoring of one's own cognitive processes is the ongoing process that one goes through to track what one is doing and to assess success while implementing plans. Evaluating one's own learning processes involves checking to see what has been done and deciding if the same approach would be good for similar tasks in the future. This process of evaluation can help learners build a repertoire of strategies that they can call upon in the future to address similar situations, and even to generate new approaches in novel situations. Revising one's own learning procedures involves modifying plans, strategies, learning approaches, and goals. In hypermedia-based learning environments, users must be able to plan ahead based on knowledge about their own learning capacities, the task, and strategy. They should be able to monitor their own comprehension of information, evaluate the processes used and the strategies selected to deal with the task, and modify any ineffective strategies and approaches.

Recently, the affective and motivational aspects of learning have received increased attention in the construct of metacognition. Paris and Winograd's (1990) definition of metacognition includes metacognitive judgments, beliefs, and choices. Metacognitive judgments refer to individuals' ongoing assessments of the cognitive characteristics of the learning situation. Metacognitive beliefs involve expectations that reflect affective biases, self-concepts, and motivational disposition. These two components are important because they determine which tasks learners find worthwhile and how they choose to engage them (Paris & Winograd, 1990). Both Schoenfeld's (1985, 1987) and Lockhead's (1985) definitions of metacognition also include awareness of one's beliefs and feelings about the nature of the content domain and the self as a learner.

In summary, metacognitive processes imply active and reflective learners. If cognitive abilities are regarded as "enabling variables," then metacognitive abilities are "organizing and controlling variables" in the sense that they contribute to the selection, sequencing, combination and regulation of cognitive processes (Rowe, 1988, P. 228). As controlling variables, they enable learners to organize and regulate their own cognitive learning processes. They also help learners select and regulate the direction, duration, intensity, range, path, and speed of learning functions (Rowe, 1988; Bruer, 1993). As a result, learners can more thoroughly integrate new information into their existing knowledge schemata, since they are capable of selecting exactly what is needed for their own learning systems. Therefore, metacognitive abilities enhance learners' internal control of cognitive processes and enable learners to function successfully even in situations in which they must make decisions and behavioral adjustments.

Metacognitive Research

Research in metacognition can be organized into two broad categories. The first involves studies which specify how metacognition is developed naturally throughout life; the second concerns the research into the trainability of metacognition. For the purpose of stimulating future research on integrating metacognitive training within hypermedia systems, the second category of metacognitive research is the focus of the discussion here.

Strategy Training Research

The research in this field assumes that the more people know about strategies, the greater the probability they will use the appropriate strategies in the appropriate situations (Vernon & Marie, 1984). Most of the early research has attempted to teach specific metamemory knowledge and strategies. For example, Brown (1978) summarized a series of studies in which mildly retarded children were taught to know when to select missed items when learning a list of words, and when they were ready to recall. She observed from these studies that the training effects were less positive than expected when students were asked to generalize what they had been taught to different situations. She thus recommended that more general metacognitive strategies should be taught.

After reviewing relevant literature on strategy training, Pressley, Borkowski, & O'Sullivan (1984) defined three methods by which individuals may acquire metacognitive knowledge through strategy training. The first is the laissez-faire method in which no training intervention is needed. Learners draw conclusions about the strategies from their applications of strategies. Pressley, Levin and Ghatala (cited in Duell, 1986) did a series of five experiments on the laissez-faire method with adults and fifth-sixth graders. The findings indicated that when performing new tasks after they have been tested, adult learners selected the strategy by which they learned the most, even when it was contrary to what they had been told. Fifth- and sixth-graders tended to persist in using the strategy they were told was better despite the contrary evidence. Only when they were provided information on how the strategies should be used correctly did they select the more effective strategies. It is suggested that a laissez-faire approach is more appropriate for adults than for children (Pressley, Borkowski, & O'Sullivan, 1984).

The second method is explicit provision of metamemory strategies. This method assumes that metacognitive knowledge can be explicitly taught through providing information concerning the utility of a strategy, the importance of the strategy, and information on how to revise the strategy to meet changing task demands. Learners are most likely to use strategies spontaneously when they are given knowledge about what, how, when, where, and why certain strategies should be used (Brown, Campione, & Day, 1981). This information will provide learners with declarative knowledge (what), procedural knowledge (how), and conditional knowledge (when, where and why) of strategies. Pressley, Borkowski & O'Sullivan (1984) examined the effects of this method on transfer. They provided fifth and sixth graders with a memory task (word pairing and Latin vocabulary definitions). The experimental group was provided instruction telling them both when the strategy could be used appropriately and how it could be applied to other situations as well as applying the strategy to three diverse situations. Control group students either were told when and how to apply the strategies or were asked to apply the strategies, but were not given the combined treatment. The experimental group performed better on a transfer test consisting of new vocabulary words.

The third method is metamemory acquisition procedures. It requires learners to understand how the strategy works by experiencing instructions designed to help learners derive information about the strategy being taught (Duell, 1986). This method assumes that learners must be taught to acquire their own metacognitive knowledge. For example, Lodico, Ghatala, Levin, Pressley, and Bell (1983) taught second graders to monitor or evaluate their performances when using different ways of accomplishing the same task. The initial training included suggesting that there were many ways to play a game and in order to play well, "they must select the method that allows them to do better" (p. 267). The subjects were given two tasks, drawing circles and remembering a list of letters. Following each pair of activities, subjects given monitoring instruction were asked questions which made them evaluate their relative performances. This helped them identify which of the two activities was more effective for that task and why. Control subjects practiced the same strategies as the experimental group, but received no feedback and practice on the value of these strategies. Students in the experimental group recalled much better than those in the control group. They also outperformed control group students in giving the reasons for effectiveness of the strategy and selecting appropriate strategy for learning. However, it was also suggested by Pressley, Borkowski, and O'Sullivan (1984) that this method may not necessarily be effective for all training because the memory tasks used were limited to discrete items.

In summary, both children and adults have been taught a variety of metacognitive strategies successfully. Research has demonstrated the effectiveness of informed training, in which learners are told about when a strategy may be used, its application in a variety of situations, its effectiveness for producing better learning, and the modification of inappropriate plans and strategies. Metacognitive strategy training, especially metamemory acquisition training method, has been shown to be successful. However, all of these strategy training approaches should be adopted with caution. Sternberg and Wagner (1982), thus, propose four points that may limit the effectiveness of metacognitive training through strategy training: (1) large-scale training may be impractical and not economic; (2) externally imposed metacognitive strategy training may be less effective than the strategies spontaneously generated by students; (3) students may not elect to use a strategy despite its demonstrated effectiveness; and (4) to be effective, strategies must be so well learned that they do not interfere with actual learning.

Self-Explanation Studies

The majority of self-explanation studies are derived from the metacognitive process perspectives which support the importance of active and self-generative processing of information for a person to become an independent thinker. Learners can develop their own controlling and monitoring systems by providing self-explanations for what they are going to do, their reasons for doing it and how the process has been modified (Campione, Brown, & Connell, 1988). It has also been suggested by several other researchers that self-explanation training can induce independent metacognitive processes, i.e. processes directed at understanding of one's own solution process, rather than relying on outside cues of what has been done and how it has been done, which leads to positive transfer of skills (Alhum-Heath & DiVesta, 1986; Berry, 1983; Berardi Coletta, 1990). This position implies that explaining one's own processes may help learners obtain declarative knowledge (what), procedural knowledge (how), and conditional knowledge (when, where, why) of the strategies they use during the process of self-discovery learning, which in turn may lead to the development of independent metacognitive abilities.

There are several studies using this approach to metacognitive training which report positive transfer of skills. Most of these studies are from the literature on problem solving. Berry and Broadbent (1987) conducted three experiments with college students in investigating the effects of two different types of explanation training in a computer system on the performance of a complex search task. The task involved determining which of a set of factories was responsible for polluting a river by testing the river for the presence or absence of various pollutants. The two types of explanation training were (1) an explanation provided by the system at the start and the middle of each trial; and (2) a condition in which subjects were allowed to ask "why" each computer recommendation was made. Experiment 1 showed that subjects who received "why" explanations both at the start and the middle points of trials performed better on a transfer task than did subjects who received the explanation only at the start of each trial. Experiment 2 showed that subjects who were required to explain "why" following the explanations provided by the system performed significantly better than did subjects who were required to only explain "why", but received no explanations from the system. Finally, experiment 3 showed that subjects who received multiple "why" explanations and were required to explain "why" at the time when the necessary inferences had to be made were superior on two subsequent unaided transfer tasks. It was suggested by Berry and Broadbent (1987) that the amount, level of specificity and timing of explanation is important for the success of transfer. These studies also indicate that a combination of external and internal explanations is necessary.

Another group of studies on self-explanation dealt with puzzle types of problem solving. Several researchers found that subjects who were required to give reasons for their moves and explain how decisions were made outperformed control subjects on transfer tasks (Gagné & Smith, 1962; Ahlum-Heath & Divesta, 1986; Beradi-Coletta, 1990). These subjects made fewer moves and got more correct answers. It is suggested that predictive explanation about possible performance in hypothetical situations has the worst effects in transfer (Ericsson & Simon, 1980). Retrospective explanation on what one did after the event is little better than the predictive explanation. But, concurrent explanation is the best in helping learning (Brown & Kane, 1988; Chi, Bassok, Lewis, Reimann, & Glaser, 1989).

One possible reason for these results is that requiring problem solvers to explain their thought processes while solving problems "promotes monitoring, planfulness, evaluation and attention to problem features, and the sharpening of such executive processes yields the more efficient performance" (Dominowski, 1990, p.315). Another possible reason is that when learners have reasons for learning, their intrinsic satisfaction and ownership of knowledge will also be enhanced (Brown, 1988; Goodnow, 1988). People will become intentional learners when they have personal interest in learning. Therefore, the above approach may even have a positive effect on motivation so that learners believe deep understanding to be personally valuable and are willing to engage in the self-explanation activities. However, it should also be noted that the process of self-explanation about what one is doing and thinking can be difficult for many college age students, especially in dealing with complicated tasks (Brown, 1978) Additionally, self-explanation can have negative effects on learning when the requirement for self explanation competes for central processing capacity with the processes that must be reported (Brown, 1987). The following approaches proposed by Gray (1991) may help minimize these problems: (1) start with simple activities so that learners have the chance to practice some metacognitive skills before they attempt more difficult problems; (2) use two levels of self-explanation, first, the steps of the solution process for specific problems should be recorded, and then learners should reflect on what they have learned from this process; (3) teachers should guide at the beginning, providing learners with specific questions to direct their thinking and give them feedback about their responses and (4) students should be trained to provide explanations before encountering the questions that ask them to state reasons for their processes.

Interactive Intervention Research

This approach emphasizes the importance of social interactions and treating learners as co-investigators in the development of metacognitive skills. A lot of research in this field has taken place within the framework of Vygotsky's (1978) theory of socially mediated learning. The theory assumes that all psychological processes are initially social, shared between people (teachers, parents, peers), and learning is transformed through interpersonal processes (Brown, 1987). Paris and Wingograd (1990) have argued that metacognition is a viable candidate for social interactive learning because insight about oneself can be promoted by other people as well as by self-discovery.

The most often used interactive approach to teaching metacognitive skills is known as reciprocal training that has students interact with experts, teachers, and parents. The process of internalization of learning is gradual from external support to internal regulation. Teachers usually guide the problem solving activities; gradually students and teachers share the functions, with students taking the initiative and the teachers correcting when it is necessary; finally teachers withdraw the guidance to the students and act primarily as a supportive audience (Brown, 1987). Group problem solving and peer interaction, such as discussion and controversy, can also result in deep understanding of what one is learning (Brown, 1988). It is believed that metacognitive experiences are most likely to occur when students are required to explain their views, defend their positions and evaluate their processes to others, especially when they are challenged by others to do so (Brown, 1988; Flavell, 1987; Hatano & Inagaki, 1987). It is when students are forced to explain their positions and reasons to others that they come to understand better and deeper themselves (Hatano & Inagaki, 1987).

Reviewing the literature on interactive teaching methods, Reeve and Brown (1985) described two programs to illustrate this approach. One program was conducted by Palinscar and Brown (1984) on improving high school students' reading skills and the other was by Scardamalia and Bereiter (1982) who researched improving written composition skills. The former had students with varying levels of competence and an adult teacher take turns being the teacher and lead a dialogue on a segment of text. They were jointly trying to understand and remember text with the purpose to engage students in four important metacognitive activities relevant to effective reading: questioning, clarifying, summarizing and predicting events in the text. During the process, the teacher and students gave feedback to each other. As students became more skilled, the teacher decreased her level of participation and acted as a supportive audience. Over a several-week training, students "clearly internalized the types of interactions they had experienced," improving not only the four metacognitive activities, "but also in their ability to assume the role of the teacher, producing their own questions and summaries, and evaluating those of others." (Reeve & Brown, 1985; p. 350). Furthermore, students' feelings of personal competence and control improved dramatically. They also concluded that teaching metacognitive skills through direct instruction techniques was far less effective than reciprocal teaching (Palinscar & Brown, 1984).

The second program had novice writers think aloud while writing with the purpose of externalizing cognitive processes involved in writing (Scardamalia and Bereiter, 1982). Students were treated as co-investigators where both instructors and students modeled thinking aloud procedures, presented cues to stimulate self-questioning during the planning stage, and asked strategy questions on how to resolve controversial ideals. The procedures in Scardamalia and Bereiter's study resulted "both in an increased ability to reflect on ideas and in better-structured compositions" (Reeve & Brown, 1985; P. 351).

These results suggest that metacognitive skills can be enhanced through social interactive processes and can be used to improve academic skills. Such social interactive environments can be "supported by computers or other learners, or by both" (Brown, 1988; p. 319).

In summary, improved cognitive functioning has been shown to be related to students' involvement in metacognitive experiences (Brown, 1987). The research from these three metacognitive training approaches has also illustrated that the development of internal self-regulation is central to metacognitive development. Moreover, these studies indicate that any external support, regardless of form, will be effective for metacognitive development only when it becomes internalized by learners. Through the internalization process, individuals will be capable of generating strategies and other support for themselves. Under these enhanced self-management systems, individuals not only learn how to accomplish a particular task, but also learn how to learn (Brown, Bransford, Ferrara, & Campione, 1983). Therefore, no matter what approach is taken, the transition from external-regulated learning to internal self-regulated learning should be the focus for metacognitive training. All of these training approaches should have important implications for research in hypermedia-based instruction.

Implications to Research in Hypermedia-Based Learning Environment

What emerges from the review of the literature on metacognitive research is how learners can be trained metacognitively, how various factors may influence training, how different variables may work jointly to influence metacognitive training, and the cautions that should be considered while employing various types of training. The fundamental importance of the development of metacognitive skills is that learners will be able to guide their own learning process, make appropriate decisions independently and transfer skills to novel situations. As a metacognitive learner, one "can operate as a self-correcting system" (Rowe, 1988; p. 228) and thus is capable of exploring knowledge independently and generating strategies for one's own need. Moreover, metacognition may also enhance learners' motivation and self-esteem. Therefore, metacognitive knowledge and skills are recognized as prerequisite for academic and real life success (Rowe, 1988).

The most often mentioned learning problems in hypermedia systems are learner cognitive overload and disorientation under the situations where learners are required to control their own learning and make decisions independently. It has been suggested by several researchers that students' lack of metacognitive knowledge and skills may be one of the major reasons why learning is hindered in situations where learners are given control (Balajthy, 1990; Steinherg, 1989). When lacking metacognitive knowledge and skills, individuals cannot identify or create strategies regulating their own cognitive processes, and cannot select, adapt, access, combine and process information effectively (Rowe, 1988). If learners are capable of effectively controlling and regulating their own learning processes, they should not be confused by the flexibility and wide array of choices of the hypermedia environment. Therefore, there is a need to identify the implications of the research in metacognitive areas to the learning problems defined in hypermedia systems and suggest directions for future research that merge metacognition into the design and development of hypermedia-based instruction.

One implication arising from metacognitive research is that learner control should be more broadly defined. As described in most computer literature, learner control has been limited to the learners' selection and sequencing of events external to them. However, in addition to the external stimuli, the learners' internal systems are also operating and directing learning events. It is the promoting of internal learner control that needs to be emphasized when talking about resolving cognitive overload and user disorientation problems. Findings from metacognitive research imply that effective and efficient performance is the result of the interaction of learners' internal systems with the external stimuli which have been selected, controlled and regulated by the learners. Those learners who have developed effective internal learning systems may be able to identify what they need and to adjust their selection and control of display, content, or any external stimuli based on their internally perceived needs. Therefore, research on learner control issues in hypermedia systems should also study learner control of internal cognitive processing systems as well as internal codification schema.

Investigations of learners' internal cognitive processing systems should examine whether the learners use the most effective processing strategies available, how learners manipulate their own cognitive activities to adapt into new instructional settings, and what types of mental activities are systematically selected by certain types of learners while interacting with the system. Research is also required to assess the attitudes, motivation and attributes of different types of learners as they use hypermedia-based instruction. Another question that should be answered is how the system can be structured so that the learners will develop more effective adaptive models of their own to enhance performance in a variety of learning situations.

Controlling one's internal cognitive processes is an important aspect of metacognition. Therefore, it is necessary to investigate the types of metacognitive strategies that are important for different types of learners in dealing with specific topics given the structures of the hypermedia system. What metacognitive skills are lacking in certain types of learners while dealing with specific topics under specific system structures and why? Among those demonstrated metacognitive skills, which are the most effective for the types of learners, system structures and topics and why? Developmental data are also needed to categorize learners with different metacognitive abilities. These data should include age, maturity, cognitive style, learning experiences with hypermedia systems, motivation and attribution of learning and similar variables.

The findings that simply providing learners with controls over manipulating massive amount of unorganized information, and letting learners explore for themselves, will not be effective in improving learning also has implications for improving metacognitive abilities in hypermedia-based instruction. The real challenge for hypermedia designers and developers is not whether to impose computer control or not, but rather how to take advantage of the technology to help learners develop their own consistent internal learning capabilities to maximize those resources that are available.

A sophisticated hypermedia-based learning system should provide internal adaptive functions of some sort to provide directions for such internal metacognitive developments. Comprehension monitoring and understanding the process of one's own or other's cognitive learning should be encouraged. Providing strategy advice from the system may be ineffective or useless unless learners are informed of what strategies are available in dealing with what types of problems, how to monitor their own use of the strategies, and why, when and where to use these strategies. However, the strategies have to be perceived as important and must be practiced by the learners in order to be effective. Research has shown that learners will not automatically become involved in metacognitive processes unless forced to do so. They may be aware of the need, but do not act upon it. Thus, the systems should try to engage learners in exercising metacognitive strategies as naturally as possible. Feedback provided by the systems should reflect the nature of informed training in which learners are encouraged to find out through self-discovery what, how, why, where, and when certain answers come into being. In summary, any externally provided support or activities should have the potential to facilitate learners to transform from other-regulation to self-regulation of the learning process.

Carefully examining research findings from the metacognitive literature may stimulate ideas for designing effective and efficient hypermedia-based instruction. It is important for hypermedia researchers to identify what types of approaches are the best given certain types of learners in dealing with specific topics.

Instructional technologists should consider how to creatively merge the existing effective metacognitive training procedures into the design and development of effective hypermedia-based instruction in which learners make optimal use of the control available to them. If a self-explanation training approach is taken, it is crucial to determine the amount, the level of specificity, and the timing of the explanations that are necessary for the types of learners, topics, and systems. It is also important to investigate what types of questions human experts ask, what types of explanations they generate, and when. Such investigations may facilitate design of appropriate self-explanation training for hypermedia-based instruction.

If a strategy training approach is taken, it is important to identify the types of strategies that should be taught to certain types of learners in dealing with certain topics, and determine the order in which the strategy training should be delivered. It is also important to find out what types of strategy training (informed, self discovery, or social interactive) are most effective given the nature of learner, topic and system structure. The major concern in employing a social interactive approach is accountability of group members. Educators continually worry that one member may participate in metacognitive activities while the rest will ride on his or her coattails. How can this approach engage each member successfully in metacognitive training? The importance of motivation and self-perceived competence should also be addressed in any type of metacognitive training. Under what level of control, what types of information presentations and system structures, will learners generate high self-motivations for learning and interacting with the environment? What types of training are effective in improving learners motivation and self-confidence in learning? How will improved motivation affect metacognitive engagement? Finally, it is important to determine the impacts of these metacognitive training approaches on learners' applications of control in hypermedia systems. Will metacognitive training improve content specific and far transfer of learning? Will metacognitive training enhance learners' retention of information and understanding of the relationships among concepts? Will such training impact learners' consistency of strategy application? Will it improve learners' motivation and self-confidence in learning and interacting with hypermedia systems?

Conclusions

The metacognitive research findings are promising and encouraging in support of a positive relationship between learner control situations and learners' improved independent learning abilities as well as their motivation to learn. Findings from metacognitive research imply that learners' internal metacognitive functioning are the key for successful learning under learner control situations. Hypermedia researchers should investigate how to use the technology to help learners develop their own consistent metacognitive systems to maximize the use of the learner control provided by the system. There has not been clear guidance as to how to merge metacognitive theory with the research in hypermedia-based instruction and learning. It is not clear either what types of metacognitive training may be effective for specific types of learners given specific topics and learning environments. Because many fundamental questions related to metacognition and hypermedia-based learning still remain to be answered, the field is a fruitful area for further research and investigation.

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Title:

Collaboration as an Instructional Innovation

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The study of collaboration as an instructional strategy has been the topic of educational research for more than seventy years. Laboratory research on collaborative learning dates from the 1920's (Slavin, 1977), intensified in the 1970's and 1980's, and continues to be an active topic today (Slavin, 1991).

However, the successful introduction of collaborative methods to a classroom requires certain changes and adjustments. Students must be taught the social skills needed to work in groups; teachers must teach those skills and guide their practice; and some adjustments must be made to the organization of the class. We found the theoretical framework of diffusion of innovation to be a valuable tool in explaining how collaborative activities are incorporated into the classroom.

Last year, we began a preliminary study of collaboration in the higher education classroom. The purpose of our study was to examine how collaboration could be successfully incorporated as an instructional strategy in a class of adult learners. Research on adult collaboration in the classroom usually focuses on either learning outcomes (for example, Johnson & Johnson, 1987) or describes specific instructional tactics that can be used to promote collaboration (for example, Kagan, 1990). Our particular interest was in how collaboration can best be initially introduced, and then-maintained, as an instructional strategy.

Studies in Collaborative Learning

Collaborative learning has proven to be a powerful instructional strategy, producing consistently strong effects in both achievement and motivation to learn (Slavin et al., 1985; Johnson & Johnson, 1991; Sharan, 1980; Hamm & Adams, 1992). Cooper and Mueck (1988) define collaboration as ". . . a structured, systematic instructional strategy in which small groups work together toward a common goal." One point to note from this definition is that there is a common goal (to solve the problem, for example), but there may or may not be a common group product. Each individual may produce her or his own product in a collaborative situation.

Cooper and Mueck's definition is compatible with Slavin's (1991) stipulation that group goals and individual accountability form key components of collaborative learning situations. Instructional reward systems are often structured to provide recognition of group achievement or to assign group grades. The elements of group dependency and individual accountability also form key components in the work of Johnson and Johnson. In their exhaustive research (Johnson & Johnson, 1986) on collaboration, they describe some basic elements of collaborative learning:

- Positive Interdependence: learners feel they need each other to "sink or swim" in completing the group's task;
- Face-to-Face Promotive Interaction: interaction patterns and verbal exchanges are critical to the learners' success;

- Individual Accountability: each learner must be helped to understand and participate in the task;

- Interpersonal and Small Group Skills: learners are taught and practice abilities such as trust, communication, and conflict management;

- Group Processing: learners need the time and structure for stepping back to look at how they are functioning as a group. This metacognitive process can be aided by observations from group members and outside observers.

Our Experience

We conducted our preliminary study in a graduate-level class on technology for teachers. The class was composed of ten adult learners (three men and seven women) who were all current or preservice teachers. The three-hour class met once a week for the fifteen weeks of the semester. The principle content of the class was how to select, design and use instructional technology in the K-12 classroom (video, commercial television, e-mail, slides, interactive learning centers, CBI, etc.). The class was lecture based and often included lab sessions on the development and use of the technology. Students were required to develop a variety of media projects for the class.

The use of collaboration was considered as a technological competency. The instructor required the learners to experiment with collaboration so that they could use it themselves in their professional role as teachers, and so that they could teach their own students to collaborate. Based on Johnson and Johnson's research (1986), we devised a three-part program to train the class in collaboration: development of basic collaboration skills, coaching and practice in small group face-to-face structures, and metacognitive group processing by the learners of their collaborative activities.

Early in the semester, during the second class meeting, we conducted a three hour training session to instruct the group in some of the basic skills of collaboration (conflict resolution, listening skills, how to ask effective questions). Throughout the semester, the learners were asked to join small collaborative groups on a range of class activities. For example, groups of three learners completed the interactive computer program Oregon Trail together, then critiqued the program as a team. For another project, students were encouraged to work in groups to produce a short, instructional video. They received a group grade for this project. Two people chose to work alone, and the others formed groups of two or three people to produce the video.

Over the course of the semester, the class was required to work in collaborative groups four times. On each occasion, we provided individualized coaching and encouragement on their collaborative performance. In addition, we coached the groups to discuss and analyze their own collaborative behavior at the end of each session (see Figure 1). Group processing has been identified by Johnson, Johnson, Stanne, and Garibaldi (1990) as an important contributor to the success and productivity of groups.

COLLABORATION JOURNAL

Please take a moment to reflect on how your group used the skills of collaboration:

- Listening
- Questioning
- Resolving Conflicts
- Providing Information
- Clarifying
- Summarizing
- Making Predictions
- Elaborating/Explaining
- Expressing Empathy
- Leading
- Following
- Energizing
- Encouraging
- Compromising
- Arguing

1) One thing I think our group did well in this session was. . .

2) One thing I think our group ought to work on is. . .

3) Collaboration contributed to our productivity in this session by. . .

Figure 1. This is the format the groups used to discuss their collaborative activities. Its purpose was to promote metacognitive awareness of what they had learned and practiced, and to articulate their own goals for progress.

One of our most consistent observations about the class was that the act of collaboration seemed somewhat foreign to the students, and, off and on, they were reluctant to collaborate. They reported that they know about collaboration, and that they had collaborated successfully in other contexts. They had been told in other situations that it was important to collaborate, or told that they had to, but had never formally been taught how to do it effectively. Consequently, they lacked organized instruction, examples, practice and feedback in the skills of collaboration. They had information, but lacked the experience.

Their lack of experience should not be surprising. Our society has not placed great cultural value or invested societal resources in promoting collaboration. Judging from the literature on workplace collaboration, there is currently a desperate need to teach and encourage adults in the skills of collaboration. For example, Lunsford and Ede (1990) surveyed professionals in various disciplines about their collaborative writing experiences. Of the 700 respondents, 42 percent answered that writing as part of a team or group was "not too productive" or "not at all productive." These responses are especially disconcerting in the face of numerous surveys of professionals confirming that collaborative writing is a major activity in the workplace (Penrose, Bowman, & Flatley,1987; Couture & Rymer, 1989; Killingsworth and Jones, 1989).

Collaborative teamwork on the job has been a prime topic in business literature over the past ten years. Many of the best selling business books of the decade has been written in response to the apparent frustration and urgency of introducing teamwork in all kinds of organizations and for all levels of employees (Senge, 1990; Peters, 1992; Larson & LaFasto, 1989; Kanter, 1983; Kanter et al., 1992).

The Denver Public Schools have faced a similar difficulty in making collaboration work. Two years ago, the system was state mandated to form school-based Collaborative Decision Making Teams, composed of parents, teachers, community members, and the school principal. According to the latest comprehensive assessment, one of the most difficult problems reported by the teams has been their lack of skills and experience in collaboration (Center for Quality Schools, 1993). The teams report that this lack of skill has led to inefficiency, ineffectiveness, and high turnover in team membership.

Collaboration as an Innovation

As it became obvious to us that experience in collaboration was somewhat new to the class members, we shifted our thinking to look at collaboration not only as an instructional strategy but as an innovation as well. We reviewed the literature on innovation in order to understand the dynamics of this process. Everett Rogers' seminal work on Diffusion of Innovations (1983) provided a helpful and enlightening structure through which to organize our observations of the classes' alternating ease and difficulty in implementing collaboration.

Rogers defines an innovation as something perceived as new to the potential adopters -- in this case, our learners -- even though it might be familiar to the rest of the world (Rogers, 1983). According to the diffusion model, an innovation often involves technology, both hardware (physical tools) and software (instructions or information). In both these aspects, the diffusion model seemed to fit the situation of the introduction of collaboration into this group of adult learners. The model proved to be an appropriate choice in helping us understand the experience of the class we observed.

The Elements of Diffusion

One of the most critical concepts of the diffusion of innovations model is that of the elements in the diffusion of an innovation (Rogers, 1983). The theory states that the more of these elements that are present in any particular innovation, the more likely it will be adopted. These are the questions that potential adopters consider prior to deciding whether to adopt the innovation:

Relative Advantage. Is the innovation seen as better than that which it replaces? More economical, more socially prestigious, more convenient, more satisfying? What is the risk involved in adoption? Is it worth the change?

Observability. Are the results of the innovation visible to others, so that they can see how it works and observe the consequences?

Compatibility. How consistent is the innovation with the values, past experiences, and needs of the potential adopters?

Complexity. Is the innovation easy to understand, use, and maintain? Can it be explained to others?

Trialability. Can the innovation be tried out on a limited basis?

As we reviewed these five elements, and applied them to our observations, what we were seeing began to make more sense. Overall, the class members reported being sometimes ready and willing to collaborate and sometimes reluctant; willingness to adopt collaboration also varied with the individuals. Specific issues that surfaced in the class seemed to be captured by Rogers' elements of a successful adoption. For example:

- They wondered if the effort was worth the work (Relative Advantage).

- After the first successful collaboration, they were more willing to collaborate the second time (Trialability).

- They commented that there were too many communication rules to juggle (Complexity).

- They feared they wouldn't have time to collaborate and get their assignments done (Relative Advantage).

- They said that collaborating was hard because that they weren't used to it (Compatibility).

- Members that did not collaborate as much commented at the end of the class that those who did collaborate seemed to have more fun doing the projects (Observability).

According to Rogers theory, concerns and feelings like these will typically be experienced by the potential adopters of an innovation whether we and they are aware of them or not, and whether we and they want to deal with them or not. We believe that considering Rogers' five elements will assist us to more successfully implement collaboration by helping us decide how and when to best adopt and implement an instructional strategy like collaboration.

An Innovation Checklist

Rogers' theory states that the more of the five elements that are present in any particular innovation, the more likely the innovation will be adopted (Rogers, 1983). Looking back on our experience with the class, we realized that if collaboration were indeed an innovation, it would be helpful to give that innovation some serious consideration before adopting it. We thought it would be helpful to develop a structured way to think in advance about how to plan for successful collaboration.

We offer a checklist of questions for several reasons. First it can be a preparation tool to trigger the thinking of teachers prior to implementing collaboration. We need to assess whether we want to incorporate collaboration, how much to incorporate it, and how to design the class to support it. Secondly, we found that collaboration was an innovation to our learners, and that it was important to prepare them thoroughly as well. We offer the checklist as a way to structure a conversation with the learners so that concerns about the innovation can be considered, articulated, and taken into account when designing instruction. Here are our initial suggestions:

Relative Advantage: (Is it worth it to us?)

What is the advantage to our using collaboration in this class? What will be the advantage to the learners? What will be the advantage to the teacher? How can we support our goals while using collaborative techniques? Is there a way that this experience in collaboration will be useful to us outside of this class? How much additional time and effort will it require to prepare for and implement collaborative activities? Given everything else we are doing in this class, is it worth our time and effort? Are collaborative activities better than the ones they will replace? How can we make collaboration interesting or fun?

Observability: (Can we see it in action first?)

Can we observe how collaboration is being used in other classrooms like ours, either in person or through other media? Can we obtain information about collaboration and how it works? In our own class, can we observe our more experienced members collaborate?

Compatibility: (Does it fit for us?)

What are our experiences with collaboration, both in and out of the classroom? Is collaboration compatible with our personal and educational values? What are our group and individual needs in this class and how can collaboration contribute?

Complexity: (How complicated is it?)

How can we keep our experiment in collaboration simple to begin with? What is an easy way to describe collaboration to ourselves and others? What kind of training and coaching will be necessary in order for our group to be successful in a collaborative activity; how can we get that training?

Trialability: (Can we try it first before we bet the ranch?)

Is there a way to try out collaboration on a limited basis at first? Instead of redesigning the whole class, can we incorporate a few collaborative experiences? How could we debrief about our experiences in order to correct our mistakes and capitalize on our successes?

Conclusion

Although educational researchers may agree that collaboration is beneficial to learning, and we may agree as a society that collaboration is a worthwhile behavior, the skills of collaboration are not understood and practiced on a regular basis. If it is true that collaboration is still an innovation for us as adults in both the classroom and the workplace, then models that explain the process of innovation can help us understand how to promote the innovations we want. We have found Rogers' diffusion of innovations model to be especially useful in understanding how to better promote an instructional innovation like that of collaboration. We offer a checklist of questions based on the diffusion theory to prompt thought and discussion among students and teachers on how to promote the instructional innovations that they want to try.

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Title:

Practicing VS Future Teachers: Comparisons and Correlates of Computer Use

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Perspectives

There is much support for the opinion that educational technology—especially computer technology—could have a major positive impact on improving the educational system (See The National Task Force on Educational Technology, 1986; Shanker, 1990; Sheingold & Hadley, 1990; United States Office of Technology Assessment [OTA], 1988). Indeed, the availability of computers for teaching has increased rapidly (OTA, 1988). Yet, despite the increased availability and support for computers in teaching, relatively few teachers have integrated them into their teaching. A recent survey of teachers who were exceptional users of computers for teaching averaged only about one such teacher per school (Sheingold & Hadley, 1990). This paucity of teachers existed even though the availability of computers (59) in the schools surveyed was more than double the average number of computers (26) reported available for schools in the United States (Becker, 1989). Extraordinary availability of computers was not matched by an abundance of extraordinary users of computers. The result of this imbalance is that computers are underutilized.

This research was undertaken to gain insight into what teacher variables may be related to their computer use. First, computer use was classified as a process of the adoption of innovation (see for example Hall, 1982; Rogers 1962, 1983; Rogers & Shoemaker, 1971; Rutherford & Hall, 1982) or more specifically Instructional Transformation (Rieber & Welliver, 1989; Welliver, 1990). Secondly, teachers' computer use was examined from an internal perspective—of the influence of personological variables to levels of computer use. In a comprehensive study of the implementation of innovation in education (Berman & McLaughlin, 1977) this class of variables was excluded. Yet, information about the internal variables—the predispositions and the decision-making processes of the person—may be the most valuable for influencing behavior or performance (See also Coovert & Goldstein, 1980; Gallo, 1986; Jorde-Bloom & Ford, 1988). This viewpoint was supported by data gathered in Sheingold and Hadley's (1990) survey from which teachers who were exceptional users of computers for teaching had been characterized as being highly motivated. We focused on motivation since it appeared to be a dominant internal characteristic. From within the broad construct of motivation, Expectancy Theory (Vroom, 1964) guided the selection of variables.

Sample and Setting

Practicing teachers and preservice teachers were studied. There were 170 elementary school teachers constituting the "practicing group." Teachers were eligible to participate in the study if they and their schools met criteria which controlled for the influence of environmental factors and ensured that the of availability of computers was uniform for the groups of teachers. First, the teachers taught a variety of subjects. This was necessary to control for the influence of the dominance of computer use for a specific subject. For this reason elementary school teachers were studied since they typically teach a variety of subjects. Second, computers had to be available to teachers. Availability was defined as a computer-to-pupil ratio of 1 : 44. (In fact, all teachers' schools had a ratio of better than 1 : 25.) Third, computers had to have been available at the schools for at least three years. Four schools from an eastern state participated.

There were 167 undergraduate students constituting the "preservice" group. Two different teacher locus of control scales were used with this group. One half used the Rose and Medway scale (1981); the other section used the Maes and Anderson scale (1985). There were 86 and 81 participants respectively. The preservice teachers differed from the practicing teachers also in that they were instructed to complete the questionnaires based on their expectations (Marcinkiewicz & Grabowski, 1992).

Method

Computer use, the dependent variable, was classified into three ordered levels: *Nonuse, Utilization*, and *Integration* using the Levels of Use scale (Marcinkiewicz, in press; Marcinkiewicz & Welliver, 1993) based on the Model of Instructional Transformation. The independent variables were: innovativeness, teacher locus of control, perceived relevance (of computers to teaching) and self-competence (in the use of computers). These last three variables fit the formula of expectancy theory which was structured to predict behavior based on three elements: 1) valence—a goal one values or desires; 2) expectancy–the expectation that one's effort is capable of achieving some performance; and 3) instrumentality–the belief that an achieved performance results in attaining the valued goal (Vroom, 1964). The performance studied was the use of computers for teaching. The goal of the performance was "quality instruction." Valence of providing quality instruction was assumed to be true and positive for teachers.

Expectancy was assessed by teacher locus of control and self-competence. Teacher locus of control reflected teachers' belief in their influence over students' outcomes. The Teacher Locus of Control Scale by Rose and Medway (1981) and the Teacher Role Survey by Maes and Anderson (1985) were used. Self-competence reflected teachers' feelings of capability in achieving competence in using the computer in teaching. An originally developed measure was used. Instrumentality was assessed by perceived relevance—teachers' perception of computer use as relevant to teaching. An originally developed measure was used.

Innovativeness defined as "willingness to change" was assessed using the Innovativeness Scale by Hurt, Joseph, and Cook (1977). Data were collected for three relevant demographic variables: age, gender, and years of computer experience. An attribute which the demographics share contrasts them importantly with the other variables—they are not amenable to influence by any sort of intervention, remediation, or staff development. Yet, they may be significant in influencing teachers' computer use. All variables were assessed using a composite questionnaire.

Results

Table 1 shows the distribution of the groups by levels of computer use. More practicing teachers were at the Nonuse level than were preservice teachers. For preservice teachers, the percentage at the Nonuse level appears to be nominal.

Within the practicing group, the Nonuse and Integration levels were similar roughly half each of the group total. Within the Preservice group, the greatest number of respondents was at the Utilization level.

Table 1
Classification of Sample Groups by Levels of Computer Use

Computer Use Levels	Practicing Teachers	%	Preservice Teachers	%
Nonuse	71	43.5	4	2.7
Utilization	79	48.5	126	84
Integration	13	8.0	20	13.3
Total	163	100	150	100

Note: *n* excludes observations with missing variables.

To determine which level of computer use distinguished the two groups statistically, a chi-square test was computed. The 2 x 3 chi-square was significant $c^2(2, n = 337) = 69.06$, $p < .01$) and verified the apparent differences between the expected and the reported computer use of the groups. Nonuse distinguished these two groups the most; the value for this level contributed the most to the overall c^2. The differences in the groups at the Utilization level contributed somewhat to the c^2. The differences between the groups for the Integration level contributed nominally.

Univariate intercorrelations of all variables were also computed. The correlations between perceived relevance and self-competence were high for both the practicing ($r = .53$; $p < .001$) and the preservice group ($r = .376$; $p < .001$). The same variables were both most highly correlated with computer use for both groups: for practicing teachers, self-competence ($r = .42$; $p < .001$) and perceived relevance ($r = .33$; $p < .001$); for preservice teachers, perceived relevance ($r = .28$; $p < .01$) and self-competence ($r = .23$; $p < .05$). These relationships may support the theoretical complementary nature of these two variables.

Stepwise logistic regressions were computed to identify which of the variables contributed to computer use. A significance level of $p = .05$ was the criterion for adding and retaining variables in the regression models. For the practicing teachers, two variables were retained. Self-competence $c^2(2, n = 170) = 19.07, p < .001$ and innovativeness $c^2(2, n = 170) = 5.12, p < .05$ were identified as most closely related to teachers' levels of computer use. For the preservice teachers, perceived relevance of computers to teaching $c^2(1, n = 167) = 12.06, p < .001$ was identified as most closely related to their expected levels of computer use. No other variables from the set contributed to the predictiveness of the respective models.

There was no one predictor common to both groups of teachers, although, the high correlations between self-competence and perceived relevance for both groups suggest that these variables may share attributes.

Analysis

The reported levels of use of practicing teachers differs widely from the expected levels of use of preservice teachers. Most importantly, preservice teachers overwhelmingly expect to use computers for teaching.

As for the correlates and predictors of computer use, it appears that there are shared variables for both groups. This suggests consistency of the variables in their relationship to teachers' computers use whether actual or expected.

Educational importance

This research was motivated by the concern that practicing teachers were underutilizing computers, and that perhaps preservice teachers' expected computer use would mirror the low levels of the practitioners. The results show that preservice teachers' expectations of computer use are high. This may be an indication that the expectations of the new generation of teachers will result in more integrated computer use in teaching, allowing the promise of educational computing to be fulfilled.

Computer use was predicted for both groups by variables which are also highly correlated, namely, self-competence and perceived relevance. In planning intervention, remediation, or staff development—designing instruction for computer use, these characteristics might deserve addressing.

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Title:

Subjective Norms Predicting Computer Use

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Perspectives

There is much support for the opinion that educational technology-- especially computer technology—could have a major positive impact on improving the educational system (See The National Task Force on Educational Technology, 1986; Shanker, 1990; Sheingold & Hadley, 1990; United States Office of Technology Assessment [OTA], 1988). Indeed, the availability of computers for teaching has increased rapidly (OTA, 1988). Yet, despite the increased availability and support for computers in teaching, relatively few teachers have integrated them into their teaching. A recent survey of teachers who were exceptional users of computers for teaching averaged only about one such teacher per school (Sheingold & Hadley, 1990). This paucity of teachers existed even though the availability of computers (59) in the schools surveyed was more than double the average number of computers (26) reported available for schools in the United States (Becker, 1989). Extraordinary availability of computers was not matched by an abundance of extraordinary users of computers. The result of this imbalance is that computers are underutilized.

This study was the most recent in a series in which the relationship of teacher variables to their adoption of computer use are being systematically researched. First, computer use was classified as a process of the adoption of innovation (see for example Hall, 1982; Rogers 1962, 1983; Rogers & Shoemaker, 1971; Rutherford & Hall, 1982) or more specifically Instructional Transformation (Rieber & Welliver, 1989; Welliver, 1990).

Secondly, teachers' computer use was examined from an internal perspective--of the influence of personological variables to levels of computer use. In a comprehensive study of the implementation of innovation in education (Berman & McLaughlin, 1977) this class of variables was excluded. Yet, information about the internal variables—the predispositions and the decision-making processes of the person—may be the most valuable for influencing behavior or performance (See also Coovert & Goldstein, 1980; Gallo, 1986; Jorde-Bloom & Ford, 1988; Marcinkiewicz, in press; Marcinkiewicz & Grabowski, 1992)). This viewpoint was supported by data gathered in Sheingold and Hadley's (1990) survey from which teachers who were exceptional users of computers for teaching had been characterized as being highly motivated. From within the broad construct of motivation, Expectancy Theory (Vroom, 1964) guided the selection of variables. In this version of the research series, the variable of subjective norms was included (Ajzen & Fishbein, 1980) because it suggests a means for accounting for a person's decision making behavior by specifying influential envrionmental factors--significant other people.

Sample and Setting

There were 138 elementary school teachers from twelve schools in a rural midwestern state who participated in the study. Teachers were eligible to participate if they and their schools met criteria which controlled for the influence of environmental factors and ensured that the of availability of computers was uniform for the groups of teachers. First, the teachers taught a variety of subjects. This was necessary to control for the influence of the dominance of computer use for a specific subject. For this reason elementary school teachers were studied since they typically teach a variety of subjects. Second, computers had to be available to teachers. Availability was defined as a computer-to-pupil ratio of 1 : 12 (The state average ratio was 1 : 9). Third, computers had to have been available at the schools for at least three years.

Method

Computer use, the dependent variable, was classified into three ordered levels: *Nonuse*, *Utilization*, and *Integration* using the Levels of Use scale (Marcinkiewicz in press; Marcinkiewicz & Welliver, 1993) based on the Model of Instructional Transformation. The independent variables were: subjective norms, innovativeness, perceived relevance (of computers to teaching) and self-competence (in the use of computers). Subjective norms were measured using a measure based on the steps described by Fishbein and Ajzen (1980). Four significant others—members of the environment—were identified who may impact on the teachers intent to use computers in teaching. Subjective norms reflects a person's choice to behave based on the influence of others.

Innovativeness defined as "willingness to change" was assessed using the Innovativeness Scale by Hurt, Joseph, and Cook (1977). Data were collected for three relevant demographic variables: age, gender, and years of computer experience. An attribute which the demographics share contrasts them importantly with the other variables—they are not amenable to influence by any sort of intervention, remediation, or staff development. Yet, they may be significant in influencing teachers' computer use. All variables were assessed using a composite questionnaire.

The last two variables, perceived relevance and self-comptetence, fit the formula of expectancy theory which was structured to predict behavior based on three elements: 1) valence—a goal one values or desires; 2) expectancy–the expectation that one's effort is capable of achieving some performance; and 3) instrumentality–the belief that an achieved performance results in attaining the valued goal (Vroom, 1964). The performance studied was the use of computers for teaching. The goal of the performance was "quality instruction." Valence of providing quality instruction was assumed to be true and positive for teachers.

Teachers' feelings of self-competence of capability in using the computer in teaching were assessed to reflect expectancy. A measure developed for this study was used. Instrumentality was assessed by perceived relevance—teachers' perception of computer use as relevant to teaching. An originally developed measure was used.

Results

Table 1 shows the distribution of categories of computer use for the sample.

Table 1
Distribution of Teachers by Levels of Computer Use

Level	Number	Percentage
Nonuse	31	31
Utilization	66	66
Integration	3	3

Note. The observations with missing values were not included.

A univariate intercorrelational analysis was computed. Subjective norms, innovativeness, and perceived relevance were equally correlated with computer use ($r = .26$). The relationships may suggest a theoretical complementary nature of these variables or collinearity. Other high correlations that emerged were between perceived relevance and self-competence ($r = .53$) perceived relevance and innovativeness ($r = .42$) and innovativeness and self-competence ($r = .31$). Age and computer experience were moderately correlated ($r = .30$).

A partial correlation was computed to remove the influence of the overlapping variables to identify the variable with the strongest relationship to computer use. Subjective norms was shown to have the highest partial correlation to computer use ($r = .23$). The correlations between perceived relevance and both innovativeness and self-competence remained nearly unchanged as did that between gender and innovativeness, age, and experience.

Intercorrelations were cast to test for relationships among variables. Because of the categorical nature of the criterion variable, logistic regression procedures were computed to identify the contribution of the variables to teachers' computer use. First, the predictiveness of the entire set of variables was examined $c2(7, n = 100) = 15.7, p < .028$. Then, a stepwise procedure was computed to identify the predictiveness of individual variables. Subjective norms was retained, $c2(7, n = 100) = 5.11, p < .024$. No other variables added to the predictiveness of the logistic regression model. Another logistic regression was computed for the simple main effects of subjective norms,
$c2(1, n = 100) = 7.09, p < .01$.

Analysis

The results indicate that the selected internal variables, subjective norms is predictive of teachers' levels of computer use. These results support the theories which suggested the strength of its being an indicator of behavior—the theory of reasoned action. It is possible that the summary of studies in this series will be informative for the characterization of teachers with respect to computers.

Educational importance

This research was motivated by the concern that teachers were underutilizing computers. The goal was to identify internal variables which would predict computer use. In planning intervention, remediation, or staff development—designing instruction for computer use, teachers' subjective norms deserve addressing. It is also important to consider that the construct of subjective norms is based on one's perceptions of the expectations of others. In light of this assumption, it can be inferred that the expectations of computer use from among teachers' significant others'—principals, colleauges, students, and the profession - are influential in developing teachers' own expectations of computer use.

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Title:

Adapting Instruction to Individual Learner Differences: A Research Paradigm for Computer-Based Instruction

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Classrooms of the twenty-first century will experience great changes due to emerging technologies and the development of new instructional delivery systems. Several companies have attempted to incorporate many of the instructional strategies of effective instruction into computer-based instructional programs called integrated learning systems. An integrated learning system (ILS) consists of computer hardware and software that is generally configured as a local area network (see Figure 1). An ILS provides a comprehensive package of software called courseware that provides computer-assisted instruction on a network of computers or terminals. The courseware also includes a management system that tracks individual learner progress and adjusts the instruction to a level appropriate for each learner.

COURSEWARE

CMI Management System | CAI Programs Curriculum

USER INTERFACE SHELL

NETWORK OPERATING SYSTEM SHELL

OPERATING SYSTEM SHELL

HARDWARE PLATFORM

File Server | Workstations
Printer | Network Interface Cards

Figure 1. A Conceptual Model of an Integrated Learning System.

Computer-based instruction is having a profound impact on both the field of education and our society. ILSs are experiencing enormous popularity and sales for most of the major systems have grown, some at a near phenomenal rate (Sherry, 1992). Large textbook publishing companies have purchased ILS companies and are investing heavily in reshaping them for the future. ILSs account for a large portion of the computer-based instructional systems currently used in public schools and many educators believe that these systems will continue to become more common in public schools (Sherry, 1990a).

In the 1950s educational researchers attempted to solve learning problems by applying the techniques of behavioral analysis as theorized by B.F. Skinner through programmed instruction. The concepts of programmed instruction were then applied to crude teaching machines which first appeared in the late 1950s and the early 1960s. Teaching machines and programmed instruction were used throughout the decade of the 1960s by colleges, public schools, and the military services. Price (1989) submitted that although research on programmed instruction generally indicated that it was effective, programmed instruction never achieved a high degree of popularity because it was tedious and dull and did not fit well with group oriented, fixed-schedule school settings.

Computer-assisted instruction (CAI) was one of the earliest and most significant applications of computer technology to education. The computer industry itself was among the first to use CAI in the late 1950's when CAI was used to train industry personnel (Suppes & Macken, 1978). At a time when programmed instruction was the focus of educators for individualizing instruction, CAI emerged as a natural integration of computer technology and the programmed instruction movement (Schoen & Hunt, 1977). In the early 1960's federal funds to education provided a stimulus to develop CAI models (Atkinson & Wilson, 1969).

Early efforts to use computers in instruction developed from the guiding principles of programmed instruction. One such effort was a project at Stanford University headed by Patrick Suppes that created a complete system for computer-based arithmetic skills practice. The Stanford Project was begun in 1963 and its purpose was the development of a tutorial system to provide instruction in elementary mathematics, language arts, and reading. By the end of the second year of operation approximately 400 students received daily computer-assisted instruction in either reading or mathematics (Suppes, Jerman, & Brian, 1968). Computer Curriculum Corporation was formed in 1967 as a direct consequence of the Stanford Project and the need for curriculum-relevant CAI courseware. Computer Curriculum Corporation marketed computer-based instruction for minicomputer systems. Suppes and Morningstar (1972) validated the use of computers as effective teachers. Suppes and Morningstar maintained that the creation of many articulated programs instead of isolated topical lessons is required for computers to be used effectively to deliver instruction.

The purpose of this manuscript is to examine a research paradigm that is particularly suited to experimentation related computer-based instruction and integrated learning systems. This model for research is relevant when an experimental treatment incorporates an individualized or adaptive instructional strategy. Computer-based instruction possesses the attributes necessary to provide both the adaptive learning strategies and management capabilities for highly individualized instruction. The model is applied to an instructional treatment using a popular integrated learning system by Computer Curriculum Corporation (CCC).

Theoretical Bases for Research on Integrated Learning Systems

Recent theory development in human learning and cognition has narrowed the focus of educational research to variables and conditions that are directed to the promotion of learning rather than the improvement of teaching. The research paradigm for educational technology has evolved from testing an instructional technology, media, or method versus conventional instruction to one that identifies possible instructional variables that facilitate learning. A large number of the studies concerning the use of computers for instruction are described as media comparison studies (Parry, Thorkildsen, Biery, & Macfarlane, 1985). These studies generally emphasize the instructional capabilities of the media with little or no regard to the components of instruction and learning including instructional objectives, instructional strategies, learner characteristics, or the content of the instruction.

Salomon and Clark (1977) attribute the migration of educational research away from media comparison studies to a distinction in the ranks of researchers between "research with" and "research on" media (p. 102). Salomon and Clark further explain that research with media considers media as modes of stimulus presentation and provides little knowledge about the specific medium used, nor does it provide insights about how learners learn. Research on media deals with the relevant attributes of media that interact with individual differences to promote learning. Clark (1983) makes the analogy that media are vehicles that deliver instruction but do not influence student achievement any more than a truck that delivers groceries causes improvements in nutrition. While media comparison studies may indicate that one method of presentation is better than another under a given set of circumstances and based on student achievement measures, the studies fail to demonstrate which attributes of the instruction are responsible for the results (Stowitschek & Stowitschek, 1984). Media comparison studies limit the extent to which component variables are defined and operationalized (Parry et. al., 1985).

Differences in learning using instructional media should be attributed to certain characteristics of the instructional medium that provide conditions to facilitate learning. Research using media first considers a medium's attributes and determines its ability to actually relay these strategies. What is implied here is to study the capabilities of the medium and determine which instructional strategies it effectively conveys. If computers are utilized as a modern delivery system for instruction, research questions regarding the effectiveness of computer-based instruction should concern variables related to media attributes and instructional design.

One of the primary goals of computer-based instruction is to optimize learning through individualized instruction (McCombs, Eschenbrenner, & O'Neil, 1973). Computer-based instruction provides adequate technology to produce a learning environment that adapts instructional presentations to the individual differences of learners than would be possible under instructor management alone.

Since computer-based instruction is a relatively new instructional tool, many researchers and educators are interested in its potential to enhance learning. Much of the research comparing computer-based instruction to other instructional methods or media provides evidence of significant learning gains using computer-based instruction. Although the research indicates that computer-based instruction often promotes more learning than some other medium or method, these learning gains may be attributed to some feature of the media rather than the media itself. Clark (1983) maintains that there is clear evidence of consistent confounding in the research and submits that the confounding variable is the design of the instruction. Computer-based instruction generally requires a greater effort to design the presentation than the comparative media. Clark (1984) concludes that learning gains are attributed to adequate instructional design theory and practice and not from the medium used to deliver instruction.

The main contributions of evaluative and comparative research related to computer-based instruction may be the cost benefits and learner motivational issues to be considered when using computers for instructional purposes. The most constructive insight to be derived from this research is that although the computer as a medium may not possess any intrinsic value for increasing learner achievement, the important issues for research with computer-based instruction are concerned with the design variables used in the development of computer software.

Definition of Terms

Most terminology in this manuscript is used in the conventional sense of educational research. However, some terms require additional explanation for specific usage in this manuscript.

Adaptive Instruction. An adaptive instructional strategy uses one or more procedures to modify instructional activities to adjust for the variance in the aptitudes of learners. For purposes of this investigation adaptive instructional strategies are inference made by a computer program about the aptitudes of learners that modifies the instructional presentation--usually by increases or decreases in the grade level, quantity, tutorial assistance, or speed of the presentation. Atkinson (1976) describes adaptive instruction as a process in which the sequence of instructional presentation and activities vary as a function of a learner's performance history. Hansen, Ross, and Rakow (1978) define adaptive instruction as a corrective instructional process that facilitates appropriate interaction between the learner and the learning task by systematically adapting the allocation of learning resources to the learner's aptitudes and recent performance. Hativa and Lesgold (1991) state that instructional software systems adapt instruction mainly to learning-rate differences. Corno and Snow (1986) note that the most direct manifestation of cognitive aptitude differences is learning-rate differences and that instructional designers usually build programs that adapt to learning-rate differences through individualized pacing with repetition.

Aptitude. Aptitude is generally considered to be a broad, multivariate concept that refers to the individual differences among learners (Corno & Snow, 1986). For purposes of this study aptitude is defined as a variable that is measured in terms of time. According to Carroll (1963) aptitude is the amount of time that a learner is willing to attend to a learning task in relation to the amount of time required by the learner to learn the task. The amount of time a leaner needs to learn a task under these conditions is the primary measure of the variable called aptitude. The measurement of aptitude is inversely related to time such that Carroll noted that "the shorter the time needed for learning the higher the aptitude" (p. 726). This notion of aptitude is particulary useful for research on integrated learning systems because individual differences among learners may be quantified as measures of engaged learning time and gains as recorded by the management program.

Computer-based instruction. Many discussions of computer-based instruction distinguish between computer-assisted instruction (CAI) and computer-managed instruction (CMI). In CAI the learner receives all of the instruction from the computer including tests and performance feedback while in CMI all learner testing is virtually accomplished on the computer but the learner may be directed to other media for further study (McCann, 1981). In this manuscript computer-based instruction includes both CAI and CMI or any comprehensive instructional system using computer hardware, software, and/or computer networks to deliver instruction.

Courseware. Courseware is software that is designed specifically for educational and training purposes. Courseware is a program or bundle of programs that provides instruction using a computer. In this manuscript courseware includes both the management and instructional components of the software.

Invidivualized Instruction. In this manuscript individualized instruction is a term used to denote the effects of adaptive instructional strategies. Individualization of instruction takes place when adaptive instructional strategies account for individual differences among learners and adjust instruction to a level and mode of presentation that is appropriate for each individual learner.

Strands. Strand is a term used by the CCC integrated learning system to define a set of exercises in one content area and arranged in order of increasing difficulty. A strand contains only exercises involving a particular skill or content area and spanning several grade levels. Skills are linearly ordered within each strand and are assigned approximate grade-level equivalents. Skills are presented in a cyclic pattern by introducing a skill at a lower grade level and then embedding it within another context and in a more complex exercise at higher grade levels.

Description of Integrated Learning Systems

Integrated learning systems are also called integrated instructional systems (IISs), integrated teaching systems (ITSs), or intelligent learning systems (ILSs). Van Horn (1991) describes ILSs as microcomputer systems that contain multi-year curriculum sequences. Maddux and Willis (1992) describe ILSs as comprehensive packages of software and hardware used for accomplishing educational goals, usually utilizing a local area network.

An ILS compiles an instructional program at the level a learner begins instruction and then continuously updates the instruction according to a cumulative assessment of learner progress. An ILS assesses a learner initially and then continuously during instruction and iteratively adapts the instruction to improve acquisition of knowledge. An ILS generally possesses an assortment of instructional variables and conditions to adapt the learning interface to the individual differences among learners. They contend that an ILS demonstrates characteristics generally associated with an experienced teacher such as knowledge and application of learning theory, subject matter expertise, appropriate assessment and measurement, and management of an effective and efficient learning environment.

Norton and Resta (1986) suggest that ILSs are the consolidation of two branches of instructionally related computing: (1) computer-assisted instruction (CAI) utilizes the computer as an instructional medium to provide tutorials and drill and practice of related skill areas; and (2) computer-managed instruction (CMI) utilizes the computer as a management information system enabling teachers to cope with the record-keeping requirements of individualized instruction.

Sherry (1990b) provides a number of general characteristics which describe the design and function of ILSs:

- Computer-based in which a majority of instruction is accomplished on a computer system.
- A networked system of multiple microcomputers or terminals.
- A management system which collects and maintains student records, prints reports, and provides diagnostic/prescriptive information for students based on individual progress.
- Courseware that spans several grade levels and several curricula (math, reading,

and language)
• Ongoing upgrades, revisions, and expansion of existing courseware.
• Links its lessons to an accepted standard curriculum and suggests sequences for lessons.

Maddux and Willis (1992) define ILSs as comprehensive packages of software and hardware used for accomplishing educational goals, usually utilizing a local area network. They suggest that ILS courseware accomplishes the following tasks:

• Assessment and diagnosis of student skills
• Delivery of instruction
• Continuous monitoring of student performance and automatic adjustment of instruction
• Generation of student and class performance data in a variety of formats

Instruction is individualized and personalized with ILSs and teachers are able to identify and individualize remedial activities. According to Bailey and Lumley (1991) the underlying instructional objectives of ILSs are based on individualized instructional strategies. These strategies include random generation of problems, adjustment of the difficulty and sequence of problems based upon learner performance, and provision of appropriate and immediate feedback.

Features of Best-Known Integrated Learning Systems

Several companies have invested heavily in ILSs in recent years. These companies include Computer Curriculum Corporation now owned by Paramount Communications, Curriculum Networking Specialists, Ideal Learning, Jostens Learning Corporation, MacMillan/McGraw-Hill, New Century Education Corporation, PLATO Education Services--The Roach Organization, Wasatch Education, and WICAT Systems. While each ILS may utilize distinctive instructional strategies and management approaches, there are many hardware, software, and instructional features and characteristics that ILSs have in common. These commonalities among ILSs are examined in more detail in this section.

Instructional Strategies

The instructional goals of the various ILSs cover a wide spectrum. Some systems are designed to be used for remediation, others for comprehensive instruction, and others for development of higher-order thinking skills. The instructional strategy used in the development of lessons can be categorized as either "skills-based" or "concept-based" (Wilson, 1990). Skills-based programs are designed to provide diagnostic or prescriptive intervention for remediation of precise skills. Concept-based programs are designed to develop problem-solving and higher-order thinking skills.

While many segments of ILSs consist of drill and practice and tutorials, a number of the systems offer more open-ended activities that combine basic skills development with an emphasis on problem solving and higher-order thinking skills. Many systems are incorporating tools for research and exploration by adding word processors and reference tools (electronic encyclopedias, atlases, and dictionaries) to their systems.

Maddux and Willis (1992) argue that ILSs generally follow a behavioral, competency-based model of instruction that was more popular in the past than it is today. They charge that ILSs do not fit well with the cognitive models of learning and teaching that have largely replaced behavioral theories. They criticize ILS vendors for commercial exploitation and being unresponsive to changing circumstances and developing turnkey systems that reflect the desires of the vendors and not the needs of teachers, parents, and students.

White (1992) declares that one's basic educational assumptions determine if ILS instruction is "good" education. According to White, ILS instruction provides systematic exposure to the curriculum, individualized pacing and review, tracking of errors and re-exposure to more instruction in order to reach the desired mastery level, and accurate and comprehensive records of each learner's progress. ILSs offer systematic drill and practice based on the premise that some learning has to be practiced until it is automatic, such as reading, vocabulary acquisition, and estimating of quantities. The more systematic the practice, the sooner the skills are mastered.

Shore and Johnson (1992) note that ILS vendors follow an instructional design and development process that attempts to ensure that the instructional strategies of the ILS are effective. They explain that the product development process at Jostens Learning Corporation begins by gathering information from teachers, school administrators, and parents in dozens of school systems within and outside the United States. The field data is evaluated and concepts grounded in theoretical, curricular, and instructional design expertise are developed.

Curriculum Areas

The most common curriculum among ILSs is mathematics followed by reading or a combination of reading and language arts. Science, computer skills, computer tool skills (word processing, spreadsheet, database), social studies and foreign languages are included in several of the systems (Wilson, 1990). Several systems include modules for GED preparation and ESL.

Computer Curriculum Corporation (CCC) and Jostens Learning Corporation software both offer learning activities appropriate for the development of higher-order thinking skills and problem solving. Computer Networking Specialists (CNS) specializes in reprogrammed versions of third-party software distributed through its Classworks management system. Customers select software from a list that includes programs from many leading educational software publishers. New Century Education Corporation offers a special reasoning skills module for grades three through nine. PLATO 2000 software offers courseware that includes modules which teach job search strategies, life coping skills, and parenting skills. Students using Wasatch Education System software have access to an online spelling checker, calculator, graphing function, Logo Language, glossary, database, and word processor while performing learning activities. WICAT Systems courseware is designed and keyed to complement major textbooks and several national and statewide tests used in schools today.

According to Power On! New Tools for Teaching and Learning, a 1988 report produced by the U.S. Congress's Office of Technology Assessment, the size and age of an ILS company corresponds to the grade span and scope of the courseware offerings. Bigger and older companies offer greater coverage while newer and smaller companies target fewer subject areas and a narrower range of grade levels.

Management Systems

Generally, ILSs provide sufficient program capabilities to manage a learner's program and measure the achievement of objectives. However, management programs vary greatly among the ILSs. The management approaches range from simple tracking of a student's time spent on a given learning activity to a complete evaluation of a student's programs each time the Enter key is pressed (Wilson, 1990).

In the past several years some of the ILS companies made significant changes in their management systems in response to customers' concerns for more flexibility and openness. Jostens and WICAT developed instructional management tools to integrate a broad set of curriculum materials. Several companies now offer systems that can simultaneously manage several different hardware platforms. Some of the management systems make it easy for teachers to create customized, multidisciplinary course sequences. Several of the ILSs allow educators the ability to customize student reports.

Some companies are favoring an approach that leaves more management control in the hands of teachers over an approach that automatically assesses students and assigns lessons. Additionally, some companies have added new testing and prescription capabilities that reflect the objectives of widely-used standardized tests and then provide individual prescriptions specific to those tests' requirements (Sherry, 1992).

Learner Characteristics

Most educators subscribe to the premise that individual learning differences, characteristics, and abilities exist among learners and that these factors should be taken into account in instruction. In a heterogenous classroom each individual has a different set of prior skills and understandings. Instructional activities are best constructed on an individual basis. ILSs have the capability to evaluate the achievement level and monitor the progress of all learners using the system across all grade levels, domains, and abilities. Learners are automatically channeled to appropriate lessons by the ILS.

Hardware Platforms

The ILS industry has been quick to respond to new developments in the personal computer market. The majority of the established systems operate on an MS-DOS network. However, with the introduction of a competitively priced color Macintosh several ILSs now offer Mac versions of their systems. A few companies still offer Apple II courses, but most new offerings do not run on an Apple II. Many of the ILS companies are moving to support their software under a Windows environment on IBM and IBM-compatible machines. The trend appears to be that within a few years all ILS vendors will offer their systems on Windows and Macintosh platforms only (Sherry, 1992).

Multimedia, Third Party Software, and Other Features

Multimedia is impacting the ILS world with more and more systems offering high quality sound effects, digitized human speech and music, still photos, animation, and video Several ILSs use CD-ROM to deliver encyclopedias with a variety of multimedia elements and some systems allow students to record and playback their own voices.

Another trend in the ILS industry is to offer networked versions of popular stand alone software as options on the ILS. Additionally, many ILS companies are making it easier for school districts to launch third-party software from within the ILS. Some systems are going a step further by allowing third-party software to be included and delivered as part of the basic course activity sequence. This approach allows teachers to implement a combination of ILS courseware and third-party software.

Jostens and WICAT have developed instructional management tools that integrate a wide range of curriculum materials. These tools allow educators to develop a curriculum design that links ILS courseware with school-district objectives, lessons plans, and other off-line materials. Some systems allow teachers to create customized, multidisciplinary course sequences by picking and choosing from available ILS offerings.

ILS Configurations

Although most ILSs are designed around a local area network, several implementation patterns are utilized in different educational settings. In a lab configuration all the computers in the network are physically located in one room or area of a building. A coordinator or aide may schedule students or classes in the computer lab and manage the operations of the computer network (hardware and software). The lab coordinator or aide may also tutor students while in the computer lab.

In a distributed system several workstations in the network are located in various classrooms around the school building or school system. Since computer resources are distributed to various learning areas, a distributed system requires the classroom teacher to manage computer resources.

A Research Paradigm for Conducting Research with ILSs

As the costs of computing technology have steadily declined, the availability of computer-based instruction has become a reality for classroom applications. Most courseware includes advanced features such as graphics and animation, interactivity, and individualized feedback. Although these features certainly enhance the appeal of computer-based instruction, the fundamental questions regarding computer-based instruction ask how well the instruction actually teaches and how much the learners actually learn.

Research findings that examine the effectiveness of computer-based instruction are often positive (Bangert-Drowns, Kulik, & Kulik, 1985; Kulik, Bangert, and Williams, 1983; Kulik & Kulik, 1987), However, these findings are not always convincing or consistent enough to sanction computer-based instruction as better than conventional instructional strategies (Clark, 1983; Salomon & Clark, 1977). One of the goals of research related to computer-based instruction is to determine better ways to utilize its attibutes, features, and delivery capabilities more productively.

The research regarding computer-based instruction is generally organized around the dual role of the computer in providing effective instruction. Some researchers advocate the use of the computer as a problem-solving aid or tutor (CAI) in a conventional educational environment while other researchers champion the computer in the role of managing instruction (CMI). This study considers the effectiveness of of both the CAI and CMI capabilities of computer-based instruction through an investigation of the adaptive instructional strategies used in the courseware of a popular ILS.

The main assumption of this research paradigm is that one of the most powerful capabilities of computer-based instruction and, specifically integrated learning systems, is the capacity to adapt instruction to the individual differences that exist among learners. Through individualized or adaptive instruction ILSs have the potential to deliver an appropriate level of instruction for all learners and, therefore, improve instructional efficiency and effectiveness. The research model described in this manuscript considers the adaptive learning strategies by Computer Curriculum Corporation's (CCC) courseware. The CCC Curriculum Profiles (1989) describe CCC courseware as "performance-based instruction that leads to rapid academic gains" (p. 2) as a result of an individualization process that continuously adapts instruction for each learner.

Adaptive instructional strategies facilitate learning by adjusting learning conditions to the individual learning differences among learners (Tobias, 1976; Rothen & Tennyson, 1978). A computer based adaptive instructional strategy employs on-line, iterative algorithms to access an extensive data base and adjust the learning environment to the unique learning characteristics and individual differences of each learner (Tennyson & Rothen, 1979). The underlying assumption of a computer-based adaptive instructional strategy is that the effectiveness of the learning process is increased over conventional instructional methods because learners receive only the amount of instruction required to master the instructional objectives (Rothen & Tennyson, 1978).

According to Rothen and Tennyson (1978) the primary data sources for implementing adaptive learning strategies are pretask measures and on-task measures of learner achievement. Pretask measures are used to diagnose a learner's aptitude for learning particular skills and are derived from such measures as scores on an aptitude or achievement tests or pretest scores on the learning task. On-task measures are based on an analysis or evaluation of learner performance during the instruction. Rothen and Tennyson claim that pretask and on task measures of learner achievement using adaptive instruction differ substantially from data obtained using conventional instructional methods. Conventional instructional methods identify how the learner answers but do not identify the cognitive strategies leading the learner to the answer. Tennyson and Rothen propose that the most important consideration of an adaptive instruction strategy is to identify psychological causes for learning and therefore decrease the probability that mistakes will occur.

The adaptive strategies frequently employed by commercial courseware are often weak and involve merely determinations of pacing and sequencing that are derived internally by the learner or externally by the computer program (Ross & Morrison, 1988). Learner control strategies are adaptive only to the extent that learners possess the appropriate knowledge, maturity, and motivation to apply effective judgements about their learning needs (Carrier, Davidson, & Williams, 1985, Ross, 1984; Ross & Morrison, 1988, Steinberg, 1977). The elaborate management system of ILSs purportedly possess the

531

capability to provide a comprehensive strategy for adapting instruction based on both pretask and on-task measures.

Another assumption evident in this research model is that individual learners require different levels of instruction based on their aptitude in the skills being taught and that measures of prior learning generally constitute strong indicators of learning needs in inverse relation (e.g. low prior achievement indicates a need for high instructional support) (Tobias, 1976). This study hypothesizes that an ILS adapts the magnitude of instructional support for each learner through successive revision of the difficulty, type, quantity, and sequence of instructional activities and exercises based on the on-task learning trends of the learner.

Stated another way, the problem of adaptive instruction is to diagnose in any group of learners where each is located in regard to individual learning characteristics and the nature of the knowledge and performances required at a given point in the instructional process (Seidel, 1971). Once this assessment is made, the control processes of the instructional system must utilize the feedback from the learner to continuously refine the estimate of the learner's progress. The focus of research for the model described in this manuscript concerns the adequacy of the adaptive learning strategies utilized by a model integrated learning system to accurately assess a learner's achievement level and provide an appropriate amount of instructional support.

A Micro Theory of Adaptive Instruction

Most applied individualized instruction models or programs such as mastery learning or Keller's (1968) Personalized System of Instruction (PSI) establish conditions for learning based on high instructional support that features the availability of as much time and resources as the learner requires to achieve the learning objectives. A frequent problem with these approaches to individualized instruction may be the selection of too much support by high achievers and too little support by low achievers due to the fact that personal prescriptions as to how much instructional support is necessary for each learner are not provided, leaving it to the learner to make those decisions (Ross, 1984). Interest in this problem and the potential that computer-based instructional systems possess for adapting instructional support to individual differences among learners has prompted some researchers to propose alternative designs of individualized instructional models.

Ross and Morrison (1988) developed a model for systematically adapting the amount of instructional support to individuals. The pre-instructional components of the model consisted of selecting predictor variables, developing predictive equations, and selecting appropriate instructional prescriptions. The instructional components consisted of prearranging and administering learning materials according to the individual learner's prescriptions, administering a formative lesson posttest upon completion of each lesson, and use of the lesson posttest to refine instruction. The Ross and Morrison model selected pretask (entry) variables as a basis for predicting learner performance. As a result of prior research (Hansen, Ross, & Rakow, 1978; Ross, 1984; Ross & Rakow, 1982) Ross and Morrison developed predictive equations about learner achievement by regressing lesson subtest scores on entry variables.

Data analysis in educational research is traditionally performed using classical statistical theories that compute a coefficient based on some sort of group average. When research projects examine the effects of individualized instructional strategies, the analysis must compute a coefficient based on factors that characterize a different treatment for each individual learner because the treatment is different for each individual learner. Macken, Suppes, and Zanotti (1980) explained that such a design is more appropriate for research projects that analyze individualized instruction because this design considers a different treatment for each individual learner. Macken et al. argued that a global analysis of data involving individualized instruction requires operationalizing on factors that characterize the individual treatment conditions.

Suppes, Fletcher, and Zanotti (1975, 1976) proposed a micro theory for analyzing and evaluating individualized instruction. The model is similar to the Ross and Morrison (1988) model. In the Suppes et al. model the amount of time a learner spends on a learning activity is a function of the learning progress made by the learner. A learner's achievement as related to the course objectives is expressed as post-treatment grade placement. This theory was tested and used to achieve precise individualization of instruction both in the quantity of instruction and the achievement goals for each learner (Malone, Suppes, Macken, Zanotti, & Kanerva, 1979; Suppes, Macken, & Zanotti, 1978; Suppes et al., 1975, 1976).

Suppes et al. (1975, 1976) micro theory of individual performance expresses a predictive equation about expected learner outcomes using variables based on the individual performance of each learner. Each learner's progress through a curriculum, the learning trajectory, is expressed by a family of curves in the form

$$y(t) = bt^{k} + a$$

where $y(t)$ is a learner's grade placement, t is the amount of time spent in the curriculum, k is a parameter estimated for a particular curriculum, and b and a (slope and intercept) are individually estimated for each learning trajectory.

Malone et al. (1979) refined this micro theory model to predict a future trajectory based on observations of past performance. In an analysis of ten possible models Malone et al. determined that a model in which the learning trajectory increased linearly from the last observed point at a learning rate b that is the slope of a line determined by data for all learners best predicted future achievement. The learning trajectory for this model is expressed in the form

$$y(t) = b(t-t_r) + a(t_r)$$

where $y(t)$ is a learner's predicted grade placement after t amount of time spent in the curriculum, b is the slope of a line that best fits all the points for all students, t_r is the time of the most recent observation, and a is the grade placement at the intercept. This model basically predicts that a learner's estimated grade placement continues to rise from the last observed point at a rate that is about the average rate for the population as a whole.

A corollary of this model postulates that a learner's grade placement increases with the square root of engaged learning time was also determined by Malone et al. (1979) to effectively predict future achievement. This model takes the form

$$y(t) = b(t^{.5}-t_r^{.5}) + a(t_r)$$

Malone et al. (1979) distinguished two uses of this model as curve fitting and prediction. They explained that the model may be used to approximate student learning curves based on data from an entire school year or the model may be used to predict grade placement at some future point based on observed data for part of the school year.

A critical feature of the adaptive models and theories advanced by Suppes et al. (1975, 1976), Malone et al. (1979), Ross and Morrison (1988), and Ross and Rakow (1982) is the capability to formulate prescriptions systematically tailored to the inferred needs of individual learners. This critical feature of adaptive instruction provides a basis for the primary research objective proposed for the model described in this manuscript that it is possible to determine reliable prescriptions for learner achievement when an instructional model is effectively adapting instruction. Furthermore, one way to measure the effectiveness of an adaptive learning strategy is to measure the reliability of predictions about learner achievement based on observations of learners' past achievement during the adaptive treatment. Specifically, this manuscript proposes to extend the micro theory research of Suppes et al. and Malone et al. by correlating the predictive quality of an instructional treatment with the adaptive quality of an instructional treatment.

The present research proposal identifies and describes the adaptive processes and strategies programmed in the CCC courseware and hypothesizes the predictability of learner outcomes based on the adequacy of these adaptive mechanisms. To determine the adaptive quality of the instruction provided by the CCC integrated learning system, several research questions are considered. Is the instructional treatment sufficiently adaptive to formulate reliable predictions about individual learner achievement? Does the CCC integrated learning system provide a better estimate of learner aptitude than an external measure of achievement? Does increased instructional time provide a more reliable prediction of learner achievement?

CCC Instructional Design

CCC courseware is organized into strands that contain a sequence of exercises from the same content area. Exercises within strands are grouped into equivalence classes and ordered according to their relative difficulty. Grade levels are assigned to each equivalence class according to the appearance of similar exercises in elementary textbooks and standard achievement tests (Malone, et al , 1979). During an instructional session a learner receives a random mixture of exercises from all the strands appropriate for that learner's grade level and then the difficulty level of exercises is adjusted to the learner's achievement level in the strand. The management system determines a weighted average of the learner's grade placement across all strands in a course (Macken et al., 1980). This grade placement across all the strands is the variable that is of particular interest for this study in determining the adequacy of the adaptive strategies employed by the courseware.

According to the CCC Curriculum Profiles (1989) CCC employs a mastery learning model in their integrated learning system. The CCC learning model bases proof of mastery on answer patterns rather than on a percentage of correct answers. This strategy ensures that each learner automatically advances within a skill area as soon as mastery is achieved. Progression through a skill area is paced by the learner's actual performance. CCC maintains that this performance-based strategy based on answer patterns keeps learners fully engaged and challenged. The Curriculum Profiles state that CCC courseware can produce rapid academic gains in learners as a result of an individualization process that produces instruction that is continuously adapted for each learner. Several features in the design of CCC courseware contribute to the individualization of instruction:

- The foundation of the instructional strategies employed by CCC courseware is the availability of a comprehensive curricula in several skill areas. In order to individualize and adapt instruction for a large number of learners working at a variety of skill levels a vast amount of instructional material is required.
- Initial placement motion adapts the beginning level of instruction to learner performance. During the first ten sessions a learner spends in a course, the system automatically adapts the level of instruction to the learner's functional level based on the learner's actual performance regardless of initial enrollment level.
- Special tutorial support in the form of focused sequential practice, interactive tutorials, repeated prerequisite instruction, and immediate or delayed review is activated when a learner has difficulty in mastering a learning objective.

<u>CCC Adaptive Instructional Strategies</u>

CCC courseware attempts to improve learning conditions through individualized instruction in which learning activities are continually adapted to individual learning differences. The CCC courseware used for this study is Math Concepts and Skills. The Teacher's Handbook for Math Concepts and Skills (1991) identifies several adaptive strategies that occur in this program:

(1) <u>Motion algorithms.</u> A learner's path through the curriculum is determined by an evaluation of his or her performance by the automatic management system as the learner works each exercise. The management program uses this evaluation to select the next exercise or tutorial. Therefore, each learner advances through a course along a unique path that is shaped dynamically based on the learner's responses. The selection of exercises during a learner's session is based on the learner's performance level in each active content area or strand and the sequence of responses the learner makes to the exercises. A skill remains active until the learner demonstrates mastery of it or takes the maximum number of exercises allowed for the skill. Figure 2 summarizes the decisions the CCC management system makes while a learner works a sequence of exercises in a particular skill.

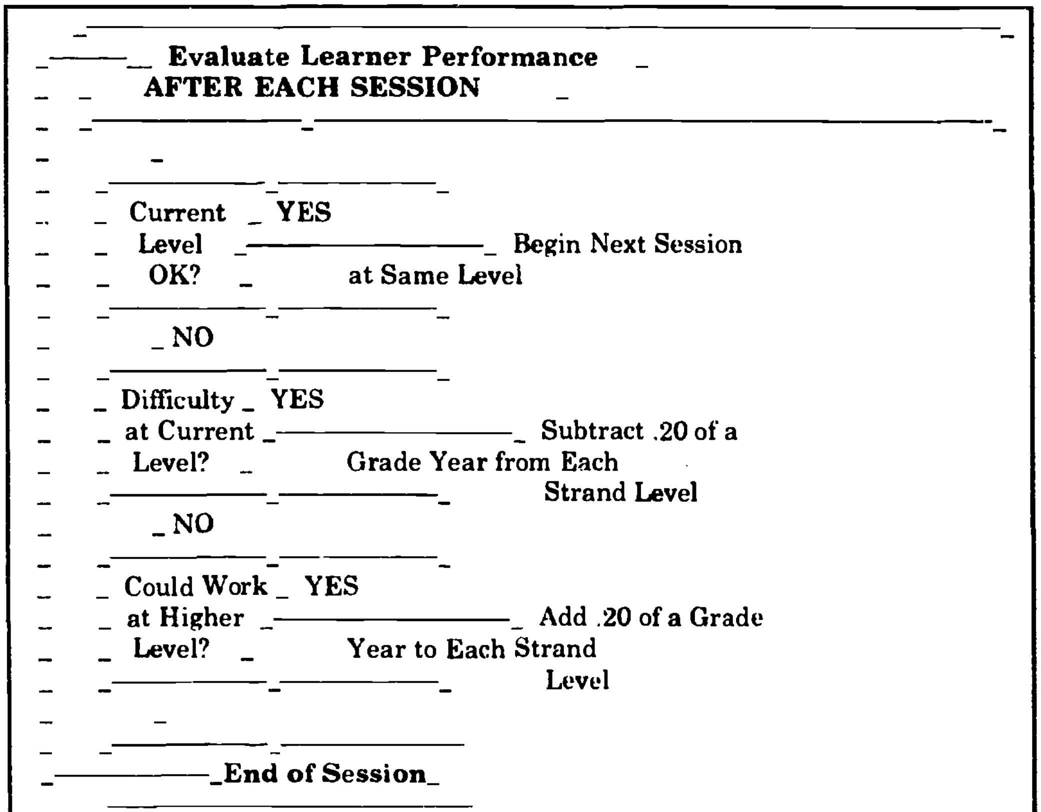

Figure 2. Decision process used to determine Initial Placement Motion in CCC's Math Concepts and Skills.

(2) Initial Placement Motion (IPM). IPM is an adaptive process that successively revises the learner's grade level in each strand as set by the standard course motion. Each learner is enrolled in the course based on performance or achievement external to the program. The IPM process is active during the learner's first ten complete sessions and evaluates learner performance and revises the learner level at the end of each session as shown in Figure 3. The assumption is made by the CCC management program that the duration of IPM and the magnitude of its increases are such that the process provides a comparable measure of the learner's performance and stabilizes on the learner's functional level in most cases.

(3) Proportion of exercises. The proportion of exercises presented from each strand is based on a fixed proportion and an individualized proportion. The fixed proportion weights each strand relative to the other strands and is derived from the standard weighting provided in most elementary mathematics textbooks. The fixed proportion sets the initial probabilities the

management system follows in selecting strands and is modified by the management system for an individual learner based on his or her performance in the strands. When a learner falls behind in a particular strand, the proportion of exercises provided to a learner in the respective strand where the learner is below his or her average level is automatically increased. Adjustment of the individualized proportion is independently determined for each learner.

Evaluate Learner Performance
AFTER EACH EXERCISE

Learner Performance Excellent? — YES → Pass current skill and select and present next skill
NO ↓

Learner Performance Good? — YES → Present another exercise from current skill using mixed presentation format
NO ↓

Learner Performance Lower? — YES → Present another exercise from current skill using sequenced practice format

Learner Performance Low? — YES → Present tutorial for skill if available
NO ↓

Continued Low Performance? — YES → Present series of prerequisite skills
NO ↓

Not Reached Mastery after 20 ex.? — YES → Mark skill for review immediately or later depending on skill
NO ↓

No mastery after all instruction? — YES → Complete skill without mastery and move to next skill

End of Exercise

Figure 3. Decision process used to deter[mine] standard motion and learner progress in CCC's Math Concepts and Skills.

Several system resources allow learners to control the instructional process. These resources include Help, Audio Repeat, and Tutor. Help provides an example of how to answer a particular exercise. Audio Repeat is present during any session that includes exercises in which audio instructions and reinforcement are available. General tutorials provide examples of how to work a particular type of exercise. Context-specific tutorials explain a specific step or operation in an exercise.

CCC Courseware Content and Structure

According to the Teacher's Handbook for Math Concepts and Skills (1991) the skills presented by the course reflect the content of current elementary mathematics. Course content includes a broad range of higher-order thinking skills to complement the basic skills taught in the course. Math Concepts and Skills is organized by grade level within each strand. Each objective in a strand includes at least one sample exercise. There are 16 content areas or strands and a total of 1,186 mathematics skills that are typically taught in kindergarten through the end of the eighth grade. The CCC management program adds or drops strands as learners progress through various grade levels of the course.

The Teacher's Handbook for Math Concepts and Skills states that the most effective way to ensure long-term rentention of skills is a "mixed presentation . . . in which the student sees a mixture of exercises from all the strands active at his or her grade level" (p. 14). Course sequencing employs a mixed presentation strategy by selecting exercises from several strands during each session.

Math Concepts and Skills uses two formats for presentation of math exercises on the computer screen. Standard arithmetic formats require learners to respond by typing words or numbers. Graphic formats use graphic representations of figures and objects to illustrate concepts and skills and learners respond by clicking the mouse pointer on objects on the screen, moving objects, drawing lines, or entering numbers or words. Both exercise types are instructional, reinforcing, and corrective.

Hypotheses and Research Objectives for Micro Theory Research

There is evidence in research related to learning and instruction that individual learners require different levels of instruction based upon their aptitude in the skills being taught. There is further evidence that measures of prior and on-task achievement generally provide strong indicators of individual learning needs. Computer-based instructional systems possess the potential for adapting instructional support to the individual differences and aptitudes among learners.

Rather than employ classical statistical theories that compute a coefficient based on some sort of group average, research projects that examine the effects of individualized instructional strategies should compute a coefficient based on factors that characterize a different treatment for each individual learner because the treatment is different for each learner. This paper proposes research objectives that examine the effects of the adaptive instructional strategies employed by the CCC integrated learning system by formulating a predictive equation for each learner about expected learner outcomes using variables derived from the individual performance of each learner. This predictive equation is based on a theory developed by Suppes, Fletcher, and Zanotti (1975, 1976) in which the amount of time a learner spends on a learning activity is a function of the learning progress made by the leaner. A learner's achievement as related to the course objectives is expressed as post-treatment grade placement.

Based on the adaptive processes and strategies employed by CCC courseware, this paper proposes four research objectives that hypothesize the predictability of learner outcomes as a result of the adequacy of these adaptive mechanisms. These research objectives are relevant for validation through statistical procedures:

(1) The instructional treatment provided by the CCC integrated learning system is sufficiently adaptive to formulate reliable predictions about individual learner achievement. This hypothesis is intended to test the degree of adaptation of instruction through standard motion and other adaptive strategies by determining if there is a significant difference between predicted learner outcomes and actual learner outcomes.

(2) The CCC integrated learning system provides a more reliable estimate of learner

aptitude than an external pretask measure of learner achievement. This hypothesis is intended to test the Initial Placement Motion strategy of the CCC management system.

(3) Increased instructional time and adaptive iterations using the CCC integrated learning system increase the reliability of the prediction of learner achievement. This hypothesis is intended to determine if the precision of the predictive equation is improved as engaged learning time is increased.

(4) Differences between aptitude and achievement among learners using the CCC integrated learning system decrease as instructional time and iterative adaptations increase. This hypothesis is intended to test the assumption that an effective adaptive learning strategy induces a leveling effect or flattens differences between high and low aptitude learners.

Summary and Conclusion

To improve the effectiveness of their products, ILS vendors and developers must continually analyze how to revise and refine their courseware, basing it on a morecomplete and accurate theory of effective instruction and learning. Computer Curriculum Corporation, as well as most ILS vendors, claims that its system of computer-based instruction provides significant increases in learner achievement based on individualized instruction through adaptive strategies that account for individual learning differences. Research must be conducted to determine the success or failure of instructional strategies employed by ILSs and validate the claims of ILS vendors.

The basis for a school in purchasing technology in many cases is the improvement of achievement scores in all areas (Bender, 1991). Companies that market ILSs often claim that their product can improve scores on achievement tests. If ILSs are proven to improve scores on achievement tests, the next questions asked are by how much and what is the cost? For school officials price is obviously a major consideration when purchasing educational technology. School officials must have the data available to compare the relative advantages of ILSs to other forms of instructional technology in order to determine which technology provides the most education per dollar.

The research model described in this manuscript is intended to contribute to the body of knowledge regarding computer-based instruction as well as propose possible research objectives for statistical validation. This research model attempts to focus on particular design variables of computer-based instruction. When highly individualized instructional strategies are used in a research proj ct, classical research designs often do not produce a satisfactory analysis of the data. The research paradigm described in this manuscript employs a micro analysis technique based on a regression model as proposed by Suppes et al. (1976) and Malone et al. (1979) that operationalizes on variables for each individual.

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Title:

Promoting Generative Learning with Elaboration Training in Computer-Based Instruction

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Despite the emphasis on cognitive learning principles in contemporary instructional theories, strategies that initiate only a superficial level of processing continue to dominate computer-based instruction (CBI) (Hooper & Hannafin, 1991; Winn, 1988). A direct response to this problem is to make greater use of generative strategies in CBI designs (Jonassen, 1988). Generative learning is intended to promote interpretation and comprehension by requiring learners to relate new information to their existing knowledge (Jonassen, 1988). Consequently, the level of processing is deepened through the activation of existing knowledge schemata (Craik & Lockhart, 1972; Wittrock, 1978, 1989).

A common means of engendering generative processes is through elaboration strategies (Jonassen, 1988; Mayer, 1980; Wittrock, 1989). Researchers and practitioners have described elaboration strategies in several ways, including cognitive skills that add meaning to new information (Rohwer, 1970), encoding strategies that link new information with existing knowledge (Brezin, 1980), comprehension/retention strategies that increase the memorability of material (Dansereau et al.,1979), and information-processing strategies through which learners make the material more meaningful by "adding to" or "expanding on" the presented information (Jonassen, 1988).

Uses of elaboration strategies have generally shown positive effects on learning, provided the elaborations are meaningful to learners and directly relevant to instructional objectives (see Mayer, 1980). Previous studies have shown positive effects on achievement using a variety of verbal and/or imaginal elaboration strategies with diverse learner groups, including elementary school students (Barker, 1987), secondary students (Weinstein, 1978b) undergraduates (Dansereau et al., 1979), and military recruits (McCombs & Dobrovonlny, 1982). In cases where elaboration has not proven effective, the major problems inferred have been subjects' inexperience with the particular elaboration strategies used or lack of congruence between the elaboration activities and the learning outcomes assessed (e.g., Agesilas, 1987; Weinstein, Rood, Roper, Underwood, & Wicker, 1980).

Concerns about student abilities to generate appropriate elaborations have prompted efforts to examine the effects of subject-generated as opposed to experimenter-generated elaborations. Although results from verbal learning studies have generally favored subject-generated elaborations on memory tasks (e.g., Bobrow & Bower, 1969; Slamecka & Graf, 1987), concerns have been expressed regarding how effectively students can generate elaborations on their own in more complex learning situations. This consideration raises the question of whether elaboration skills training could be used to help learners improve the quality of their elaborations (Jonassen, 1988.) The most common form of elaboration skills training is "detached programs" (Rigney, 1978) which operate independently of the instructional presentation. Dansereau et al. (1979), used this orientation by giving undergraduates two hours of weekly training in comprehension/retention techniques over a 12-week period. Results from that study as well as several others (e.g., McCombs & Dobrovonlny, 1982; Pflaum, Benton, Glover, & Ronning, 1980; Weinstein, 1978a) supported the training condition over a control (no-training) condition.

An alternative elaboration training method is the embedded approach (Rigney, 1978). Jones (1983) describes an application in the Chicago Mastery Learning Reading Program with Learning Strategies (CMLR/LS). The program incorporated information processing instructions directly into reading materials used by teachers and students. Step-by-step prompts, multistep directions on how to think, adjunct study questions, and study prompts are examples of the types of embedded training aids used. Unfortunately, no formal evaluation of the CMLR/LS program was conducted; nor have embedded strategies received much attention in the literature. Relative to detached strategies, the embedded approach has the advantage of making the training contiguous and directly integrated with the instructional task (Linder & Rickards, 1985; O'Dell, 1990). The embedded approach also seems highly compatible with CBI due to the ease of making appropriate training frames and/or elaboration prompting standard or adaptive features of the instructional program. As the learner acquires increased experience in making elaborations independently, such support can be gradually faded and eventually eliminated.

The purpose of the present study was to extend previous research by examining the relative effects for adult learners of receiving experimenter-provided elaborations or generating personal elaborations, using strategies taught via detached versus embedded training. Where previous studies have concentrated primarily on the effects of elaboration on rote learning, the present focus included higher-order learning as well (e.g., application of new information). It was hypothesized that higher achievement would be associated with uses of: (a) learner-generated and experimenter-provided elaboration strategies relative to a control (no-elaboration) condition, (b) learner-generated relative to the experimenter-provided elaborations, and (c) embedded- relative to detached-elaboration training. Additional research interests were the types of elaborations generated and the relationships between types of subject elaborations and learning outcomes.

Method

Subjects and Design

Subjects were 80 employees enrolled in a professional development course at a large corporation in a midwestern city. The course content dealt with diverse topics such as improving communications with managers and co-workers, understanding one's own job, interacting with others to improve performance, and similar topics related to interpersonal communications. The subjects were all administrative assistants with extensive typing and computer experience, but no prior experience with the particular course. The experimental treatments were integrated with the regular course instruction so as to serve as the actual lesson material. Subjects were recruited by sending a letter to 350 corporate employees asking for volunteers for a training study. Employees called and signed-up for a convenient time to participate.

The first 80 subjects who volunteered were randomly assigned to one of four groups (n=20 in each): (a) a control group that received no elaborations or elaborations training, (b) a group that received experimenter-provided elaborations during the lesson, (c) a group that received detached elaborations training and generated elaborations during the lesson, and (d) a group that received embedded elaborations training and generated elaborations during the lesson. Major dependent variables were recall, recognition, and application of the lesson content as measured by a posttest. In addition, content analyses were made of the elaborations produced in the two learner-generated elaboration treatments. An alpha level of .05 was used in judging significance in all statistical tests.

Training Program and Materials

Elaboration strategies training program. A one-hour training unit on elaboration strategies was designed based on effective programs described in the literature (Dansereau et al., 1979; Weinstein, 1978b; Weinstein et al., 1980). The unit was presented to the entire group in one session by the first author. The introductory section emphasized the need for instructional training that stimulates thinking and engages participants in the learning process. Several techniques, such as mnemonic devices and analogies, were then introduced using specific examples from the corporation's existing training courses. Part 2 described elaboration in terms of its value, features, specific techniques (mnemonics, paraphrasing, etc.), and effective procedures. Part 3 discussed and illustrated uses of elaboration in other training and work situations.

Instructional unit. The instructional unit, adapted from "Communicating for Productivity" (D'Aprix, 1982), focused on a model of supervisory communication. The unit contained three sections: introduction to the lesson, new instruction, and summary of main points. The new instruction section covered six supervisory tasks and specific communication practices for each task. Using HyperCard™, four variations of the instructional section were designed for use on a Macintosh™ computer.

One course variation, designed for the control group, presented primary displays (major content) but no secondary displays (elaborations). The first computer frame presented a description of the supervisory principle while the second frame presented the specific communication activities for the principle.

A second variation designed for the experimenter-generated elaborations group, presented primary displays (major content) as well as secondary displays (elaborations). Experimenter-provided verbal elaborations included descriptive information that related the content to current job experiences and/or stated implications for use of the supervisory model. To design the elaborations as precisely as possible, a company subject matter expert assisted in the development of the elaborations.

A third variation, designed for the learner-generated elaborations detached training group, presented primary displays but no secondary displays. Instead, orienting tasks instructing the subject to generate elaborations after each primary display were incorporated. The learner was specifically told to type descriptive information relating the content to current job experiences and, where relevant, stating implications of the concepts described to the job environment.

A fourth version, designed for the learner-generated elaborations, embedded training group, contained primary displays followed by an elaboration strategies instructional unit. The unit was patterned on the detached-training program described in the preceding section, with appropriate modifications required for computer presentation and immediate on-line applications of the strategies. The instruction provided an overview of elaboration strategies, descriptive information regarding their value and features, and an overview of specific elaboration techniques. As for the detached-training treatment, subsequent lesson frames included orienting directions instructing the subject to generate elaborations relating the content of each primary display to current job experiences. An on-line help system for the using elaboration strategies was incorporated. The help system was an electronic version of the "effective elaborating procedures" section (Part 2) of the detached training unit. The learner-generated elaborations were stored on disk for latter analysis.

The four lesson formats were evaluated by one corporate and two academic instructional designers, and were field tested with 10 administrative assistants from the same population as participants in the study. Revisions of the lesson formats were made based on the review and developmental testing.

Achievement test. A paper-and-pencil achievement test, consisting of 8 recall, 10 recognition, and 8 applications items was designed. Recall questions required subjects to name the supervisory principles and specific communication activities. For example, one item was "Name the principle that provides the employee with the answer to the question 'How am I doing?'" Recognition questions listed communication activities contained in the lesson, and asked subjects to associate each with one of the six principles listed. To measure ability to apply the content, a case study describing a work situation was presented. Multiple-choice questions required subjects to resolve different case-related problem situations based on what they had learned from the lesson.

The achievement test was evaluated for face validity by three instructional designers and was pilot tested with 10 administrative assistants who had reviewed the lesson material and 20 who had not reviewed it. The instrument was revised as suggested by the panel review and by the item analysis (e.g., individual items that were correctly answered by 75% or more of the pilot test sample were replaced or increased in difficulty). Internal-consistency reliability coefficients for the final test, computed via Cronbach's Alpha formula, ranged from a low value of .82 for the recognition section to a high of .92 for the recall section.

Procedure.

One week prior to the initiation of the instructional phase, subjects in the detached-training group attended the elaboration strategies training session in the corporation's training facility. The instructional phase was implemented during a normal work week as done for most training courses at the corporate headquarters. Subjects reported to the assigned training room in groups of five, one per computer. Before beginning the lesson, the proctor read instructions stating that (a) participants should try to do their best in learning the new information; (b) there would be a test on the material; and (c) there would be no time limits. Subjects in the two elaboration conditions were also told that spelling, punctuation, capitalization, and typing mechanics could be disregarded; and there was no need to spend time on formatting text. The proctor remained in the room to provide assistance when needed. After each subject completed the assigned treatment, he/she took a 10-minute break and then returned for administration of the posttest.

Results

Achievement

Posttest scores were analyzed via a one-way multivariate analysis of variance in which the dependent variables were recall, recognition, and application. Treatment means and standard deviations on these variables, along with total score (maximum points=26), are shown in Table 1. As shown in the table, the direction of the means on all subtests and on the total score favor the two learner-generated elaborations groups (detached and embedded) over the control group and the experimenter-provided elaborations group. Statistical results showed the overall multivariate treatment effect to be significant. Univariate analysis of variance indicated significant treatment effects on recall scores, F (3, 76) = 7.90, MS_W = 2.12; and application scores, F (3, 76) = 5.41, MS_W = 1.47; but not on recognition scores.

Insert Table 1 about here

Tukey pairwise comparisons of the recall means indicated that the performance of both the detached-training group (M = 6.80) and the embedded-training group (M = 7.35) surpassed the performance of the control group (M = 5.20). The experimenter-provided elaborations group (M = 6.30) did not differ significantly from any of the groups.

Results of Tukey followups on the application means indicated that the embedded-training group (M = 5.50) surpassed the control group (M = 4.00). The experimenter-provided elaborations group (M = 4.65) and the detached-training group (M = 5.00) did not significantly differ from any of the groups.

Analysis of Elaborations

The elaborations generated by subjects in the embedded- and detached-training groups (total n per individual = 6) were analyzed initially via a total word count to determine verbalization length. Although the embedded-training group gave slightly longer elaborations (M = 477.45 words) than did the detached-training group (M = 446.45 words), a t-test comparison of these means was not significant. Both group means, however, were significantly lower than the word count of 659 for the experimenter-provided elaborations. Word counts were not significantly correlated with recall, recognition, application, or total scores in any elaboration treatment or for all elaboration subjects combined.

Each elaboration was further analyzed and categorized in two ways. One dimension was "personal" vs "impersonal." Elaborations that contained personal nouns, specific names of people and departments, or examples of private or personal situations were classified as "personal." The following elaboration given by one subject exemplifies this category:

> In my group, I have yet to hear what our goals and mission are. I have not had a review with my supervisor or manager and have asked for one. I feel like I'm doing a good job, but no one has confirmed this. I have to prompt my supervisor for feedback and receive very little guidance. I feel out of place in our department because I am not sure what all the services are that we offer. I have been there for 9 months and feel an overview of the department would have been helpful. Luckily, I am the type of person that finds out for myself. I feel our department needs a lot of help.

On the other hand, elaborations that contained second-person language (you, your), generic names of people and departments (employees, managers, etc.), and company-wide policies or procedures for examples were classified as "impersonal." The following elaboration represents this classification:

> By clarifying work unit goals and objective, the employees are better informed of the mission, goals, and objectives of the department. Without the knowledge, the employees would be going off in different directions. Having a manager keep you current on the department's goals and objectives helps you do a better job and be more productive. Also, by keeping your employees informed, they feel more like part of the team and their contributions are valued.

Second, each elaboration was classified in relation to the lesson content as "irrelevant," "paraphrased," or "new idea." If the elaboration was obviously not related or incidental to the content, it was categorized as "irrelevant." If it was a restatement of the principles and activities presented in the lesson, it was categorized as "paraphrased." When the elaboration expanded on the information presented so that new concepts, principles, and/or activities emerged, it was categorized as "new idea." Classifications were made independently by two raters. Where disagreements occurred, the classifications were discussed and revised to achieve consensus.

Inspection of the descriptive data indicated a tendency for subjects to generate personal elaborations more often than impersonal elaborations (71 percent and 29 percent respectively), C^2 (1)= 40.83; and to paraphrase content (60 percent) more often than they generated new ideas (33 percent) or gave irrelevant elaborations (7 percent) C^2 (2)=104.25.

A 2(embedded vs. detached-training group) x 2(type of elaboration) chi-square analysis of the frequencies of personal and impersonal elaborations was conducted to determine the relationship between elaboration training and type of elaboration generated. Overall, subjects in the embedded-training group generated a significantly greater number of personal elaborations (83 percent) than did those in the detached-training group (58 percent), C^2 (1) = 56.68. A 2(group) x 3(type of elaboration), chi-square was then conducted on the number of irrelevant, paraphrased, and new idea elaborations made by subjects in the two elaboration groups. It yielded a significant value of C^2 (2) = 109.02. The embedded training group paraphrased the content more frequently (67%) and gave new ideas less frequently (28%) than did the detached training group (54% and 38%, respectively). In a final series of analyses, the frequency counts for the different elaboration categories were each correlated with recall, recognition, application, and total posttest scores. None of the relationships was significant.

Discussion

It was hypothesized that subjects either generating elaborations or receiving experimenter-generated elaborations would learn more effectively than would a control group that received no elaborations or instructions to elaborate. The results supported this hypothesis for subject-generated but not for experimenter-generated elaborations.

Consistent with the findings of Mayer (1980), Barker (1987), and Speaker (1987), subjects generating elaborations surpassed control group subjects, on three out of four posttest comparisons. The generally rich and detailed elaborations (averaging close to 100 words each) of the two learner-generated groups are evidence of subjects attempting to form relations between the content and their own experiences. While the majority of elaborations (60%) were paraphrases of the content, two-thirds were new ideas generated from the content. Further, almost three-fourths were examples from subjects' experiences, thus including personalization as a dimension to increase the memorability of information (Kulhavy, in press) and its relatability to existing schemata (Anand & Ross, 1987; Davis-Dorsey, Ross, & Morrison, 1991). Only on the recognition measure, which was least cognitively demanding of the three subtests, did an advantage for learner-generated elaborations fail to occur.

However, in contrast to other studies (Bobrow and Bower, 1969; Slamecka and Graf, 1978), there were no significant advantages for either learner-generated elaborations group relative to the experimenter-generated elaborations group. However, results on the all posttests directionally favored the learner-generated elaborations groups, and, as just described, the latter groups significantly surpassed the control group on two out of three subtests where the experimenter-generated condition failed to do so on any.

In contrast to the verbal learning tasks employed in previous studies on experimenter-provided vs. subject-generated elaborations (e.g., Bobrow & Bower, 1969), the experimenter-provided communication principles and activities used here directly related to subjects' jobs and common events that most individuals should have found easy to relate to everyday work experiences. Several open-ended attitude responses suggested covert attempts to generate relations between the experimenter elaborations and individual experiences[1]. For example, one subject wrote:

> Some managers, like my own, really don't have the qualifications to be a manager. She doesn't give you any feedback, unless you've really done something terrible, and she doesn't know the organization of the company. We need an effective training program for all managers. This course made me think about how to better communicate with my manager, and what steps I can take as an individual to get the results I think are due me as an employee.

It is thus possible that the level of generative processing achieved in the experimenter-provided group was sufficient for those elaborations to serve similar functions as the learner-generated ones. However, higher-order learning, such as application and synthesis of information, is difficult to measure, particularly using instruction of short duration and objective-type test items. Limitations of the present instruments for assessing such outcomes might have masked stronger treatment differences reflecting deeper processing by the learner-generated group.

It was also hypothesized that the embedded training group would demonstrate higher achievement than would the detached training approach. This hypothesis was not supported by posttest comparisons. However, from an efficiency standpoint, the embedded strategy had the advantage of integrating the delivery of the elaboration training and the lesson in the same presentation. Accordingly, subjects could proceed through the training at their own pace and, in future lessons, bypass the training if it were no longer needed. The savings from eliminating the detached session would far exceed over time the development costs of the elaboration unit (which, with minor modifications, could be easily used on other CBI units as well). The detached training also seemed more successful in engendering attempts to relate the material to personal experiences.

From an instructional design standpoint, the results overall are supportive of incorporating elaboration strategies, where reasonable and feasible, in CBI lessons. In particular, two major advantages are indicated for the embedded strategies approach. First, the time required to develop the embedded training and orienting tasks for the learner-generated elaborations was considerably less than the time required to develop the experimenter-provided elaborations. Second, with instructional time at a premium in both school and corporate training environments, the elimination of the pretraining session by the embedded approach can substantially increase its efficiency relative to the detached training strategies.

Another consideration for designers is learners' ability to generate verbal elaborations from the content presented. In fact, all subjects attempted to construct some type of elaboration at each prompt to do so. Of the 240 (40 subjects x 6) elaborations generated, only 16 (6.7%) were classified as "irrelevant." In the present study, subjects generally found it easy to relate the material, which dealt with a work-related theme, to their everyday experiences. This personalization and higher level of learning is in agreement with the outcomes predicted by constructivists when using a generative learning approach (Biggs, 1987; Duffy & Jonassen, 1991). By comparison, Mayer (1980) presented material on computer programming that was less familiar to subjects, and therefore needed to be accompanied by special prompting and illustrations to guide subjects' production of elaborations. Effective design of elaboration strategies therefore requires careful front-end analyses of the instructional content in relation to learner backgrounds.

Further research that emphasizes qualitative analyses of elaborations is needed to obtain additional insight into how types of elaborations influence different levels of learning. The present results were inconclusive in this regard, perhaps as a result of insensitivity of the dependent measures. If such effects are known, researchers could explore uses of embedded strategies training to guide learners on-line in generating the specific types of elaboration most suited to particular learning objectives.

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Table 1

Means and Standard Deviations for Achievement Subtests

Group	Achievement Subtests							
	Recall		Recognition		Application		Total	
	M	SD	M	SD	M	SD	M	SD
Control	5.20	2.29	6.45	1.76	4.00	0.97	15.65	3.54
Experimenter-provided	6.30	1.17	6.25	1.83	4.65	1.42	17.20	3.07
Learner-gen., detached	6.80	1.15	6.80	1.15	5.00	1.56	18.60	2.56
Learner-gen., embedded	7.35	0.75	6.55	1.61	5.50	0.69	19.40	2.19

Note: n = 20 in each group. Scores could range from 0 to 8 for recall, 0 to 10 for recognition, 0 to 8 for application, and 0 to 26 for total score.

Footnotes

[1]Attitude data comparing treatment groups' reactions to the lesson and to the elaboration strateg where used, were also collected but are not reported in this article.

Title:

Initiating School Restructuring: A Case Study.

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INTRODUCTION

Purpose of the study

The purpose of this study was to examine how Sunny Days Elementary School (a pseudo name) initiated school restructuring using Dr. Charles Reigeluth's School Restructuring Process Model. The purpose of this study aimed to examine how the actual experiences of Sunny Days Elementary School could be used to refine and improve Dr. Reigeluth's process model.

Background

School Restructuring.

Our rapidly changing economy, environment and society are changing the expectations placed on public schools (Reigeluth, 1992). Public schools are being asked to do more with less resources than ever before (Sizer, 1989 & Governors Task Force). In order to meet these new and changing challenges, schools are turning to restructuring as a way of changing how they deliver educational services. Jim Oglesby indicates we are actually asking public schools to "re-invent education" (Oglesby, 1993).

Unfortunately, our schools have little experience in restructuring or "re-inventing education". Many schools are finding themselves unprepared to implement the types of changes restructuring requires. Schools are increasingly turning to models for assistance and guidance for their restructuring efforts. Dr. Reigeluth's process model was designed to offer such guidance.

Reigeluth's Process Model.

Reigeluth's model recommends school restructuring follow a three phase process. These phases are:

Initiation/Preparation Phase

1. Assessing the readiness of the community.
2. Get an outside facilitator.
3. Get commitment from all stakeholder groups.
4. Select an approach for the change effort.
5. Select participants for the coordinating council and design team.
6. Prepare the participants.
7. Relate with non participants.

Design/Development Phase

8. Find common values and analyze learner and societal needs.
9. Develop core ideas and goals.
10. Develop an image, and design a systems of functions.
11. Design enabling systems.
12. Analyze the feasibility.

Implementation/Documentation Phase

13. Plan the implementation.
14. Implement the design.
15. Document the system.

Although the activities in each phase are not considered linear or independent of one another, the model does suggest the phases build on one another.

Significance of the study

The findings of this study are intended to generalize beyond Sunny Days Elementary School to the process model itself. Formative evaluation has proven very successful in improving materials, in this case it was applied to a process model. By using this case as a means to formatively improve a much needed process model, future restructuring efforts will be benefit from a better model to guide them as they attempt to initiate school restructuring.

This study focused on the initiating phase of school restructuring and sought to understand how Sunny Days Elementary School initiated their restructuring process. Factors that influenced Sunny Days' efforts in starting the process were identified and analyzed. Recommendations for modifying Reigeluth's process model to better serve Sunny Day's Elementary School are presented. The following research questions guided this study.

Research Questions

This study investigated the following questions:

1. How does what they are experiencing match Reigeluth's model?
2. Does Reigeluth's model represent the significant events of their experiences during the initial phase of restructuring ?
3. Are other events occurring during this phase that are not represented by the model?
4. What obstacles are they encountering and what inferences can be made about they process form these obstacles?
5. What strides are they making and what inferences can be made to the process concerning these strides?

METHODS

Research Design

The need to explore school restructuring in the complex setting of actual public schools is important to understand the rich interaction of the many factors involved. A case study methodology was selected for this study due to its ability to examine the dynamic processes of school restructuring. Formative research methods were used in order to identify possible improvements to Reigeluth's process model based on insights generated by the case study.

The researcher served as a process facilitator at bi-monthly meetings of the Renovation Committee at Sunny Days Elementary School. The Renovation Committee was a group of six teachers and six parents that volunteered to serve in an advisory role for the school restructuring the renovation of the school building. Their bi-monthly meetings were video taped. The video tapes were analyzed to identify themes and patterns of interactions which were used to guide and focus the formal and informal interviews.

The researcher collected and analyzed documents created by the staff of Sunny Days, including materials developed in their committee meetings. Written communications to parents and community members, such as, news paper articles, notes sent home with students, etc., were collected and analyzed.

Informal interviews were conducted and focused on how the school came to be involved in this process, what other options they considered and how they see the process progressing. These interviews often took place before and immediately after the committee meetings.

Committee members were also interviewed using more formal interview techniques. The interviews sought to validate the accuracy of the researcher's observations and gather addition information about what they were experiencing and how they were making sense of what was happening. The interviews asked participants to reflect on the process of restructuring and offer suggestions for improving the restructuring process. These suggestion were used to identify possible refinements to Reigeluth's process model.

Sample

Sunny Days Elementary School (a pseudo name) was selected for this study because of their interest in Reigeluth's model and their acceptance of the theories supporting the model.

Sunny Days Elementary School is located in central Indiana. It houses grades k-5. A faculty of 14 full time teachers, 2 part-time teachers, one principal, one secretary and two custodians provide educational services to approximately 340 students at Sunny Days Elementary School.

Students at Sunny Days come from a rural area that consists of 98% white, English speaking families. In the past, agriculture was a major industry in the area. Like most midwestern rural areas, agriculture is providing fewer jobs than in the past. An increasing number of residence are commuting to the metropolitan city 30 miles away for employment. The area has unemployment rates typical of many midwestern, rural communities. However, their unemployment and poverty rates are lower than the national averages, but greater than the cities around them.

The school consists of one building which was constructed in the early 1960s. This 30+ year old building no longer meets building codes or the needs of students, faculty and staff. Opportunities to utilize technology is greatly limited by the current condition of the school building. Faced with a major renovation project, the principal and superintendent chose this opportunity to re-examine how educational services are delivered in Sunny Days Elementary School.

Sunny Days is one of four elementary schools in their district. Two elementary schools and two secondary schools in their district have received sizable state and federal grants for implementing educational innovations. These schools and the school district as a whole, are considered innovative and progressive by local and state educational agencies (Dave Wilkinson, Indiana Department Of Education, 1992). Sunny Days is one of the last schools in the district to remodel and to make fundamental changes in how they deliver educational services.

FINDINGS

1. Leadership

The words and actions of the principal were not congruent. The principal's take charge actions were in opposition with her desire to create an empowered staff. The principal continued to make decisions and control activities the committee could have handled. They were told to take charge and make decisions, but were not allowed to do so.

2. Power of the driving force

The renovation of the building provided a powerful driving force for the restructuring effort. Unfortunately, at times it was easier and more interesting to focus on paint and carpet colors than on the future direction of education.

3. Time

The amount of time available was a problem. The volunteers were meeting on their own time after work. This also meant the quality of the time was diminished. The participants were tired and reported not having the energy they would have liked to have had to devote to this project.

4. Short term, planning focus

While this group stated they were interested in long term improvement, they continued to focus on short term quick fixes. The complicated solutions they considered were often closely related to past experiences, many of which had not been successful. They appeared to want results that were different from those in their past, but were hesitant to try new methods. Primarily, their focus remained on individual learning and what they themselves could do in the privacy of their own classroom. Learning as a group and sharing information that could lead to a stronger more responsive school was difficult for the participants.

Implications for the process model

1. Assessing readiness occurs on two levels

The facilitator and instigators must assess the availability of resources and commitment. They will initially make a "go/no-go" decision. Once the decision to "go" is made and the design team formed, they must make a different type of assessment. This assessment must focus on the current context and "what" should be done and "how" should they do it.

2. Preparing the participants and the team

Stabilize team membership

Most volunteer groups will need assistance in stabilizing the team membership. A few participants are likely to drop out and a few are likely to join late. Closing any gaps created by those who leave and orienting those that join late is very important. Group productivity is improved by a degree of cohesiveness. Participants coming and going from a group prevents cohesiveness from developing.

Develop knowledge base

Community members and teachers may not be up to date on what is considered good educational practices. Helping them develop a common understanding of instructional and educational issues is crucial to their ability to interact with stakeholders during the design and implementation phases.

Develop communication skills

A school system may lack internal and external communication skills. If they are not in the habit of communicating with parents and community members, their skills will likely be limited if they exist at all. In the past some schools have operated with very little internal communication among teachers. Teachers often had little if any time to communicate with their colleagues. In fact, they often worked more like isolated islands than as colleagues.

Initially communication is often viewed as a one-way process. "We will tell them what they need to know". The concept of two-way communication is more difficult to apply. The time and energy required for two-way communication to work is scarce in most schools and it is not viewed as important enough to warrant the expenditure of such precious resources as time and energy.

Communication appears continue to view through the mind set of independent systems and one-way communication is sufficient. Once the school is viewed as an interdependent system the importance and need for two-way communication increases. (this links to systems theory)

3. Develop an understanding of the current **Context**

Every school and community has a past, a history that shapes how it views the world and interprets events. It is crucial that the facilitator and the design team develop a rich understanding of the multiple aspects of the current context. Much as current instructional research highlights the importance of meeting the learner where they are, schools must be met where they are. The idiosyncrasies of a community and a school must be considered when attempting to instigate change. They not only have the potential to trip up the effort but also to offer keys to finding the leverage needed for success.

4. Develop a design culture

Systemically designing a school is very different from planning and implementing solutions to current problems. Creating a school that is capable of continuous improvement requires a culture that is very different from what currently exist in most schools. They must learn to move past asking "are we doing things right", to asking "are we doing the right things right". Reflection and inquiry are essential to developing such a culture. Expectations and support structures must be put in place that will allow the participants to develop the skills needed to maintain this type of culture.

Guidelines:

A The design team should explore what it takes to systemically design a school system. Books and videos have been developed that discuss continuous improvement or learning organizations and these can be used to generate discussion among the team members.

B The leadership and administration must exhibit the behaviors that they desire to develop in the faculty and staff. Simply verbally supporting two-way communication will not be sufficient. They must seek and act on input they receive from all stakeholders, including teachers and parents. They should engage in reflection and inquiry and explain the processes as they use them. As they carry out task other members will be performing in the future, they must take the time to turn them in to learning opportunities. **Teaching** how they performed the task must become as important as performing the task itself.

C Design teams should be instructed in inquiry skills. If they are to own and take responsibility for the new system they must be allowed to collect and process the data themselves. They should be allowed to determine what data they need to collect and be given assistance in exploring collection and analyzes methods. Since the schools will be the ones utilizing the data they must own the collection process, the analysis, and the synthesis of the data.

__**Reigeluth's Process Model with proposed modifications**__

Initiation/Preparation Phase

1. Assessing the readiness of the community.
    * **Facilitator go/no-go assessment**
    * **Design team what/how assessment**
2. Get an outside facilitator.
3. Get commitment from all stakeholder groups.
    * **Get quality and proper quantity of time**

*. **Develop rich understanding of current context**

4. Select an approach for the change effort.
5. Select participants for the coordinating council and design team.
    ***Stabilize team membership**
6. Prepare the participants.
    *** Develop knowledge bases**
        educational and instructional methods
        communication
7. Relate with non participants.
*. **Develop design culture**
    *** Inquiry and reflection skills**
    *** Support structures**

Design/Development Phase

8. Find common values and analyze learner and societal needs.
9. Develop core ideas and goals.
10. Develop an image, and design a systems of functions.
11. Design enabling systems.
12. Analyze the feasibility.

Implementation/Documentation Phase

13. Plan the implementation.
14. Implement the design.
15. Document the system.

Summary

Restructuring a school system is a difficult time consuming process. The nature of the task places the school in the position of not know where they are going or how to get there. A process to guide them as the discover their desired out come is very important. This case attempted to assistant an elementary school in initiating a process and to learn from their experiences as a means of helping other schools in the future.

The additions to the process model that have been suggest are grounded in the experiences of one school. Only by using this model with additional schools will we learn if they are beneficial and should remain a part of the model.

Many of the experience that emerged in this case represent global issues that may have solutions in the research of business, group dynamics and self-managed work groups. Drawing on the research from other areas is very important to developing additional guidelines and refinements. The researchers strongly encourage continued research in this area and the exploration of other research findings in order to better serve our schools and communities as they undertook the crucial task of restructuring education.

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Title:

Qualitative Evaluation of an Integrated Hypermedia Training Environment

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Introduction

Purpose of the Study

The researchers examined an intensive, week-long, adult training course which was taught with an integrated hypermedia curriculum. Trainees' and trainers' use of the hypermedia training materials, as well as interactions among participants (on-task and off-task, during training sessions, and during evening social activities) were recorded and examined.

There were two main goals of this research: To document in detail how the hypermedia course was implemented, and to formulate questions and hypotheses about aspects of learning with hypermedia which may guide future researchers.

Outcomes of the Study

A comprehensive research report now being written will describe the interactions which took place during the training course in order to convey the experience of a participant in this hypermedia training environment. Cates (1985) stated that descriptive studies of this type supply information which "contributes to the theoretical understanding of the ways in which individuals, groups, and situations operate" (p. 95). This paper identifies some questions and proposes hypotheses about teaching and learning with hypermedia which may be of interest for closer examination in future studies. Due to the constraints of this forum, it summarizes only briefly the interactions which took place during the training course.

Aspects of The Learning Environment

Overview

The hypermedia training environment evaluated was that of Cities in Schools (CIS) Program Operations training. This is a management training course for Executive Directors of local city-wide or county-wide CIS dropout prevention programs. The training is carried out at the National Center for Partnership Development (NCPD) at Lehigh University's College of Education in Bethlehem, Pennsylvania. It is managed and taught by CIS trainers utilizing an integrated hypermedia curriculum which was developed at Lehigh's Advanced Information Technologies Laboratory. The course is typically offered every other month throughout the year, and is one of a number of courses offered by CIS at the NCPD, and at CIS's five regional offices.

Cities in Schools

Cities in Schools is the nation's most comprehensive dropout prevention program. Locally-funded, not-for-profit CIS programs address the varied needs of at-risk youth and their families by coordinating existing human services resources, and by repositioning service providers into schools to work alongside teachers and other school staff. Cities in Schools, Inc., through its national and regional offices and the NCPD, provides training and technical assistance to help local groups of concerned people to replicate and operate CIS programs in their communities.

Advanced Information Technologies Laboratory(AITL). Faculty and staff of Lehigh's AITL have developed an extensive integrated hypermedia curriculum for CIS (Harvey, 1993; Harvey & Story, 1990). The hypermedia developed for Cities in Schools consists of cross-linked computer, video, and text-based materials as well as suggested implementation and evaluation strategies for trainers. The computer-based textual and graphical resources refer users to related pages in print manuals, control a videodisc player, and prescribe specific learning activities. Trainers may follow the suggested implementation plans, which are referred to as learning strategies, or they can formulate their own strategies to suit their needs or predilections (Harvey, 1993, 1993a).

Program Operations Hypermedia Training

The CIS Program Operations course, a week-long, full-day course for CIS personnel who direct a city's or county's CIS program, was the focus of this study. The Macintosh computer software portion of the CIS Program Operations hypermedia training course contains over 2500 different information and activity screens. It accesses segments of full-motion video and still video slides from a two-sided videodisc.

The print-based portion encompasses over 2000 pages, in three separate manuals.

The Trainee's Resource Book contains print-based learning resources and activity sheets. The Trainer's Manual contains all the resources of the Trainee's Resource Book, as well as the specific objectives, suggested learning strategies, activities, and evaluation strategies for each of the 127 learning sub-activities which make up the 32 learning activities. The Monroe City Casebook contains the print-based resources related to a simulation which is embedded in the hypermedia and integrated into many of the learning activities.

The training is organized into 32 learning activities. Each is composed of three or more learning sub-activities (LSA's); at least one at each of three levels of learning specified by Harvey's (1993) learning model:

Information acquisition/comprehension, wherein trainees participate in activities which help them learn background and prerequisite information and skills;

analysis/synthesis and application in a controlled setting, which affords trainees opportunities to apply their knowledge and skills to solving problems in a simulated scenario; and

action plan level, which is the trainees' opportunity to apply their new knowledge and skills to planning activities and improvements to be implemented on return to their home setting.

Each LSA in the hypermedia is designed as a complete learning unit. It is focused on the achievement of a specific performance objective. It describes activities for trainees to participate in, provides learning resources to use, and specifies performance criteria and evaluation strategies for trainers to use when assessing student learning (Harvey, 1993).

The training course. The five-day-long training course is organized by CIS trainers who select parts of the curriculum which they have identified through a pre-training questionnaire as most requested for each particular group of trainees.

The trainers. Trainers are selected from Cities in Schools, Inc.'s staff of regional trainers who normally work at the five regional offices. They are chosen by CIS' training coordinator, based at Lehigh University, in consultation with CIS' Vice-President for Training. There are usually three or four trainers including the training coordinator, for a group of anywhere from ten to fifteen trainees. Each trainer is assigned specific learning activities to teach by the training coordinator. Teaching style is left up to the individual trainer's predilections and judgment. They are free to follow the learning strategies contained in the hypermedia, or not to.

The Setting

The National Center for Partnership Development (NCPD) is a training facility created and maintained by a partnership of Cities in Schools, Inc., Lehigh University's College of Education, and Lehigh's Iacocca Institute. The objective of the NCPD is to utilize advanced technologies to assist learning and to spread the knowledge and skills needed by people from a variety of sources and organizations, and by all members of the Cities in

Schools family in particular. The NCPD facility is located at Lehigh University's Mountaintop Campus in Bethlehem, Pennsylvania. The facility is composed of a large training room containing twelve Apple Macintosh IIci computer workstations with videodisc capability. The workstations are located around the periphery of the room. A trainer's station is situated at one end of the room with the capability to project its computer display and video for large group viewing, and a central, semi-circular table is provided for group discussions and activities.

Subjects

The trainees. People who attend Program Operations training at Lehigh's NCPD are social service or school administrators, Executive Directors or board members of local Cities in Schools programs, and occasionally people from organizations other than Cities in Schools. Most have been hired by a local CIS program's board of directors to organize, set up, or manage the community's CIS program. In the past, trainees have come to Lehigh for Program Operations training from all areas of the United States and from England, Canada, and South Africa. They usually include members of several cultures, races, and backgrounds, and most have attended college. All are people who want to help children to succeed. Some have worked for social services agencies, and some have worked for local Cities in Schools programs in various capacities.

The training group. Each group of ten to fifteen CIS Program Operations trainees is composed differently and has different interactions. The group of trainees who participated in the training course examined was made up of one or two people from each of several of different states, and a small group from a single state, most of whom were unacquainted.

Method

Overview

The method applied in this study was developed for the purpose of gaining an accurate image of the occurrences which take place during a Cities in Schools Program Operations training course. The objective was to construct a methodology which would allow the researchers to gain as full an understanding of the experiences of a participant as possible, while changing the environment as little as possible. A major constraint on the prospective methodology was that the researchers could not interfere with or change the training program. The researchers determined that the goals of the research and the constraints imposed by the setting could best be accommodated by the application of a qualitative, observational data collection method. Preliminary data collected in two pilot studies validated and refined the method which was to be applied in this study.

Non-Participant Observation

The data collection method consisted of the systematic observation of a week-long training course using a method which is applied by many researchers in the social sciences (Delamont, 1992; Miles & Huberman, 1984). Observations were recorded in brief descriptions and were later expanded at the earliest possible time. When some volume of data had been collected, the data were examined in an attempt to identify explanations for unusual or unfamiliar patterns or events. Initial interpretations derived from this analysis were then reexamined as other data are collected to test their accuracy. Many of these initial interpretations needed some refinement, and some proved to be completely inaccurate.

Interview. In addition to observing passively, subjects were interviewed on specific topics at appropriate times that did not interfere with or interrupt training activities (e.g. at dinner, or on a break). The subjects were asked questions in order to test the validity of preliminary interpretations he had made.

End of course reaction forms. Although end of course reaction forms are discouraged as an evaluation method by a number of educational researchers (Dixon, 1987; Jones, 1990), they are still widely used in corporate management training programs and many other training programs. Put in the proper perspective, they may have some value as one aspect of a larger evaluation methodology (Ban & Faerman, 1990; Clegg, 1987). In the Program Operations course, the extent of formal course evaluation being done by CIS's trainers was collection of these end of course reactions, and compilation of the responses. Since these were already a part of the learning experience, the resultant data were examined, and considered when forming interpretations and drawing conclusions.

Data collected. Categories of interactions which were recorded concerned the ways in which the hypermedia course was implemented, and the other activities which were facilitated by the trainers. These categories were developed by the application of this methodology in the pilot studies which were conducted during training courses held in July, 1992, and in May, 1993 (Nelson, 1993, 1993a). The time that each observation was made was recorded, so that the duration of each interaction could be calculated. Observations made included detailed information on the content and context of interactions, including the "ecology" of the situation (lighting, heat, location and movement of participants in the room, and other aspects of the situation which may have influenced the interactions), and concerned the categories listed in Table 1.

Table 1
Taxonomy of Observation Types

Individual activities
- Individual work with computer-based hypermedia materials
- Individual reading information from print-based hypermedia materials
- Individual presents to a small group
- Individual presents to the class
- Other individual activity

Small-group activities
- Small-group work with computer-based hypermedia materials
- Small-group reading information from print-based hypermedia materials
- Small-group presents to the class
- Other small-group activity

Trainer-led activities
- Large-group discussion
- Trainer providing help to individual or small-group
- Trainer asking question of individual or the group
- Trainer presenting objective(s) to the group
- Trainer presenting information to the group
- Trainer presenting to group with non-hypermedia transparency
- Trainer presenting to group with flip chart
- Trainer directing trainees to read print-based hypermedia resource(s)
- Trainer presenting hypermedia to group with LCD panel
- Trainer playing hypermedia video segment for the group
- Trainer playing non-hypermedia video tape for the group

Other observations and data
- "Ecology" of the situation (lighting, heat, location and movement of participants in

the room, and any other aspects of the situation which may influence the interactions)

Trainees taking a break

Trainers' and trainees' comments

Other interactions and activities

Responses to questions

Questions asked

Trainers' or trainees' answers

Questions asked by trainees (and answers given)

Throughout each day of training, objective observations and perceptions were recorded. At the end of each day, the data were classified into categories which helped to organize and group related data to assist in analysis. An audio tape recorder was used to provide a more detailed record of some group learning activities, and to record comments and suggestions made during "process checks" (i.e. the last activity of each day, during which participants discuss the day's activities and suggest ways to improve the training).

Duration of The Study

Anthropological studies frequently involve a long-term immersion in a culture under study. Field work lasting one to two years is not unusual. In the field of educational research, research projects of this length are impractical. Educational researchers must deal with problems such as access to subjects, life cycles of innovations under study, and insufficient funding. Educational researchers must do more concise, focused studies (Tucker & Dempsey, 1991). As MacDonald (1981) stated, "We go for condensed field work, short, sharp bursts of data gathering leading to negotiated accounts of social action in situ" (p. 4).

Prior to conducting this study, the authors examined two other week-long training courses . For the purposes of this examination of training, the duration of the data collection phase comprised a five-day period. This was the total time that trainees had contact with trainers in the hypermedia course. The life cycle of the course, and of the training group (trainers and trainees), was limited to these five days, after which the group disbanded, likely never to reconvene in the same combination. Although some of the trainees had attended other training courses, each Cities in Schools Program Operations training course is comprised of trainees who likely have never met each other or their trainers, and each course is unique in content and personalities. Data were collected throughout the training day, and at evening functions, lunches, and breaks.

Results

Overview

The results of this research are currently being developed. The authors expect this phase of the study to be completed by the end of March, 1994. Some preliminary results are presented herein, which may guide others planning research in this area.

Written Description

The constraints imposed by this forum restrict the researchers from providing a complete written description of the week-long Program Operations course. The final report of this study will include a detailed, textual description and other representations of the events of this week-long course. This paper includes a report of the aspects of this training course which appeared to warrant further investigation. These aspects were related to a number of general areas.

The diversity of the trainees participating in the course was extreme. some had held their positions with CIS for several years, others had been hired only weeks or days prior to the course. Still others weren't even CIS employees. Trainees came to the course with vastly different knowledge, experiences, skills, and needs.

This variety, and the fact that some trainees worked in pairs, and others individually, raised questions about the pairing or grouping of learners. It was observed that those who worked in pairs displayed a far greater number of interpersonal interactions than people working individually, that they frequently answered each other's questions and discussed the content of learning materials, and that excepting one person, they participated a great deal in large group discussions. This aspect of learning with hypermedia needs to be researched in more depth because, of the thirteen trainees in this course, only four worked in cooperative pairs, and their groupings were voluntary.

presented to trainees. Comments and questions which arose indicated that the purpose of lessons was not always made clear to the learners. It is the authors' contention that learners would be more likely to achieve the objective(s) of any lesson if they were overtly presented in advance.

Evaluation of the attainment of individual objectives was conducted by trainers in this course without the aid of formal tools. Trainers analyzed the responses of trainees during large group discussions and other group activities. It was therefore impossible for the trainers to assess objective attainment for each trainee, but only to infer that if one or more trainees displayed objective attainment, that all had probably achieved the objective(s) of the learning activity.

The culminating activity of every suggested learning strategy prescribed by the hypermedia curriculum used in this course is the development of an action plan by each trainee. This was described to trainees as the writing of a plan for implementing the knowledge and skills they gained in the course. It was to be a detailed list of things to do and investigate upon return to their CIS programs. It was observed however, that after the first day, this activity was rarely mentioned, and was skipped over, in spite of the fact that it was scheduled on the course agenda. On two days, trainees were dismissed early, despite the fact that this scheduled activity was being passed over.

Although the hypermedia curriculum used in this course prescribed specific learning strategies for trainers to facilitate, the trainers often implemented activities of their own design. When questioned, they reported that the objectives were those listed in the hypermedia learning activities, but that they had developed activities which combined a number of the objectives in order to cover more content in the time available.

Some of the trainer-developed activities involved the use of learning resources which trainers had developed in order to supplement those available in the hypermedia. These varied in content and quality.

After activities which prescribed trainees' use of the hypermedia resources, trainers commented to each other that they had noticed little or no use of print-based resources by the trainees. Although they had observed this, and expressed that they felt it was a problem, they did not instruct the trainees to more fully utilize these resources.

It has been concluded that trainers' predilections are an extremely important factor in determining resource utilization and learning of trainees. The instructions given, information resources examined, and activities carried out are directly related to each trainer's favored teaching style. Some trainers use hypermedia as an integrated part of the learning activities they facilitate. Others use it as an information database, to provide rapid access to information for display to a group. Trainers who teach in this way use hypermedia much like an electronic flip chart or overhead transparency. When they allow trainees to access hypermedia, it is frequently in a manner similar to the way they might have used printed trainee manuals in the past. Still others avoid its use, preferring more traditional, trainer presentation teaching strategies. In the course studied, each trainer utilized hypermedia in different ways. They varied their teaching and presentation styles, and did not seem to display a clear preference for one particular mode of teaching.

Time management appeared to be difficult during this course. Several times throughout the week, the course agenda was revised to accommodate activities that took longer or shorter than predicted. Thursday's agenda was changed to reflect the trainees' needs with regard to completing an out-of-class assignment, then trainees were released from class early, despite the fact that they had not worked on action plan development, which was on the agenda. Management of the duration of breaks also seemed to be difficult in this course. Many times, when trainees were allotted a specific amount of time for a break, they didn't reconvene until the trainers called them back, often long after the allotted time had expired.

At the end of each day of this course, the trainers conducted what they called a "process check." This was their way of evaluating that day's activities, and allowing trainees to comment and offer suggestions for improving the activities. It seemed that this would have been an ideal time for trainees to rate the relevant activities using their reaction forms, as they had been instructed to do on the first day.

On Monday, the trainees had been told to rate each day's activities on the same night, so that their thoughts and reactions would not be forgotten. Trainers did not remind them to do so however, so the trainees completed the Likert-type reaction forms when the course was finished.

Questions and Hypotheses

Developing questions and hypotheses about teaching and learning with hypermedia was the major projected outcome of this study. Because the use of hypermedia as an instructional tool is so new, little research has been done regarding the ways that it can best be employed for this purpose. Some of the unique attributes of hypermedia afford users new ways to teach and to learn. It may be that old paradigms of teaching and of learning will need to be changed to most efficaciously utilize hypermedia.

The questions and hypotheses which follow have been derived by examining the occurrences of a Cities in Schools Program Operations training course held November 8 through 12, 1993, and by comparing that data set to the occurrences during two pilot studies (Nelson, 1993, 1993a). They are related to the observations presented above, and concern a number of aspects of the use of hypermedia as a learning tool.

Diversity of Trainees

Hypothesis 1: There will be no significant difference in achievement based on trainees' pre-existing levels of experience or knowledge in hypermedia training courses which include people possessing various levels of experience or knowledge of the subject matter .

Pairing Learners

Hypothesis 2: There will be no significant difference in achievement of course objectives, learning efficiency, retention of course content, or post-training job performance for trainees learning with hypermedia in cooperative pairs or those working individually.
Hypothesis 3: There will be no significant difference in the number of requests for trainer assistance related to course content or to the use of hypermedia from trainees learning with hypermedia in cooperative pairs or those working individually.

Hypothesis 4: There will be no difference in the action plans developed by trainees learning with hypermedia in pairs, and those of trainees who work individually.

Introduction of the Participants

Question 1: What effects on the outcomes or objective attainment of trainees working with hypermedia do trainer's instruction have?

Objectives and Evaluation

Question 2: Are objectives for hypermedia courses that are developed by practicing professionals valid?

Question 3: What is the effect on post-training job performance of teaching practical information-retrieval skills, rather than teaching specific information?

Hypothesis 5: Trainers will more consistently implement learning activities designed to expose trainees to content in a shorter time than those that take longer to implement, regardless of the potential learning outcomes.

Hypothesis 6: Trainees will demonstrate no significant difference in objective achievement, retention of content, or training-related job performance if the objectives of a hypermedia learning activity are presented to them, or not.

Hypothesis 7: Trainers will evaluate the objective attainment of trainees in a hypermedia-assisted course if they are provided with easily-applied measures.

Hypothesis 8: When used as an information resource, an indexed hypermedia structure facilitates more efficient information retrieval than does a hierarchical, activity-oriented structure.

Hypothesis 9: There is no correlation between one or more trainees demonstrating achievement of the objective(s) of a hypermedia learning activity in a group discussion, and objective attainment by other trainees in the group.

Course Evaluation Forms

Question 4: If evaluation forms were completed after each hypermedia learning activity, rather than at the end of a course, would the ratings or comments be different?

Question 5: What is the correlation between the trainees' ratings of a hypermedia activity, and objective attainment, content retention, or successful post-training application?

Question 6: When designing or modifying hypermedia learning activities, do trainers formulate a lesson plan which includes one or more objectives and evaluation strategies?

Hypothesis 10: A course evaluation which included the objectives which were to be achieved would yield significantly different responses than a simple, Likert-type reaction form.

Action Plans

Question 7: Is the development of an action plan in a hypermedia-assisted course correlated to increased retention or application of learned skills and/or information?

Question 8: Why was little emphasis placed on the development of a plan for implementing the skills and knowledge gained in this hypermedia-assisted course, even though trainers had earlier stressed the importance of such a plan?

Question 9: Why are trainers reluctant to point out problems they have noticed in each other's hypermedia learning activities or in trainees' performance?

Trainer-Developed Activities

Question 1: What effects on the learning outcomes or objective attainment of trainees do trainer's instructions have?

Question 10: Do activities which are less-than-directly related to achieving the objectives of

training, but which trainees enjoy, effective or valuable parts of a hypermedia training course?
Hypothesis 11: There will be no significant difference in trainees' objective achievement from hypermedia learning activities whether they are assisted in locating relevant information, or not.
Hypothesis 12: Trainees are no more likely to achieve the objectives of a hypermedia learning activity when objectives are overtly stated, than when they are not.
Hypothesis 13: Trainers will cover less content, albeit more thoroughly, in a hypermedia course which is to be evaluated based upon trainees' objective attainment, than in one which utilizes "smile sheets" (i.e. Likert-type reaction forms) for evaluation.
Hypothesis 14: Trainers who are thoroughly familiar with the resources available in a hypermedia curriculum are no more likely to integrate their use into learning activities, than trainers who are not.

Supplemental Learning Materials
Hypothesis 15: There will be no significant difference in learner achievement between a course which is taught with the aid of projected hypermedia resources and a comparable course taught with hand-drawn transparencies.
Hypothesis 16: In a course which is chiefly taught using computer-generated teaching aids, the incongruity of hand-drawn teaching aids distracts learners, resulting in inferior learning of the content of those resources.

Entertaining Activities and Video Tapes
Hypothesis 17: There will be no significant difference in objective achievement by trainees in a hypermedia course which follows lesson plans to the letter, or in a course which includes entertaining asides and activities.
Hypothesis 18: Short, entertaining asides help trainers to gain and hold trainees' attention, thereby leading to more effective learning.

Poor Use of Print Resources
Question 11: Do trainees prefer to use computer and video-based hypermedia resources rather than print-based resources?
Hypothesis 19: The use of print-based hypermedia resources in addition to computer and video-based resources does not significantly increase learning, retention, or post-training application.

Hypermedia and Trainers' Predilections
Hypothesis 20: A single training course in the use of hypermedia for teaching is insufficient to change trainers' normal patterns of behavior.
Hypothesis 21: There is no significant difference in trainees' objective achievement between those taught with a hypermedia curriculum, and those taught using more traditional, trainer presentation strategies.
Hypothesis 22: Objective achievement when learning with hypermedia is not significantly different when the hypermedia is used in a group setting which allows for interpersonal interaction, or in an individualized setting without human interaction.
Hypothesis 23: The provision of sample forms, plans, or other materials, which demonstrate how others have applied the content of a hypermedia course, will result in increased post-training application of skills and knowledge.

Time Management

hypothesis 24: There will be no significant difference in information retention or training-related job performance among trainees participating in a hypermedia course which covers more content, and one which covers less content in more depth.

Question 12: When a number of hypermedia learning activities are grouped and taught together, are all the objectives achieved?

Question 13: Is there any affect on trainees' attitudes in a hypermedia course, when trainers allow breaks to run longer than scheduled?

Process Checks

Question 14: Do trainers change their lessons or hypermedia learning activities in future courses that they facilitate, based on previous trainees' comments?

Discussion

These questions and hypotheses have been developed by examination of the data collected during the November 8 - 12, 1993 Program Operations course, and by comparison with data collected during two other Cities in Schools training courses. A full description of the week-long course, a breakdown of each activity by time, and support for the questions and hypotheses developed will be included in the final report of this study which the researchers expect to complete by the end of March, 1994.

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Title:

Learning How to Teach: A Computer-based System to Enhance Teacher Reflection

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Background

Conceptions of teaching, especially outside the profession, often maintain simplistic and narrow beliefs that teaching is a skill that can be acquired relatively easily by any reasonably intelligent individual. However, learning and development theories suggest that a complex skill like effective teaching is acquired over thousands of hours of practice (Norman, 1978); practice that includes autonomy, collaboration, and time (Wildman & Niles, 1987a). Recent trends in teacher education have stressed reflection as an important component of this learning process (Schön, 1991; Wildman & Niles, 1987b). Helping beginning teachers learn to think about and analyze their pedagogical activities is seen as an important step in developing effective teachers. The research project described in this paper elicits the help of multimedia computer technology and modified case methodologies in an attempt to encourage and facilitate the processes of reflection by beginning teachers.

The theoretical framework for this effort is drawn from two areas of research: the use of case methods in teacher education (Shulman, 1986) and cognitive flexibility theory (Spiro, et al., 1988). Case methodology is a proven instructional strategy in many areas (notably law, medicine, and business) that has become more widespread in teacher education in recent years. Many hold the belief that case-based instruction for teachers can help them to better reason about and reflect on their practice (Christensen, 1987; Schön, 1983). A number of projects developing and using case materials have been undertaken (Greenwood & Parkay, 1989; Kowalski, Weaver & Henson, 1990; Silverman, Welty & Lyon, 1992), while others are advocating the use of student-written cases as a means of encouraging beginning teachers to reflect on pedagogical issues (Kagan & Tippins, 1991; Shulman, 1991).

Coincidentally or not, there is a parallel movement in cognitive psychology that is emphasizing cases, episodes, or "stories" as a model of storage and retrieval in human memory (Neisser, 1981; Schank, 1992; Spiro et al., 1987). In particular, cognitive flexibility theory (Spiro, et al., 1988) proposes that the acquisition of knowledge in domains that are ill-structured (where content is complex and application is irregular -- teaching is certainly such a domain) needs to be decontextualized. That is, rich interconnections among knowledge components need to be developed in order for learners to access knowledge from multiple sources in the construction and adaptation of knowledge to new situations. Spiro and his colleagues assert that case-based instruction is likely to achieve the cognitive flexibility necessary to acquire relevant knowledge and successfully solve problems in ill-structured domains, especially when the cases are not organized into predefined categories, thereby requiring the learners to access the information from many different perspectives.

Cognitive flexibility theory further suggests that an appropriate vehicle for presenting the cases, and for helping learners to "crisscross the landscape" of cases while noting similarities between cases that on the surface may seem dissimilar, is a computer-based hypermedia environment (Spiro & Jehng, 1990). Hypermedia allows users to rapidly and efficiently access a large amount of information in a nonsequential manner by following "links" (cross references) between "nodes" (the actual information in the database). Further, hypermedia systems can be developed to allow learners to create their own links between nodes, actively involving the learner in reflecting on how various aspects of one case may be similar to aspects of other cases. The result is a system that supports random access instruction (Spiro & Jehng, 1990), where learners build a complex knowledge representation of the domain by experiencing cases from a variety of perspectives in order to develop a more complete understanding of the nuances in the domain.

With this theoretical framework in mind, a computer-based multimedia system that features prespecified cases for analysis, facilities for linking various aspects of one case to other cases, and capabilities for entering and linking new cases by individual students as a product of their classroom observations was developed and tested. The software seeks to effectively support the kind of knowledge acquisition and reflection necessary to develop sufficient pedagogical knowledge in preservice teachers. The formative testing of the software was conducted to both describe the kinds of activities undertaken by the students when using the system to reflect on classroom observations, and to explore various strategies for integrating the system into a teacher education ci rriculum.

Description of the Software

The software developed for the project, *Chronicles of Teaching*, features a design that encourages users to read and react to descriptions of "critical incidents" or mini-cases that typically occur in classrooms. In addition, users can enter descriptions of incidents that they have observed during their field-based activities. Besides entering descriptions of cases and solutions, users may create hypermedia links between their case and other cases or theoretical descriptions that are in the database. In this way, users must reflect on the similarities or differences between their case and other cases in the database (or descriptions of theories and methods of teaching), and establish links so that subsequent users may follow the links while examining the cases and theories in the database. Another feature that encourages reflection is a "notes" facility that can be used to create and print personal notes, or to leave comments or suggested alternative solutions for other users to view. The software also includes extensive search and indexing features so that these cases and theoretical descriptions can be easily accessed.

As shown in Figure 1, the structure of the *Chronicles of Teaching* system centers around two database modules, cases and theories, that provide search and indexing facilities to aid the user in navigation. The "Cases" module provides facilities for entering descriptions of critical incidents that the user has observed in classrooms during field observations (See Figure 2). Students enter descriptions of both the incident and the solution to the problem, and may also leave comments or suggested alternatives to cases entered by others. A user can also view cases entered by other users by following hypermedia links in the database, searching for keywords, or selecting from an index, as described below. Descriptions of the learning and/or instructional theories underlying the events depicted in the cases are also available. These descriptions were drawn from the research literature on learning and effective teaching, including behavioral and cognitive theories of learning, motivation strategies, questioning techniques, classroom management, and assessment strategies. Users are encouraged to engage in debates/analyses of the cases by accessing the notes facilities or by posing questions or leaving comments for other users. Notes can be printed for later examination and study purposes. Multimedia capabilities to display video clips of actual teaching episodes are also available to users. These video segments illustrate various features of some of the cases and theoretical descriptions in the database. Facilities to allow users to add video clips of student teaching activities are currently under development.

Figure 1.

Structure of the *Chronicles of Teaching* software.

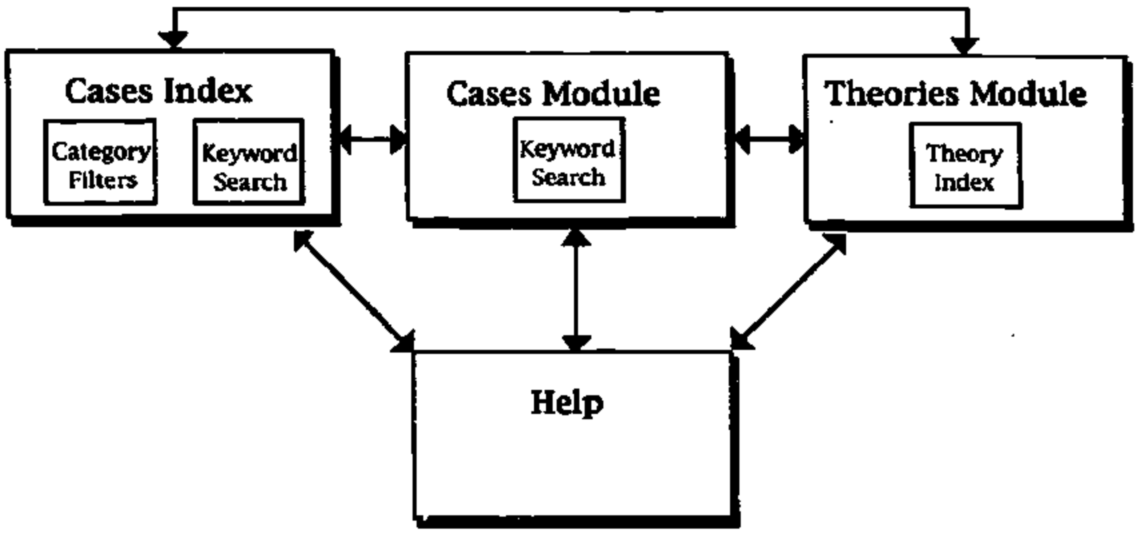
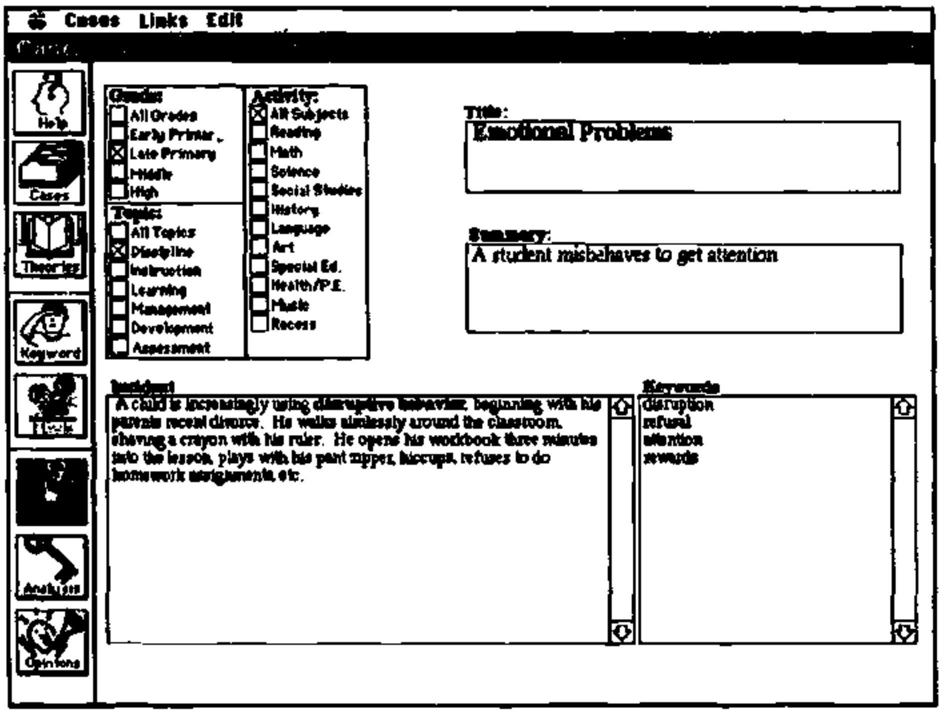


Figure 2.

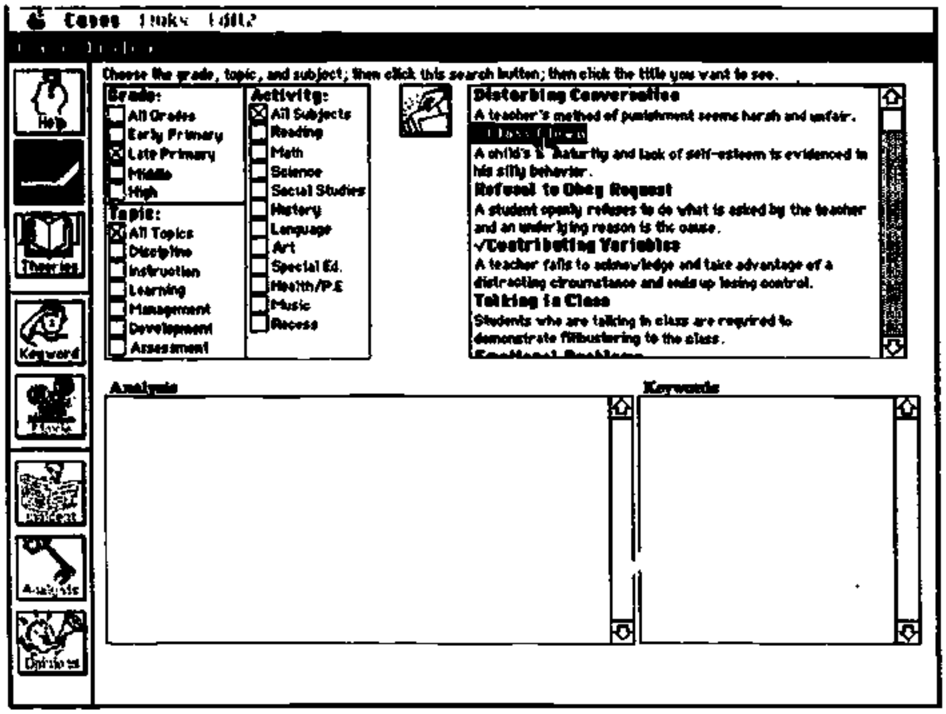
A case from the database.



The search facilities provided in the software are designed to allow easy access to both cases and theoretical descriptions. Searching for particular cases can be accomplished in several ways. First, the user can access a search facility that filters the available cases based on category selections made by the user (See Figure 3). The filters include grade level, subject, and type of teaching activity. By selecting various combinations of these parameters, the system searches the database of cases and displays the titles of cases that match the selected parameters. Users may then view a particular case by selecting its title from the list. The hypermedia links embedded in the text of the case descriptions and solutions, as described below, also provide an important facility for accessing cases. Each case in the database also includes keywords describing various characteristics of the case that are entered by the author of the case. A user may access a search facility that will sequentially display all cases where a match to the current keyword is found. At any time, users may view descriptions of various theoretical principles drawn from the literature on learning, instruction, and effective teaching. The user simply selects the desired theoretical description from a list of descriptive titles.

Figure 3.

The case index screen.



The software also provides capabilities for case authors to create hypertext links from various words or phrases in their case to other similar cases or theoretical descriptions, thereby helping them to actively reflect on how the events they have observed in classrooms are similar to, or different from, other situations described in the database. Users can easily create links by highlighting a word or phrase in the case narrative, navigating to the target case, and making a selection from the menubar to create the link. Links can also be deleted by the author of the case, but once the author is satisfied with the case and links, the text is "locked" so that other users cannot alter the author's case description or links.

Field Testing

Development of the *Chronicles of Teaching* software has proceeded using a rapid prototyping model. That is, more than 45 teacher education students from the target population have participated in several cycles of testing and revision of the software. Initially, randomly selected students from sections of the teacher education program who had completed 16 hours of course work in education (Introduction to Education, Educational Psychology, etc.), and who were entering a "block" of methods courses in elementary education that requires extensive observation in public school classrooms (20 hours per week), helped with testing of the various prototypes. Participants were introduced to the system, and to case writing and analysis procedures, during a training session prior to their scheduled observations in the schools. The students then used the system individually to enter and link cases and solutions based on their classroom observations during the remainder of the period of classroom observations.

The major activities completed by each student involved composing and entering their own case(s) derived from their classroom observations, and linking various aspects of their case(s) to other cases and to the theoretical descriptions included in the system so that subsequent users could access the student's case(s) from a variety of other points in the hypermedia database. The students also responded to other cases by viewing and commenting on analyses made by other users. The system was instrumented to collect data regarding the specific activities each user completed during interaction with the system.

Feedback from the students who tested the system was used to guide modifications and enhancements of the prototype. Specifically, users asked for a more sophisticated search system that would allow them to search for cases based on various categories of teacher activities (i. e., discipline, instruction, classroom management, etc.) as well as student level (i. e., early elementary, middle school, high school, etc.) and context (i. e., math, reading, science, recess, etc.). This search feature was added to the system, along with navigation capabilities that allow users to "backtrack" along the path they had followed while browsing with hypertext links.

Besides specific suggestions regarding modifications of the system, students also volunteered their subjective impressions, noting that the tasks involved with using the system were very appropriate for reflecting on various aspects of teaching. The activities involved in entering, linking, analyzing and commenting on cases in the database seemed to engage the students at a high level. One student even jokingly suggested that field observations be replaced with use of the system because the same outcomes could be achieved with a significant reduction in mileage on his car!

A more extensive analysis of the cases entered during testing of the prototype reveals that the students are noticing and discussing a wide variety of classroom situations in both early and late primary classrooms. An examination of the topics for the 32 cases entered in the database reveals that discipline (47%) and instructional methods (31%) dominate the concerns of the preservice teachers who have tested the prototype, while the context of the incidents is more diverse, covering reading, math, science, history, language arts, health/physical education, and even recess. It is also apparent that the system encourages the kind of reflective thinking necessary to develop teaching expertise, as exemplified by the following excerpt from an opinion entered by someone in response to a case description:

> I think proximity would be the best in this situation. By moving closer to the students and standing next to them, they will know that they were heard. Some teachers may separate them, but this causes disturbance to the lesson flow. I would continue the lesson while moving towards the student.

Integration into the Teacher Education Curriculum

The *Chronicles of Teaching* software has been integrated in several courses of the Elementary Education Program at Southern Illinois University at Edwardsville, thereby involving all elementary education majors in four stages of utilization of the software. In the first stage, students enrolled in the Foundations of American Education course (the initial course for all education majors) are introduced to the software through discussions of the cases already in the databases. The software is demonstrated by the instructor, and students are then encouraged to browse through the databases and enter opinions and alternative ideas for solutions of the problems described in the cases. In this way, the students are encouraged to reflect on the situations, and to compare what is described in the cases to what they see during the 20 hours of field observations that are required in the course.

After the introductory course, elementary education majors enroll in a general methodology course where they are required to write a description of a critical incident ("mini-case") they observed during their field work in the public schools. The students enter their case description into the database and continue to examine the other incidents that are already entered in the database. Part of the process involved in creating a new case requires the students to link aspects of their description to other cases in the database, supporting a reflective process whereby they identify similarities and differences between what they observed and what others have observed. Particularly important in this reflective process is the consideration of how the situation was resolved, and the alternative solutions that might be considered. Students also continue to respond to other cases in the database by viewing and commenting on analyses made by other participants.

The third stage of integration of the *Chronicles of Teaching* software into the teacher education curriculum occurs in several of the five methods courses that students must complete. For example, in the Social Studies Methods class, students are required to write two critical incidents they have observed during their 100 hours of classroom experiences completed during this block of the program. The critical incidents at this phase might describe incidents they have observed or that occurred while they were actually teaching. Again, participants are encouraged to respond to other cases by viewing and commenting on analyses of the other cases in the database.

The last stage of curriculum integration takes place during student teaching. All elementary student teachers are required to produce a description of a critical incident that occurred during their student teaching and place it in their final senior student teaching portfolio as well as enter the case in the database. As time permits, these students are also encouraged to continue responding to other cases. Hopefully, student teachers and even alumni will continue to take advantage of the case descriptions collected in the database to reflect on their teaching and learn from the analyses and alternatives suggested by users of the *Chronicles of Teaching* software.

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Title:

Synergistic Effects of Learning Strategies Training: Comparing "Black Boxes"

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Introduction: Theoretical Perspective and Objectives of Study

This is an analysis of experimental outcomes that resulted in different synergistic performance, motivational, and learning strategies relationships between and among the variables studied in two groups.

The hypothesis of the study was that subjects trained in selected task-related learning strategies would exhibit significantly increased performance and academic motivation over untrained subjects. Previous research had recommended learning strategy interventions based on reported correlations between selected learning strategies, performance, and self-concept related motivational dimensions (See Eison, Pollio, & Milton, 1986; McCombs, 1984, 1987; Pintrich, 1986, 1987; Pintrich & De Groot, 1988; Schutz, Ridley, Glanz, & Weinstein, 1989).

According to a social-cognitive/expectancy-value model of college learning and teaching developed by McKeachie, Pintrich, Lin, & Smith (1986), student motivation and knowledge of learning strategies not only affect each other, but lead to both self-regulated learning (engagement in learning or application of learning strategies) and academic performance. Individual student characteristics (including personal academic beliefs, attributions to success and failure, and demographics), however, may influence task-related motivation, and academic performance.

Figure 1 presents a theoretical framework of the study, and Figure 2 diagrams experimental variables.

The task was a management case study. As shown in Figure 2, training was provided in the use of techniques related to five types of cognitive, metacognitive, and resource management learning strategies. Performance was defined as scores on three parts of a case study task.

Motivation was defined as scores on each of three self-report measures of motivation: (a) perceived task-related self-efficacy for learning, (b) expectations for task-specific academic success, and (c) desire to continue learning more about business management.

Two categories of learning strategies were assessed: (a) "primary" learning strategies (general cognitive and metacognitive strategies, classified as self-regulated learning strategies by Pintrich et al., 1989), and (b) "other" learning strategies used and valued (specific study skills-like tactics).

Operational definitions for all variables appear in Appendix A.

Methods and Data Sources

Three sections of an Associate Degree introductory management course volunteered to be subjects (N = [illegible] they were located on two regional campuses of a comprehensive state university. [illegible]e students in each class were randomly assigned to be subjects in either a control group or a treatment group.

Figure 1

Figure 2

In a posttest-only two-group experimental design, both groups received training in management case study analysis over a two-week period involving four 75-minute class sessions. In addition, the treatment group received training in learning strategies. All training was transmitted via written materials developed and validated by the research investigator via expert review and extensive pilot testing (See Nuttall, 1993).

Performance was assessed by expert grading of open-ended answers. A ten-page self-report questionnaire was used to gather other data (learning strategy use, learning strategy value, individual characteristics, and motivation outcomes). MANOVA was used to assess group differences at a .05 significance level. Follow-up interviews were conducted with 17 percent of the sample.

Sources for the questionnaire included: (a) adaptations (from context of course to task) of the Motivated Strategies for Learning Questionnaire, (MSLQ, Pintrich, Smith, & McKeachie, 1989), (b) the Achievement subscale of the Multidimensional-Multiattributional Causality Scales (MMCS-IV, Lefcourt, Von Baeyer, Ware, & Cox, 1979), and (c) investigator-prepared questions. Both interitem alpha and test-retest Pearson r reliabilities were compiled for all questionnaire items.

Limitations

Limitations included possible effects of time and use of self-report assessment Concerning time, it was noted that pilot studies, which took place over longer periods of time, showed significant gains in planning, self-efficacy, and expectancy for success As related to accurate reporting by subjects, limitations were considered as related to social desirability of responses, accuracy of perceptions of use, and semantics.

Summary of Results

___A summary of results are presented for performance, motivation, learning strategies use, and interactions of variables (See also Nuttall, 1992).

Performance

The treatment resulted in significant performance increases in two tasks: (a) listing symptoms of case problem(s), and (b) labelling symptoms according to management function or process. There was no significant increase for a third task, writing a problem statement.

Motivation

Concerning the three motivation outcomes, there were no significant increases. However, raw scores on self-efficacy and expectancy for success (which were correlated with each other) were slightly higher for the treatment group; and follow-up interviews with subjects indicated that they felt the use of learning strategies was motivating.

Furthermore, analyses of interactions between all the variables in the study (discussed below) indicate that motivation, along with individual characteristics, played a key role in performance outcomes among treatment group subjects, albeit in an indirect way. In particular, correlations between self-regulated learning (primary learning strategies) and motivation were stronger for the treatment group.

Supported by results obtained in a pre-pilot study, it is anticipated that, with additional time, motivational results would have been significant, at least in the areas of self-efficacy and expectancy for success.

Learning Strategies Use

Post hoc analyses indicated: (a) significant uses of two "other" learning strategies (referring frequently to instructions and other material, and reading the case more than once), and (b) tendencies toward more overall learning strategy use in the treatment group.

Interactions of Variables

Theoretical relationships between the following sets of variables were supported: (a) self-regulated learning and motivation, (b) self-regulated learning and individual characteristics, (c) functions aspect of task and self-efficacy, and (d) task-related motivation and individual characteristics. There was no support for the relationship between self-regulated learning and performance.

Synergistic Interactions of Variables Within Groups

In this study, the learning strategies treatment appears to have caused differences between the groups that were not obvious from merely looking at significant differences for performance and motivation outcomes. Figures 3 and 4 illustrate complex, synergistic relationships at work in the "black boxes" of the mind between learning strategy value, individual characteristics, motivation, and learning strategy use. These figures are entitled "General Relationships..." because, for the learning strategies variables, only general categories are provided rather than specific strategies.

Fifteen areas where correlations were unique or higher in the control group are indicated in Figure 3 as Letters D, F, G, I, L through Q, and R through V. Seventeen areas where correlations were unique or higher for the treatment group are indicated in Figure 4 as Letters A through Q.

To show relationships between variables, Pearson correlation coefficients were computed by individual subject. Two-tailed significance at the .05 level was computed for each group--control (S) and treatment (T) as well as for the total sample.

Although individual correlations are all significant at the .05 level, no between-group significance statistics were calculated. Differences were determined by observing whether: (a) one group had a correlation between two variables that the other group did not have (a unique correlation), or (b) one group had a noticeably higher (around .1000 higher) correlation than the other.

Of the 19 correlations that are indicated as being higher for one group than the other, six differences range from .0638 to .0968, and 13 differences range from .1126 to .1710.

A summary of unique and higher correlations between the groups appear in Appendix B, Tables 1 through 11. A brief summary of types of differences between the treatment, Group T (Figure 3), and the control, Group S (Figure 4), appears below in alphabetical order.

A, B, and C signify Group T's unique correlations between motivation outcomes (self-efficacy, expectancy for success, and desire to continue learning) and self-regulated (primary) learning strategies (See Table 1).

Figure 3

Figure 4

D signifies unique correlations for both groups between self-regulated (primary) learning strategies and individual characteristics (See Table 2).

E, F, and G signify correlations between motivation and individual characteristics (See Table 3). Only Group T has unique correlations between self-efficacy and individual characteristics (E), while both groups have unique correlations between individual characteristics and: (a) expectancy for success (F), and (b) desire to learn (G).

H indicates unique correlations between symptoms and other learning strategies valued for Group T, while I indicates unique correlations for both groups between problem and individual characteristics (See Table 4).

J and K indicate unique correlations for Group T between desire to learn and: (a) self-efficacy and (b) expectancy for success, respectively (See Table 1).

L indicates unique correlations for both groups between self-efficacy and other learning strategies use (See Table 5).

M, N, and O signify differences for both groups in correlations between other learning strategies valued and: (a) self-efficacy (M),
(b) expectancy for success (N), and (c) desire to learn (O). (See Table 6.)

P indicates differences in both groups between individual characteristics and other learning strategies used. Group S's correlations appear in Tables 3 and 4, while Group T's correlations appear in Table 9.

Q indicates that Group T exhibited higher correlations between other learning strategy use and value (See footnote in Table 5 plus Tables 10 and 11).

R indicates Group S's unique correlations between functions and self-efficacy (See Table 4).

S indicates Group S's unique correlations between problem and other learning strategies used (See Table 4).

T indicates Group S's unique correlations between problem and other learning strategies valued (See Table 4).

U and V indicate Group S's unique correlations between other learning strategies used and: (a) expectancy for success and (b) desire to learn, respectively (See Table 5).

Analysis of Group Differences: Comparing "Black Boxes"

After extensive post hoc analysis of the data, it is evident that there are complex explanations of the outcomes. As Dansereau (1985) has observed:

> We...know very little about the relationships between individual difference variables and training effectiveness...(and) about why the strategies work. We don't know what alterations in the participant's cognitive processing are responsible for improved test performance (pp. 230-231).

To interpret interactions between and among variables in this study, and to thus analyze what is occurring in each group's "black box," (See Figures 3 and 4), the following categories of relationships are discussed: (a) Role of other learning strategies valued, (b) other learning strategies used and individual characteristics, (c) self-regulated learning and individual characteristics, (d) motivation and individual characteristics, (e) association of motivation outcomes with each other, (f) motivation and self-regulated learning, (g) motivation and other learning strategies used, and (h) associations with performance outcomes.

After empirical results are discussed, a theoretical discussion of the interaction of variables within groups is presented in the form of a hypothetical model. This model attempts to explain processes occurring within the "black boxes."

Role of Other Learning Strategies Valued

The role of learning strategy value was evident in several unique correlations in the treatment group. First, the treatment group had higher correlations of value with use (See Tables 10 and 11) for selected strategies. Second, the treatment group had a unique correlation of symptoms and one learning strategy valued (Value of asking others for help), a strategy presented to the treatment group and not the control group (Table 4, Code H).

Third, the treatment group had more unique correlations of learning strategies valued with self-efficacy and expectancy for success (Table 6, Codes M and N).

Fourth, although both experimental groups exhibited unique associations between motivation outcomes and other learning strategies valued, there were differences in particular strategies and specific motivation outcomes correlated (See Table 6).

Evidently the treatment evoked these associations, since all the strategies associated with all three motivational outcomes by the treatment group were recommended in the learning strategies intervention.

Other Learning Strategies Used and Individual Characteristics

Tables 7 and 8 (Code P) show the control group's unique associations between other learning strategies (12 particular skills) used and individual characteristics/demographics, while Table 9 (Code P) exhibits the treatment group's unique associations.

The treatment group's correlations between other learning strategies used and individual characteristics/demographics were generally limited to task utility, task importance, and overall task value (interest, importance, and utility). There were no associations of other learning strategy use with the following individual characteristics: task interest, test anxiety/cognitive interference, or generally any type of causality beliefs such as effort, internal or external beliefs, and attributions to failure experience.

On the other hand, for purposes of discussion, control group correlations may be grouped into four categories. In the first category are those characteristics that seem to indicate that learning strategies are not generally helpful and are used only as a last resort to avoid failing: (a) overall test anxiety, (b) low GPA, (c) no prerequisite Introduction to Business course, (d) attributions to failure experiences, and (e) external causality.

The second category indicates ease in, or time available for, using the strategies: low semester credit load. The third category of individual characteristics relates to interest in task: (a) task value (interest) and (b) negative interest in study. The fourth category indicates particular types of students: (a) high attendance and (b) male.

<u>Self-Regulated Learning and Individual Characteristics</u>

As indicated in Table 2 (Code D), the treatment group exhibited more than 30 unique correlations between self-regulated learning and individual characteristics, while the control group exhibited only two such correlations.

While the control group's associations of individual characteristics with primary learning strategies were limited to effort and task utility, the treatment group exhibited more combinations of personal academic beliefs and learning strategy use that indicated tendencies toward intrinsic motivation and overall task value; and they seemed to value the whole learning experience more, including both task completion and learning strategy use.

<u>Motivation and Individual Characteristics</u>

Since motivation and self-regulated learning variables are correlated (See Table 1), similar relationships between motivation and individual characteristics could be expected, which was the case in this study. As indicated in Table 3, for the control group there were only four unique correlations between motivation and individual characteristics. On the other hand, the treatment group had more numerous and complex unique correlations between motivation and individual characteristics, as explained below.

<u>Individual characteristics associated with self-efficacy</u>. As shown under Code E, the learning strategies treatment seems to have evoked associations with self-efficacy of overall task value (particularly interest and utility) as well as a tendency to not associate external events or luck with academic performance.

<u>Individual characteristics associated with expectancy for success</u>. As shown under Code F, the learning strategies treatment seems to have evoked associations with expectancy for success that were identical to self-efficacy associations in all but two aspects: task utility and overall task value (There was no difference between the control and treatment groups for these two associations).

Individual characteristics associated with desire to learn. As shown under Code G, the learning strategies treatment seems to have evoked more associations in both groups between desire to learn and all individual characteristics than other motivation outcomes did. Also, similar to self-efficacy and expectancy for success associations, the treatment seems to have evoked an association with desire to learn of not associating external events, luck, or past failure with academic performance. Again, the control group associated desire to learn with such variables as task utility, effort beliefs, and internal causality beliefs.

(Years since high school is an unexplainable association with desire to learn for both total sample and the treatment group unless it indicated the experimental groups were not equivalent in some combination of variables, such as gender and age.)

Associations of Motivational Outcomes with Each Other

___In the treatment group, there were higher correlations between: desire to learn and: (a) self-efficacy and (b) expectancy for success (See Table 1, Codes J and K).

Motivation and Self-Regulated Learning

As shown in Table 1 (Codes A and B), the treatment group had unique correlations between the two motivational variables of self-efficacy and expectancy for success and the two self-regulated learning variables of planning and regulating. The treatment group's correlation between desire to learn and all self-regulated learning strategies were also higher (Table 1, Code C).

Motivation and Other Learning Strategies Used

As indicated in Table 5 (Code L), the treatment group had only two unique correlations: (a) Self-efficacy and writing notes in the margin and (b) self-efficacy and referring frequently to instructions and other materials. However, these strategies were ranked as high-use and high-value by both groups. There were no treatment correlations between expectancy for success or desire to learn and other learning strategies used.

In the control group, two strategies were associated with both self-efficacy and expectancy for success (Codes U and V): Timing work and making a diagram of case facts, both which were low-use, low-value ranked strategies by both groups.

It appears that the treatment group associated referring frequently to instructions and other materials with personal ability to perform a task (self-efficacy), whereas the control group associated the same learning strategy with personal interest in the task or desire to learn more about it.

It appears that self-efficacy may have been the key to increased performance in symptoms and functions, since it was linked with the only learning strategy used significantly more by the treatment group. Furthermore, self-efficacy was linked to functions for the total sample, and functions and symptoms were linked for all groups.

Associations with Performance Outcomes

The following associations (shown in Table 4) may have influenced better performance outcomes for symptoms and functions in the treatment group.

1. The association between symptoms and valuing asking others for help (Code H). This strategy appeared in the treatment instructions although it could not be used unless students talked outside of class (the experimental site); however, the rationale for its leading to increased performance would be supported by Dansereau's (1985) finding that peer/dyad learning leads to increased achievement.

2. The inclination to not associate self-efficacy with performance (Code R). One reason for this situation may have been that, while both groups received feedback on their performance thro·:ghout the experimental training period, the treatment group did not worry about getting lo· · scores because they knew they had an arsenal of learning strategies that would help thei . perform better. In effect, the treatment group's self-efficacy would appear to be higher, despite non-significantly higher raw scores.

Theoretical Discussion of Interaction of Variables Within Groups: A Hypothetical Model

Figure 5 presents a theoretical model of the relationships of what possibly could be the most instrumental variables in the study. While results of the study indicated correlations between various types of variables, no statistical analyses of directionality were conducted. Therefore, while data suggest a possible tendency of movement from the top of the diagram downward, and from right to left, there may in fact be circular relationships operating among the variables. Also, before accepting this model, not only cause-effect relationships should be tested, but between-groups tests of significance should be conducted on the unique correlations in each group.

The treatment evoked different associations for each group between motivation and learning strategy use, which may be related to differences in performance directly, or indirectly (through the role of individual characteristics or motivational affects).

In addition, learning strategy value appears to be the variable most closely associated with training; and use of particular learning strategies appears to be the variable most closely associated with performance. Other, possibly intervening and interacting, variables are discussed below.

Learning Strategy Value, Use and Individual Characteristics

Data from the study suggest that, because the treatm·ent group associated value of learning strategies with use to a greater degree than the control group, they may have used strategies (including primary le .ning strategies) more effectively. As evidenced by unique associations with personal beliefs and attributions (individual characteristics), the treatment group may have had more unconditional acceptances of learning strategy use.

Conversely, the control group may have viewed learning strategies as generally not helpful, to be used only if the task was interesting, it was convenient or easy to do so, or as a last resort to avoid failing.

Theoretical Role of Individual Characteristics in Outcomes

Personal interest and value in a task or subject may be key individual characteristics related to academic performance, motivation, and learning strategy use (both primary and other learning strategies). Results indicate that the control group had more of a tendency to associate the use of a strategy with task interest, effort, and unproductive personal attributions (i.e., the need to avoid academic failure).

Conversely, results indicate that the treatment group had more of a tendency to associate overall task value (interest, importance, and utility) with learning strategy use. It appears that the treatment planted an unconscious, unconditional recognition of the value of learning strategy use.

In addition, follow-up interviews suggest that task value or interest may have the power to override knowledge of either subject or learning strategies as an academic motivator.

Figure 5

It also appears that the following three general principles may be at work:

1. Individual characteristics (i.e., task importance and utility) may affect use of "primary" learning strategies (groups of cognitive and metacognitive strategies), which seem to be directly related to motivational outcomes, and indirectly to performance.

2. Individual characteristics may affect use of "other" learning strategies (particular strategies and techniques, including resource management) that may directly influence performance.

3. The mix of individual characteristics, "primary" (self-regulated) learning strategies, and motivation outcomes, in combination with particular other learning strategies, may indirectly lead to different performance outcomes.

The study did not assess learning strategy goals, yet the treatment could also have affected such goals. According to Weinstein and Mayer (1986), the goal of any particular learning strategy may be the "...way in which the learner selects, acquires, organizes, or integrates new knowledge" (p. 315). Perhaps the treatment affected one or more of these variables.

Individual Characteristics, Motivation and Performance

High correlations between task interest and motivation, as well as correlations between self-regulating strategies (planning and regulating) and both self-efficacy and expectancy for success may have evoked other learning strategy use that was relevant to increased performance.

Theoretical Motivational Patterns

Results confirmed the dynamism of continuing intrinsic motivation, which has been defined by McCombs (1984) as:

a dynamic, internally mediated set of metacognitive, cognitive, and affective processes (including expectations, attitudes, and beliefs about the self and the learning environment) that can influence a student's tendency to approach, engage in, expend effort in, and persist in learning tasks on a continuing self-directed basis (p. 200).

Data from the study suggest that self-efficacy may have been the motivational variable most related to differences between the groups in relationships among the other variables. For example, the treatment group had more associations with self-efficacy than the control group, including the previously mentioned links with learning strategy use.

Secondly, the treatment group associated self-efficacy with learning strategy use, as opposed to the control group's association of self-efficacy with performance. Thirdly, although there were no significant differences in scores, the treatment group showed higher correlations (synergistic effects) between expectancy for success and desire to learn (43 percent higher), and desire to learn and self-efficacy (49 percent higher).

Although self-efficacy and active engagement in learning are seen in the literature as motivational aspects of self-regulated learning, the literature provided no definitive descriptions of motivational outcomes of self-regulated learning. What was discussed is a circular relationship between achievement and motivation; for example, Corno (1986) implied that one must be motivated to achieve, yet one may be motivated by achievement.

Follow-up interviews in this study supported the idea that learning strategy use can be motivational, and the treatment group did have higher scores on two performance (achievement) outcomes.

Pintrich and De Groot (1988) suggest that important factors in student achievement include planning (among other metacognitive strategies), self-efficacy, and motivation to employ self-regulated strategies and regulate cognition and effort. In addition, Easton and Ginsberg (1983) and Zimmerman (1986) note that planning is an achievement factor.

As related to this study, planning significantly increased for the pilot subjects (N = 90), and both self-efficacy and expectancy for success significantly increased for pre-pilot subjects (N = 20) two and one-half months after the training intervention, during which time they were enrolled in a course involving nothing else but the analysis of case studies.

It is theorized that perceived self-efficacy (a combination of perceived personal competence and self-confidence, or ability to discriminate between controllable and uncontrollable situations) leads to increased motivation (Bandura, 1986; McCombs, 1988). Perhaps the treatment caused a link between self-efficacy and some other variable, which produced the same effect as self-efficacy alone.

Various researchers (Bandura, 1986; McKeachie, 1988; McCombs, 1988; Schunk, 1987) indicate that self-efficacy may either affect learning strategies training or be affected by it.

Concerning the relationship between self-efficacy and performance, Bandura (1986) notes that people who have high self-efficacy will "mobilize greater effort and persist longer on a task" (p. 413). In this connection, self-efficacy is an important element of self-regulated learning which, when combined with low anxiety toward learning, is a good predictor of student achievement, according to Pintrich and De Groot (1988).

However, is self-efficacy necessary for performance, or is it an effect of performance? In analyzing performance results for this study, it appears that, for the treatment group, self-efficacy may have resulted from a knowledge of learning strategy use (or other related variables) and then become a precursor to performance. Conversely, it appears that, for the control group, lower self-efficacy was a result of, instead of a precursor to, performance, since the control group subjects did not have a storehouse of learning strategies presented to them in the study.

Also, since self-efficacy and expectancy for success are highly correlated, it might be said that, because the treatment group had training in learning strategies, they may have had higher expectations for success and, therefore, higher self-efficacy, despite insignificant higher raw scores with large standard deviations.

Regarding the interaction of motivation and self-regulated learning, if one agrees that the functions of learning strategies training/use are both cognitive and affective, and involve self-directed learning (Weinstein & Mayer, 1986; McCombs, 1987), it is obvious that the experimental treatment made a difference. Furthermore, if one accepts McCombs' (1987) argument that all learning is inherently autonomous (independent and self-directed) and that students ultimately have to be guided by their own motivation (including interests) and ability, it would appear that the treatment group exhibited more autonomous-like interactions.

Implications for Practice

Implications for practice include the integration, by both educators and students, of task-related learning strategies into educational programs at all levels. The instructional package would include knowledge of subject content, learning strategies, and attributions awareness (knowledge of how individual characteristics, values, and motivation may affect learning).

Recommendations for Research

Recommendations for further research are listed below.

1. Study synergistic interactions of more than one variable at a time when analyzing performance and motivational outcomes.

2. Regarding motivational variables, continue to assess self-efficacy and expectancy for success in the self-concept context. Desire to learn is a more complex variable in that it incorporates more than the self-concept context. An additional variable would be effort.

3. Regarding instrumentation, subjects need to be tested as to their actual knowledge and application of learning strategies. Such assessments as journals, observation and testing might be appropriate.

4. Allow adequate time--i.e., a minimum of three to six months--for appropriate practice, mastery, and motivation for actual use of learning strategies.

5. Incorporate peer/teacher discussion in the learning strategies package.

6. Via cluster analysis, determine if students fall into particular categories of learning strategies use and motivational characteristics.

7. Determine which particular strategies cause the most variance in particular performance and motivation outcomes.

8. Determine whether case guidelines act as strategies by setting up a control group which is not provided with such extensive instructions.

9. Complete more classroom application studies similar to this study; but use more complex problems and add problem solution to problem statement as a performance outcome.

10. Integrate learning strategies training with other types of tasks and compare results of training.

11. Apply findings to not only other subject areas, ' at all levels and types of education-- elementary, secondary, postsecondary, and adult and on-the-job training.

12. Test the proposed directional associations in the theoretical model concerning the relationships between learning strategies training, learning strategies valued, individual characteristics, self-regulated learning, other learning strategies used, and performance.

13. Continue developing theoretical models that portray relationships between significant variables that impact on motivation and performance. This involves reviewing literature in the various areas of motivation, metacognition, self regulated learning, learning strategies, instructional design, and higher education, etc.

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Appendix A

Operational Definitions

Included herein are operational definitions of variables studied. They are categorized by performance outcomes, motivational outcomes, individual characteristics, learning strategies abilities and self-regulated learning, and learning strategies training. All assessments except performance were based on self-report.

Performance Outcomes

Performance includes separate scores on three different aspects of a case problem analysis: (a) Listing symptoms that indicate management problems exist; (b) classifying symptoms as appropriate management functions (planning, organizing, directing, and controlling) and/or processes (decision making and communication).

Motivational Outcomes

Since motivation is, by definition, consciously or unconsciously decided goal-directed behavior, goal orientation and self-concept motivational variables are emphasized as outcomes in this study--i.e., desire to continue learning, expectancy for success, and self-efficacy for learning.

Desire to continue learning. Desire to continue learning includes the desire to learn more about both management in general and case study analysis in particular.

Expectancy for success. Expectancy for success relates to expectations for task-specific academic success. It indicates generally "how well" and, in particular, the extent to which subjects will obtain high scores on business case problem tasks.

Self-efficacy for learning. Self-efficacy for learning is operationalized as perceived task-related self-efficacy for learning. Components are understanding difficult written or oral information presented, learning basic concepts, mastering skills being taught, and confidence in completing assignments and tests involved in a case problem research project.

Individual Characteristics

Twenty-two individual characteristics were assessed. Ten individual characteristics are defined. An additional 12 demographic variables are simply listed since they are self-explanatory.

Ability beliefs. These reflect the causal role a student believes ability plays in obtaining good grades and understanding material presented at school.

Attributions to failure experiences. These reflect beliefs about the causal role four elements (ability, context, effort and ability) play in such assessments of "academic low points" as getting low grades, not understanding school materials, or not doing as well as expected.

Attributions to success experiences. These reflect beliefs about the causal role four elements (ability, context, effort and ability) play in such assessments of academic success as good grades, overcoming obstacles in the path of academic success, having the teacher think highly of one's work, and success on exams.

Context beliefs. These beliefs account for the assignment of causality for academic success or failure to such contextual elements as the teacher's grading scheme, difficulty level of course, teacher's opinion of student, or teacher's ability to make course interesting.

Demographic variables. These included: Ethnic group, gender, degree program, college major, class level, completion of an Introduction to Business course, interest in participating in study, years since high school graduation, number of years full-time work experience, number of current semester credit hours, total credit hours completed, and cumulative gradepoint average.

Effort beliefs. These beliefs account for the assignment of causality for academic success or failure to personal effort or degree of studying or working hard.

External causality beliefs. These beliefs assign causality for academic success or failure to luck or contextual factors listed in "context beliefs" (i.e., the teacher's actions or the course itself).

Internal causality beliefs. These beliefs assign causality for academic success or failure to personal ability and effort.

Luck beliefs. These beliefs assign causality for academic success or failure to luck--i.e., having the right questions show up on an exam or getting bad breaks.

Task value. Task value incorporates three aspects: (a) interest in the subject matter of the course, (b) the importance of understanding management case problems, and (c) the usefulness (utility) of learning about case problem analysis.

Test anxiety. Test anxiety incorporates two aspects, cognitive interference and emotionality. Cognitive interference is the degree to which students think about items on a test they can't answer, the consequences of failing, and how poorly they are doing in comparison with other students. Emotionality refers to the uneasy, upset feelings (i.e., fast-beating heart) that may arise in taking an exam.

Learning Strategies Abilities and Self-Regulated Learning

Learning strategies are flexible patterns of thoughts and behaviors used to acquire, manipulate, and retain knowledge and skills. Three major categories of learning strategies are cognitive, metacognitive, and resource management strategies. The cognitive aspect is knowledge about particular strategies; the metacognitive aspect is ability to plan for and regulate strategy use. Resource management strategies relate to the use of external sources of learning support and include, in this study: Timing work, asking others for help, and concentrating in a quiet place.

However, knowledge of learning strategies alone is not enough to affect performance and motivational outcomes. Active control over and engagement in the learning process through application of learning strategies is needed. This self-controlled use or application of learning strategies is known as self-regulated learning.

Learning Strategies Training

In this study, a variety of learning strategies were provided in the training treatment. Consequently, two categories of learning strategy use were assessed: (a) "self-regulated" or "primary" learning strategies, and (b) "other" learning strategies.

The assessment of "primary" strategies followed Pintrich et al's (1989) assessments of four categories of cognitive/metacognitive strategies related to self-regulated learning: Organization, Elaboration, Planning and Regulating. These strategies are defined below, per Pintrich et al (1989).

The assessment of "other" learning strategies involved the reported use of twelve particular study techniques, rather than groups of strategies, that had been listed as being useful in completing the case study tasks in the pilot study. These other learning learning strategies are also listed below; they included organizing, regulating, and resource management techniques, as indicated in parentheses.

Elaboration strategies. Elaboration, as related to business case studies, includes a composite of: (a) pulling together information from different sources, such as lectures, handout information or readings; (b) trying to relate new material to what the subject already knows; (c) writing brief summaries of main ideas in a case; (d) making connections between readings and concepts from lecture; (e) applying ideas from other classes to cases; and (f) relating ideas learned from management case studies to other courses.

Organization strategies. Case-related organization strategies include a composite of: (a) locating important ideas; (b) outlining both case study materials and personal notes; and (c) making simple charts, diagrams or tables to organize or summarize materials.

Planning strategies. Case-related planning strategies include a composite of: (a) skimming new material before studying it thoroughly; (b) making up questions about written materials; (c) setting goals to direct activities in each study period; and (d) thinking through what is to be learned rather than just reading written material.

Regulating strategies. Case-related regulating strategies include: (a) Rereading confusing material to figure it out; (b) changing the way difficult material is read; (c) adapting studying and learning style to instructor's requirements and teaching style; and (d) sorting out confusing ideas or instructions and doing something about it before next class meeting.

Other learning strategies. Other learning strategies included individual (rather than composite) assessments of use (LSU) and value (LSV) of the following twelve strategies: (1) having all materials organized before beginning task (organizing); (2) timing work (resource management); (3) asking others for help (resource management); (4) reading the case more than once (regulating); (5) underlining or highlighting important points (organizing); (6) writing notes in the margin of the case (organizing); (7) taking written notes about the case (organizing); (8) making a diagram of the case facts (organizing); (9) using a worksheet to organize symptoms (organizing); (10) writing a rough draft of problem statement (organizing); (11) concentrating in a quiet place (resource management); and (12) referring frequently to instructions and other materials.

Appendix B

Tables 1 - 11

Table 1

Figure Codes A-C and J-K. Summary of Experimental Group Differences: Group T's Unique or Higher

Correlations between Motivation Outcomes (Self-Efficacy, Expectancy for Success, and Desire to Learn)

and Self-Regulated (Primary) Learning Strategies

Variables Correlated	Group S	Group T
CODE A:		
Self-efficacy and Organization	.4294	.5135
Self-efficacy and Elaboration	.5633	.7801
Self-efficacy and Planning	-	.6204
Self-efficacy and Regulatin	-	.6677
Self-efficacy and Total Metacognition	-	.6855
CODE B:		
Expectancy for Success and Elaboration	.5315	.7345
Expectancy for Success and Planning	-	.6690
Expectancy for Success and Total Metacognition	-	.6490
CODE C:		
Desire to Learn and Organization	.5410	.6215
Desire to Learn and Elaboration	.6094	.7029
Desire to Learn and Planning	.6087	.7320
Desire to Learn and Regulating	.6261	.6937
Desire to Learn and Total Metacognition	.7049	.7687
CODE J:		
Self-efficacy and desire to learn	.4281	.6114

CODE K:

Expectancy for success and desire to learn	.3852	.5750

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

N for total sample = 54; N for Group S = 28; N for Group T = 26

Table 2

Figure Code D. Summary of Experimental Group Differences: Unique or Higher Correlations between

Individual Characteristics and Self-Regulated (Primary) Learning Strategies

INDIVIDUAL CHARACTERISTICS CORRELATED WITH ORGANIZATION STRATEGIES:

Group S - None

Group T - Importance of task, utility of task, overall task value (interest, importance and utility), negative context beliefs, negative externality causality, and negative overall externality causality beliefs (All unique with range = .4301 to .6176)

INDIVIDUAL CHARACTERISTICS CORRELATED WITH ELABORATION STRATEGIES:

Group S - None

Group T - Unique (ranging from .4435 to .5075) - Interest in task, negative context beliefs, and negative externality causality beliefs. Higher - importance of task (.5964 vs. .3935) and overall task value (.6104 vs. .4070).

INDIVIDUAL CHARACTERISTICS CORRELATED WITH PLANNING STRATEGIES:

Group S - Task utility (.4090)

Group T - Unique (ranging from .4158 to .5778) - Interest in task, importance of task, and negative relationships with context beliefs, luck beliefs, externality causality, overall externality causality beliefs, attributions to success experiences, and attributions to failure experiences. Higher - Task value (.5452 vs. .4326)

INDIVIDUAL CHARACTERISTICS CORRELATED WITH REGULATING STRATEGIES:

Group S - Effort (.4424)

Group T - Unique (.4011 to .5978 range) - Interest in task, years since high school, and negative relationships with test anxiety (cognitive interference), context beliefs, luck beliefs, externality causality beliefs, and attributions to failure experiences. Higher - Importance of task (.6104 vs. .4022) and overall task value (.6291 vs. .3971)

Notes: This material has been extracted from Table 24, Nuttall (1991). $p < .05$ for correlations within each group; between-group significance was not calculated. Total sample N = 54; N for Group S = 28; N for Group T = 26.

Table 3

Figure Codes E-G. Summary of Experimental Group Differences: Unique or Higher Correlations

between Motivation Outcomes (Self-Efficacy, Expectancy for Success, and Desire to Learn) and

Individual Characteristics

Variables Correlated	Group S	Group T
CODE E (Group T is unique or higher):		
Self-efficacy and task interest	-	.6779
Self-efficacy and task utility	-	.4739
Self-efficacy and overall task value	.4046	.6756
Self-efficacy and luck beliefs	-	-.4145
Self-efficacy and external causality beliefs	-	-.4045
CODE F (Both groups have unique correlations):		
Expectancy for success and task importance	.4331	-
Expectancy for success and task interest	-	.6308
Expectancy for success and luck beliefs	-	-.4961
Expectancy for success and external causality beliefs	-	-.4171
CODE G (Both groups have unique correlations):		
Desire to learn and task utility	.4765	-
Desire to learn and effort beliefs	.4866	-
Desire to learn and internal beliefs	.3949	
Desire to learn and task interest	.4815	.7153
Desire to learn and task importance	.4993	.5961
Desire to learn and overall task value	.5594	.6759
Desire to learn and context beliefs	-	-.5081
Desire to learn and luck beliefs	-	-.4197
Desire to learn and external causality beliefs	-	-.5085
Desire to learn and attributions to failure experiences	-.5306	

Desire to learn and years since high school graduation	-	.5411

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

Total sample N = 54; N for Group S = 28; N for Group T = 26.

Table 4

Figure Codes H, I, and R-S. Summary of Experimental Group Differences: Unique or Higher Correlations between Performance (Symptoms, Functions, and Problem) and Other Variables

Variables Correlated	Group S	Group T
CODE H (Group T is unique):		
Symptoms and valuing asking others for help (LSV3)	-	.5588
CODE I (Both groups have unique correlations):		
Problem and luck beliefs	-.4418	-
Problem and semester credit hours	-.4185	-
Problem and female gender	-	.4694
CODE R (Group S is unique):		
Functions and self-efficacy	.4744	-
CODE S (Group S is unique):		
Problem and concentrating in a quiet place (LSU11)	.4408	-
CODE T (Group S is unique):		
Problem and valuing asking others for help (LSV3)	-.3981	-
Problem and valuing concentrating in a quiet place (LSV11)	.5825	-

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

Total sample N = 54; N for Group S = 28; N for Group T = 26.

Table 5

Figure Codes L, U, V, and Q*. Summary of Experimental Group Differences: Unique or Higher

Correlations between Motivation (Self-Efficacy, Expectancy for Success, and Desire to Learn) and Other

Learning Strategies Used

Variables Correlated	Group S	Group T
CODE L (Both groups have unique correlations):		
Self-efficacy and timing work	.4466	-
Self-efficacy and making a diagram of case facts	.5151	-
Self-efficacy and writing notes in margin		.3922
Self-efficacy and referring frequently to instructions and other materials		.5199
CODE U (Group S has unique correlations):		
Expectancy for success and timing work	.3754	-
Expectancy for success and making a diagram of case facts	.5292	-
CODE V (Group S has unique correlations):		
Desire to learn and having all materials organized before beginning task	.5480	-
Desire to learn and reading the case more than once	.5850	-
Desire to learn and concentrating in a quiet place	.4737	-
Desire to learn and referring frequently to instructions and other materials	.4133	-

*Figure CODE Q indicates that Group T exhibited higher correlations between other learning strategy use and value (See Tables 10 and 11), with one exception: Group S's correlation of use with value was higher for referring more frequently to instructions and other materials (.7080 vs. .5467).

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

N for total sample = 54; N for Group S = 28; N for Group T = 26.

Table 6

Figure Codes M-O. Summary of Experimental Group Differences: Unique or Higher Correlations

between Motivation (Self-Efficacy, Expectancy for Success, and Desire to Learn) and Other Learning

Strategies Valued

Variables Correlated	Group S	Group T
CODE M (Both groups have unique correlations):		
Self-efficacy and valuing timing work	.4666	
Self-efficacy and valuing making a diagram of case facts	.5347	
Self-efficacy and valuing having all materials organized before beginning task	-	.4124
Self-efficacy and valuing referring frequently to instructions and other materials	-	.4872
Self-efficacy and valuing underlining or highlighting important points	-	.4362
CODE N (Both groups have unique correlations):		
Expectancy for success and valuing making a diagram of case facts	.4242	
Expectancy for success and valuing having all materials organized before beginning task	-	.4377
Expectancy for success and valuing underlining or highlighting important points	-	.4267
Expectancy for success and valuing referring frequently to instructions and other materials	-	.4872
CODE O (Both groups have unique correlations):		
Desire to learn and valuing having all materials organized before beginning task	.5253	-
Desire to learn and valuing reading the case more than once	.5057	-
Desire to learn and valuing concentrating in a quiet place	.4598	-
Desire to learn and valuing using a worksheet to organize symptoms		.4410
Desire to learn and valuing referring frequently to instructions and other material	-	.4850

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

Total sample N = 54; N for Group S = 28; N for Group T = 26.

Table 7

Figure Code P, Summary of Experimental Group Differences: Group S's Unique Correlations between

Other Learning Strategies Used and Individual Characteristics

Variables Correlated	Group S
Task interest and:	
(a) asking others for help (LSU3)	.3869
(b) reading the case more than once (LSU4)	.4291
Test anxiety (emotionality) and timing work (LSU2)	.4070
Overall test anxiety and timing work (LSU2)	.3867
Effort beliefs and:	
(a) having all materials organized before beginning task (LSU1)	4554
(b) timing work (LSU2)	.5122
(c) reading the case more than once (LSU4)	.6523
(d) referring frequently to instructions and other materials (LSU12)	.6020
Internal causality beliefs and:	
(a) having all materials organized before beginning task (LSU1)	3864
(b) reading the case more than once (LSU4)	.5255
(c) underlining or highlighting important points (LSU5)	.4262
(d) referring frequently to instructions and other materials (LSU12)	.5154
External beliefs and timing work (LSU2)	.4565
Attributions to success experiences and:	
(a) having all materials organized before beginning task (LSU1)	4578
(b) timing work (LSU2)	.5063
(c) reading the case more than once (LSU4)	.5171
Attributions to failure experiences and timing work (LSU2)	.4266

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

N for total sample = 54; N for Group S = 28; N for Group T = 26

Table 8

Figure Code P, Summary of Experimental Group Differences: Group S's Unique Correlations between
Other Learning Strategies Used and Demographics

Variables Correlated	Group S
Negative relationship between Introduction to Business course and:	
(a) timing work (LSU2)	.4568
(b) taking written notes about the case (LSU7)	.4217

Negative relationship between interest in study and:
(a) having all materials organized before beginning task (LSU1) .3945
(b) reading the case more than once (LSU4) .3871

Male gender and underlining or highlighting important points (LSU5)* 4074
Negative relationship between semester credit hours and:
(a) writing notes in the margin of the case (LSU6) .3811
(b) concentrating in a quiet place (LSU11) .5051

Negative relationship between GPA and:
(a) timing work (LSU2) .4658
(b) asking others for help (LSU3) .6080

Negative relationship between absences and making a diagram of the case facts (LSU8) .4383

*There were no significant main effects for gender at the .05 level for using this strategy.

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.
N for total sample = 54; N for Group S = 28; N for Group T = 26

Table 9
Figure Code P. Summary of Experimental Group Differences: Group T's Unique Correlations between
Other Learning Strategies Used and Individual Characteristics/Demographics

Variables Correlated	Group T
Task utility and:	
(a) having all materials organized before beginning task (LSU1)	.4022
(b) using a worksheet to organize symptoms (LSU9)	.4101
(c) referring frequently to instructions and other materials (LSU12)	.6352
Task importance and:	
(a) using a worksheet to organize symptoms (LSU9)	.6839
(b) referring frequently to instructions and other materials (LSU12)	.4704
Overall task value (interest, importance, and utility) and:	
(a) using a worksheet to organize symptoms (LSU9)	.4829
(b) referring frequently to instructions and other materials (LSU12)	.6232
Test anxiety (emotionality) and making a diagram of the case facts (LSU8)	.3890
Attributions to success experience and writing a rough draft of problem statement (LSU10)	.4241
Associate degree major (vs. bachelor's) and timing work (LSU2)	.4799

Notes: $p < .05$ for correlations within each group; between-group significance was not calculated.

N for total sample = 54; N for Group S = 28; N for Group T = 26

Table 10

<u>Correlations of Other Learning Strategies Valued (LSV1-6) with Other Learning Strategies Used for</u>

<u>Total Sample and Experimental Group</u>

	Strategies Valued					
Strategies Used	LSV1	LSV2	LSV3	LSV4	LSV5	LSV6
LSU1	.8452 .8640S .7797T				 .4104S	
LSU2		.8335 .7669S .8911T	.3933 · .4940T			.4913 .5730S .4002T
LSU3	 .3957S	.3963 · .6120T	.7831 .7549S .8363T		.3161	
LSU4	.3128 .4614S			.5083 .6135S		
LSU5	.3842 .6123S			.3691 ·	.6836 .5558S .9068T	
LSU6		.4364 .4136S .4619T		 .4002T	 .4320T	.8457 .7200S .9595T
LSU8		.2925 .4221T				
LSU9	.5057 .4408S .5314T					
LSU11	.3258 .5592S				 .5179S	
LSU12	 .4318T			.3131		

<u>Notes</u>: $p = < .05$. A complete listing of LSU/LSV is in Exhibit A. N for total sample = 54; N for Group S = 28; N for Group T = 26

Table 11

Correlations of Other Learning Strategies Valued (LSV7-12) with Other Learning Strategies Used for Total Sample and Experimental Group

	Strategies Valued					
Strategies Used	LSV7	LSV8	LSV9	LSV10	LSV11	LSV12
LSU1			.3452 .4112T		.2676	.3250 .4411T
LSU2	.2977	.3703 .3800S		.2975		
LSU3	.3022 .4274T			.3091		
LSU4						.4088 .4762S
LSU5					.4231S	
LSU7	.8196 .6971S .9323T			.3227 .6553T	.2714	
LSU8		.8615 .8707S .8243T	.3476 .5579S	.3659 .5809T		
LSU9		.3547 .5933S	.8748 .8292S .9466T			
LSU10	.4343 .6388T	.4067T		.8680 .7681S .9755T		
LSU11					.7662 .7895S .7889T	
LSU12					.5467T	.6568 .7080S

Notes: $p = < .05$. A complete listing of these items is in Exhibit A. N for total sample = 54; N for Group S = 28; N for Croup T = 26

Title:

Situated Learning and the Limits of Applying the Results of These Data to the Theories of Cognitive Apprenticeships

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In this paper, we try to describe in detail the characteristics and elements of situated learning. We then describe some of the manifestations of instruction that are intended to exploit this perspective. Strengths and weaknesses of these perspectives will be described in the context of the data presented in support of situated learning theories. While providing provocative alternatives to current conceptions of learning, we conclude that it may not be possible to integrate notions of situated learning into instructional design as currently practiced.

Situated Cognition: Alternative Conceptions of Learning

Situated cognition proposes a radically different explanation of learning, conceiving it as a largely social phenomenon. Rather than occurring within the mind of the individual, learning is instead described as a characteristic of many social interactions that take place within a framework of participation (Hanks, 1992). Increasing participation in "communities of practice" has the effect of engaging the whole person, focusing on "ways in which it [learning] is an evolving, continuously renewed set of relations" (Lave & Wenger, 1991; p. 50). Indeed, from the perspective of situated cognition, learning requires a rich repertoire of essential actors and participatory relationships beyond those common to education and training as now practiced. Situated cognition also proposes a different location for knowledge, and a different philosophy of knowledge in the learning process, along with an emphasis on legitimate peripheral participation in social groups that is characteristic of learners in a variety of settings and cultures.

Situated action

Theories of situated cognition take the view that human activity is complex, involving social, physical and cognitive factors. Proponents of these theories believe that rather than acting on symbolic representations of the world that are located in the mind, we are in direct contact with the environment. Cognitive representations only become necessary when normal, situated activity fails (Dreyfus & Dreyfus, 1986; Greeno, 1989; Winograd & Flores, 1986). Suchman (1987) describes two types of activity in which humans engage: ad hoc improvisation during action and representations of action as plans or retrospective accounts. Situated action is not driven by plans, or in other words, humans "do not anticipate alternative courses of action, or their consequences, until some course of action is already underway" (Suchman, 1987, p. 52).

For example, suppose we wanted to build a robot to navigate the rocks, boulders, and craters of Mars. We have two basic approaches. In the first approach, we can build a robot with an "intelligence" based on the computational metaphor of the mind. The robot would utilize video input devices to view the terrain, convert the input into symbols used by the on-board computer to recognize patterns in the terrain, then carefully compute plans about where to move next (e. g., which leg, how far, what angle, etc.). In the second approach, we could build a robot that had "mini-intelligent" legs and arms that could automatically sense the changes in terrain and adjust to the undulations each leg might encounter. Its actions would be situated in the context of walking on Mars, and it would only need to stop and "plan" if it encountered a vertical wall, a canyon or some other obstacle that caused its "mindless" functioning to stop. The outcome of purposeful, goal-directed behavior has seemingly been achieved by each robot, the former using symbolic computation methods, the latter by situated action.

As a more realistic example, consider Lave's (1988) systematic examination of the nature of situated mathematics as a part of the Adult Mathematics Project. One of the most commonly reported anecdotes from her work is the description of a man who is implementing a diet program and trying to cut his intake of food by three-fourths. One of the items he needs to use in a recipe is three-fourths of two-thirds of a cup of cottage cheese. Instead of selecting the appropriate school-based algorithm and performing the necessary calculation to determine the appropriate measurement, the man uses a somewhat "unorthodox" approach. He measures two-thirds cup cf cottage cheese, empties the contents of the measuring cup on the counter, shapes the substance into a pie-shaped pile, cuts it into quarters, and removes a quarter section. The man's actions are situated, in the sense that he employs a procedure that is largely based on the context of the situation, even though it reflects some school-based knowledge (e. g., a circle represents the whole, divide the circle into equal fractional portions, etc.). If there were many of these calculations, the man's problem-solving strategies might change to a more efficient approach that incorporates some form of planning -- perhaps he might even choose to use an algorithm. But, this change in strategies would only occur after the man stopped his situated action in order to reflect on the situation so as to develop a more efficient plan of action.

Schon (1983) has extended the notion of situated action to include an important additional characteristic; that practitioners often reflect on their situated action in order to deal with some troublesome phenomenon of the situation. For Schon, knowledge is "ordinarily tacit, implicit in our patterns of action and in our feel for the stuff with which we are dealing. It seems right to say that our knowing is in our actions" (p. 49). As practitioners become more experienced, this tacit knowledge increases in its complexity and usefulness, but all practitioners still experience problems in which it is necessary to cope with divergent situations where their situated actions are not effective in solving the problem. In these cases practitioners employ reflection-in-action to construct new ways of framing the problem so that situated action can resume. Studies of practitioners in a variety of domains, from design to psychotherapy to town planning, reveal practices that alternate between situated action and reflection-in-action. If such behavior is characteristic of practitioners, it may be advantageous to encourage learners to adopt similar behavior when learning to solve problems.

Assumptions about Knowledge

The nature and role of knowledge in the learning process is challenged by situated cognition. Rather than viewing knowledge as internal to the mind, situated cognition suggests that knowledge is a relation between an individual and a social or physical situation. Greeno (1989) explains that such a conceptualization is "..analogous to the concept of motion in physics. The velocity and acceleration of an object in motion are not properties of the object itself, but are properties of a relation between the object and a frame of reference" (p. 286). In fact, the objective nature of knowledge has been questioned by many in the social sciences with some suggesting that there may be no "right" way to represent knowledge or structure content (Wilson & Cole, 1992). The view offered by Suchman (1987) is that the common practices of participants in social situations are the source of an individual's knowledge structures and rules governing her or his behavior. Objectivity is accomplished through "systematic practices, or members' methods for rendering our unique experience and relative circumstances mutually intelligible. The source of mutual intelligibility is not a received conceptual scheme or a set of coercive rules or norms, but those common practices that produce the typifications of which schemes and rules are made" (pp. 57-58).

There is a growing body of evidence, much from the study of learning of mathematics, suggesting that knowledge acquired in specific situations is more powerful and useful than so-called general knowledge that is often decontextualized and represented in abstract structures that cannot be applied in specific situations. This idea manifests itself in the phenomenon that many people's mathematical constructions are independent and quite different from the mathematics that people learn in schools. One of the most often cited studies in this regard is the Carraher, Carraher, and Schliemann (1985) study of children's mathematical abilities in the streets of Brazil. These children were able to perform complex mental arithmetic in the context of street vending in their parents' stands. However, given pencil and paper in the classroom, these same children were unable to perform even the most simple calculations. Further, when the arithmetic problems were stated in terms familiar to the children, they were still unable to perform the calculations. Even though the study may be somewhat flawed due to the mixing of ethnographic methods with quantitative analyses, the results remain compelling.

Saxe (1989) suggested that these children had certain limits in their ability to perform the school-based tasks, specifically that the children in the Carraher, et al., study had little or no school-based mathematical knowledge (orthographic mathematics). Saxe argued that the differences would disappear if the children had more prior knowledge of school-based learning. Working with the Carrahers in Brazil, Saxe carried out a similar study using children who were street sellers, urban children from the same community who were not involved in street selling, and a group of rural children with limited exposure to currency and transactions with currency. The latter two groups were matched with the sellers on age and school background. Performance on the orthographic problems was clearly related to educational background. Those students with less than a third grade level of education correctly solved 40% of the problems, while children with more than a fourth grade level solved close to 90% of the problems correctly. In analyzing strategies, the children with more schooling tended to make use of school-based algorithms in the context of the street calculations. Apparently, it is not that cognition is situated, but that the greater the knowledge of school-based mathematics, the more likely a person will use school-based knowledge in other contexts.

Does the knowledge gained in the street transfer to the school? In the Saxe (1989) study, second and third grade sellers' and non-sellers' performance on school-like computations and word problems revealed that second-grade sellers performed better than the second-grade non-sellers. This result was attributed to the fact that the second-grade sellers used strategies that were very much like those used in selling candy in the street. By the third grade, the non-sellers caught up to the sellers; however, the sellers still used many of the strategies they learned in the street, while the non-sellers continued to use their school-based knowledge. The results suggest that the extent to which mathematical knowledge is situated is much less than that suggested by the Carraher, et al. study. Apparently the better a child can use school-based knowledge, the more it can be used in other situations, and knowledge that children acquire outside of school can be used in school to some extent. The degree to which this knowledge is ultimately useful, however, will certainly be dependent upon the contexts for learning provided in the schools.

Shirley Brice Heath (1983) conducted an extensive ethnography in Appalachia that focused upon three different communities; its purpose was to better understand how learning was valued in the institutions within these communities. After determining the kind of knowledge and abilities that were valued within the three communities, school-based programs were designed to take advantage of cognitive abilities and remediate cognitive weaknesses. The instructional interventions were quite successful, focusing on the knowledge utilized in the community domain and how the knowledge within the school domain could be made to correspond to the community knowledge. In order to help learners to find these correspondences, a variety of translation processes were used. For example, community verbal knowledge largely consisted of opinions, sayings, proverbs, and the like. The corresponding verbal knowledge in school was predominantly written, consisting of facts, scientific principles, scientific methods and the like. Translations would require the specification of gaps between knowledge types and identification of common elements. This explicit activity helped learners see the utility of both forms of knowledge. Furthermore, many of these activities brought the community into the classroom, meaning that many family and community members participated more fully in the education of the children.

Clearly, this method has broader social aspects. The increased involvement of significant others in the schooling process increases the motivation of the learners, helping them to see the importance of schooling. If it is important for a parent to come to class, then the information that is being learned there perhaps has some merit. Given the above evidence, it becomes apparent that knowledge is acquired in both formal and informal ways, and that these types of knowledge can interact through purposeful activities that are designed to take advantage of the strengths of one or the other knowledge types. It may also be concluded that all knowledge is not necessarily situated, as advocated in the radical view of situated cognition. Formal knowledge can be used in an informal context if the formal knowledge is understood well enough. The question is, is school-based knowledge distinct from situated knowledge? The evidence suggests that there is overlap and interaction.

Characteristics of Situated Learning

Learning requires more than just thought and action, or a particular physical or social situation, or just receiving a body of factual knowledge; it also requires participation in the actual practices of the culture. Adopting a relational view of knowledge and situated activity changes the focus of the analysis of learning to characteristics of social participation in communities of practice. Lave and Wenger (1991) suggest that participation is a key element, requiring negotiation of meanings in various situations, with the result that "understanding and experience are in constant interaction" (p. 51-52). As discussed below, a variety of approaches to the design of environments that promote the processes of situated learning have been developed.

Cognitive Apprenticeship or Legitimate Peripheral Participation?

One of the most widely discussed features of situated cognition as it was originally proposed is the notion of cognitive apprenticeships as a means for learners to become participants in communities of practice. As described by Brown and his colleagues (Brown, Collins & Duguid, 1989; Collins, Brown & Newman, 1989), cognitive apprenticeships provide a general framework with four components -- content, methods, sequence, and sociology - for designing learning environments. Content includes domain knowledge, heuristic strategies, control strategies, and learning strategies, all of which are well explicated in the literature on cognitive learning theories and instructional design. Methods refer to teaching methods, including modeling, coaching, scaffolding, fading, articulation, reflection, and exploration. Instructional sequence includes notions such as increasing complexity, increasing diversity, and global before local skills. Sociology, the only category that seems to have emerged directly from theories of situated cognition, includes five aspects: situated learning, culture of expert practice, intrinsic motivation, exploiting cooperation, and exploiting competition. Motivation, cooperative learning and competition have each played a role in the design and development of instructional systems for some time. That leaves only the first two as something to be incorporated into our design models. The second, the culture of expert practice is actually something that should always be examined in instructional design. Part of the analysis phase of design is to determine the tasks to be performed and how they are performed, including the devices that are employed and the skills required to use such devices. The only difference is that Collins, et al. argue for a fairly "rich" analysis that incorporates many subtle aspects of the culture, including all of the various nuances of communication that occur in expert practice. Rather than taking the final aspect, situated learning, to mean that the knowledge ought to be situated within the context in which it exists, Collins, et al. imply that knowledge can be situated if it is acquired in the process of learning-by-doing. If learning involves some activity encompassing the to-be-learned knowledge that requires the active participation of the learner, then according to Collins, et al., this knowledge is situated.

It is curious that the only element of the Collins, et al. model that directly relates to situated cognition is a distinct component. Rather than trying to integrate situated cognition into a model, it is left as a separate component. The use of the term apprenticeship has also been criticized because the characteristics of master-apprentice relationships in many cultures may represent too narrow a view of situated learning. Lave and Wenger (1991) prefer to describe the central concept of situated learning as legitimate peripheral participation, in order to promote a decentered view of learning that shifts analysis away from the notion of "master as locus of authority" to an analysis of "the intricate structuring of a community's learning resources" (p. 94). The notion of legitimate peripheral participation differs from cognitive apprenticeships in several ways, not the least of which is that the terminology does not include the social connotations commonly associated with the word apprenticeship. For Lave and Wenger, learners must be "legitimate members of the community, not passive observers, and their activities must be performed in the context of the work of the community. "Peripheral" participation refers to the fact that by their nature as novices, learners cannot be full participants in all community activities, but at the same time they must be recognized as participants in some aspects of the work of the community. There should be time to learn, and to discuss ideas with peers and old-timers. The old-timers should not be threatened by the potential of the newcomer, but should be in a position to offer the best of their knowledge and skill. "Participation" means apprentices (newcomers) should be doing the thing that they are learning to do, not just observing.

Lave and Wenger suggest that legitimate peripheral participation is the mechanism of enculturation for a learner that includes relationships between apprentices and masters, but also includes all of the other participants, skills, artifacts, symbols, and ideas that are part of the culture of practice. As a result, their study of legitimate peripheral participation focuses on that form of social participation which includes learning as a necessary component. Learning as a characteristic of social interaction cannot be extricated from its legitimate context. Unfortunately, legitimate peripheral participation is not an instructional method. Rather, it is a lens for viewing and understanding learning in new ways.

Patterns of Situated Learning

Legitimate peripheral participation serves to help learners develop a holistic view of what the community of practice is about, and what there is to learn within that community. Opportunities for learning are structured by the requirements of work, rather than teacher-student relations. In fact, Lave and Wenger (1991) note that in many situations apprentices learn mostly from other apprentices. For example, among Liberian tailors learning their trade (Lave, in preparation, as cited in Lave & Wenger, 1991), much of the communication of technique comes from more experienced peers. The old-timer (master) mainly serves as a model for the ideal professional in the field performing the daily duties, and only to a lesser degree does the master provide formal instruction. What they also learn is how to talk within the community. The shared practice within a community includes both "talking within" to share information about ongoing activities, and "talking about" through stories that support "communal forms of memory and reflection" (p. 109). The case of the "nondrinking" alcoholics (Cain, in preparation, as cited in Lave & Wenger, 1991) demonstrates that the role of language in situated learning does not just contribute to the development of complex skills. Predominantly, the learning activities employed in the Alcoholics Anonymous organization are based upon language, in the form of public speaking to groups and writing in newsletters. Older members adapt their personal story telling to the experiences of newcomers, while newcomers learn to construct personal stories from the models that are provided.

Lave and Wenger (1991) also suggest that learning in communities of practice is not highly structured and sequenced, but rather "unfolds in opportunities for engagement in practice" (p. 93). There are no rules dictating what should be learned, or when it should be learned. Opportunities to learn are mainly improvised from the situation at hand, following a curriculum that includes the resources of everyday practice. Mayan midwives (Jordan, 1989, as cited in Lave & Wenger, 1991) do not provide any explicit instruction at all. In fact, the midwives report that much of their knowledge comes to them in dreams. The data indicates that they actually learn their profession by observing the practices and participating in increasingly complex practices from a very young age. U.S. Navy quartermasters (Hutchins, in press, as cited in Lave & Wenger, 1991) stated that they preferred apprentices (newcomers) who had not received the traditional classroom instruction prior to coming on-board, because it took more time to correct this erroneous learning than it did to work with someone who knew little or nothing. Also, while there was some "traditional" instructional materials (workbooks) on board, most of the learning occurred in the context of the actual operation of the ship. Newcomers were to perform increasingly more complex tasks in a spiral curriculum that included previously learned tasks. These tasks were performed under the constant guidance of the old-timer, who would correct errors or take over the task if needed. The case of the Liberian tailors (Lave, in preparation, as cited in Lave & Wenger, 1991) again confirms that curriculum can emerge from the practice of formal apprenticeships. The situations involving the Mayan midwives and the Navy quartermasters were not strictly defined as apprenticeships, but the Liberian tailors entered into a formal contract with the old-timer. An interesting attribute of the tailors' learning is that the curriculum is reversed. Rather than beginning with the initial steps in the procedure of making clothes, the apprentices begin at the end, working on finishing touches first in order to observe the quality of workmanship and models for the finished product. In all of the cases cited here, curriculum is situated in practice, and cannot be "considered in isolation, manipulated in arbitrary didactic terms, or analyzed apart from the social relations that shape legitimate peripheral participation" (p. 98).

Structuring Learning (Instruction?) from a Situated View

As mentioned above, the descriptions of learning provided by theories of situated cognition are based upon assumptions about learning that are vastly different from those embodied in current instructional design models. Several general principles have been suggested that can guide instructional designers in the development of strategies to facilitate situated learning. For example, the Cognition and Technology Group at Vanderbilt (1992) suggests that "students need to engage in argumentation and reflection as they try to use and then refine their existing knowledge and attempt to make sense of alternate points of view" (p. 67). They emphasize that instruction should be "anchored" in meaningful contexts that allow situated learning to be simulated in classrooms (Cognition and Technology at Vanderbilt, 1991). In this way, environments can be designed that allow "sustained exploration" of the various aspects of a problem, helping students to "understand the kinds of problems and opportunities that experts in various areas encounter and the knowledge that these experts use as tools" (Cognition and Technology Group at Vanderbilt, 1992, p. 67). This sustained exploration can also be facilitated by technology, as in the approach to developing cognitive flexibility suggested by Spiro and his colleagues (Spiro, Feltovich, Jacobson, & Coulson, 1991; Spiro & Jehng, 1991). In this application, learners examine various cases or scenarios from many perspectives, assisted by the rapid and efficient access to information provided by hypermedia technology. Rieber (1992) echoes these suggestions in discussing guidelines for designing computer-based microworlds. He advocates the design of meaningful contexts that support self-regulated learning, establishing a spiral curriculum, and nurturing incidental learning.

As noted above, one area that will require extensive consideration in designing environments based on principles of situated learning is the amount of control that is provided to the learners. Current models of instructional design tend to assume a great degree of control for the teacher (or the "system") with respect to sequencing, strategies, questioning, etc. Tobin and Dawson (1992) note that this problem leads to a "dysfunctional learning environment" in which learners have "little autonomy, and hence lose interest in the curriculum" (p. 91). Several alternative approaches to teaching have been cited as examples that better support situated learning. One example is Schoenfeld's (1985) approach to mathematics instruction, in which the teacher explicitly models problem-solving strategies to the students, and students are given chances to generate their own problems. Reciprocal teaching (Palinscar & Brown, 1984) is another approach in which control of the learning activities is given to the learners. In this method, small groups of learners assume roles including "teacher", "critic", and "producer" in the process of comprehending written passages. Control of learning activities and communication among learners also can be encouraged with technology, as in the Computer-Supported Intentional Learning Environment (CSILE project described by Scardmalia and Bereiter, 1991). At a school where CSILE has been tested, children of varying grade levels share ideas, criticisms and explanations over a computer network, reflecting characteristics of the legitimate peripheral participation discussed earlier. In these and many other similar cases, the role of the teacher seems to be more like "Yoda" from the "Star Wars" trilogy, rather than "Professor Kingsfield" as depicted in the television series "Paper Chase". Learners are in control, while the teacher serves as a model and facilitator rather than directly controlling the learning process.

Conclusions

After careful consideration of the data cited in support of situated learning, it is evident that integrating the principles of learning suggested by the proponents of the theory into current instructional design practice will not be easy. In fact, we agree with Brown and Duguid (1993) that what is necessary is a complete redefinition of instruction and teaching. There are just too many problems involved in trying to make explicit the knowledge of experts, to abstract that knowledge, and to communicate the knowledge to novice learners. In the end, we are left with the question of whether there can be an instructional theory based on situated cognition, and what the role of technology might be in such a theory. It is apparent that we need to focus efforts on the development of tools and environments that support communication and collaboration among learners and experts, as has been successfully demonstrated in the examples cited above. Beyond that, perhaps Tripp (1993) is correct: we should build and test the artifacts before we formulate the theory.

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Title:

Visualization Techniques for Examining Learner Interactions with HyperMedia Environments

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The unprecedented freedom for users to control the scope and sequence of their interactions with hypermedia systems presents many challenges to those who design and study these systems in educational settings. Early efforts to develop hypermedia systems revealed that the inherent node-link structure is both advantageous and problematic (see Conklin, 1987). But when users have the freedom to follow any of a multitude of link permutations, disorientation often results. Further, without appropriate training, novice users do not possess the strategies necessary for effective "browsing" of large hypermedia documents (Duffy & Knuth, 1991). Many designers, therefore, advocate that features such as visual maps, search facilities, and guided tours be included in hypermedia systems to alleviate some of these problems (e.g. Hammond, 1989; Laurel, 1990, 1991).

With the emergence of hypermedia systems as a major architecture for educational and other information-oriented software comes the related problem of how to document and analyze user interactions with these systems for the purposes of research and evaluation. Many hypermedia systems to date have employed a "browsing" interface, but alternative approaches are also emerging (See Nelson & Palumbo, 1992). Regardless of the type of interface, many questions can be generated when studying the interactions of users with hypermedia systems. For example, how many users chose to follow a particular link, and why was one link chosen over another? How does the choice of one link affect choices of subsequent links? When are graphic images, animations, and video segments accessed? What user tasks are appropriate for guiding interaction with the system? Are there patterns of navigation that lead to more complete learning? These and many other questions need answers when designing, developing, and evaluating hypermedia applications for education and other settings.

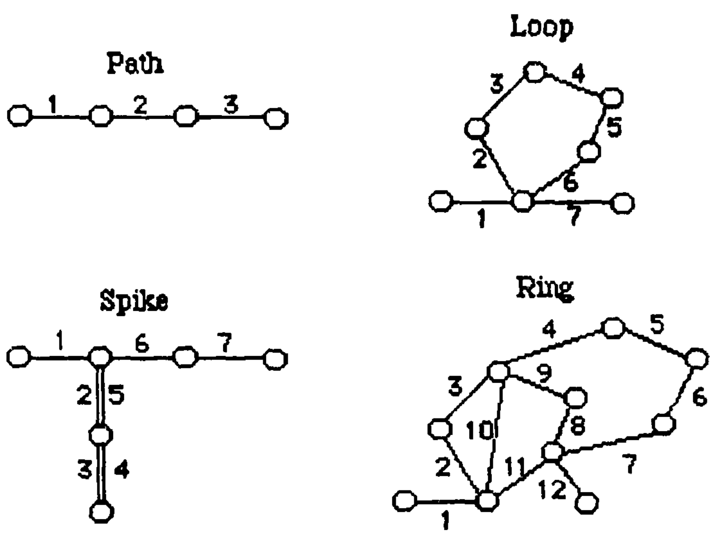
A wealth of user interaction data can be easily collected within many hypermedia development environments in order to study aspects of the interface, including the nature of user navigation patterns, the time spent at each node, and the use of help and other orienting facilities. The data can represent the paths a user follows through the system, and the choices made at each node in the system. The problem is that because of the nature of this data, traditional methods of analysis such as surveys or pretest-posttest designs, are not particularly effective for determining usability or comparing alternative interface designs. Researchers have had to develop new techniques for analyzing patterns of user interaction in order to evaluate the design and effectiveness of hypermedia systems (e. g. Misanchuk & Schwier, 1992). There is a need to categorize and compare groups of users in order to compare the effectiveness of alternative system features, as well as describing characteristics of interaction by individual users within the same system. This paper will discuss several methods for visualizing and characterizing user interactions with hypermedia systems that have been found effective in several development and evaluation studies.

Characterizing user interactions using path algebras

Characterizing the interactions of individual users, or comparing groups of users, can be accomplished using several methods derived from mathematical set and graph theories (Backhouse & Carré, 1975; Carré, 1971). In the first method, path algebras are employed to describe and compare the routes users take through hypermedia systems (Alty, 1984). Users may follow a variety of types of paths through the two-dimensional space of a hypermedia database (Canter, Rivers & Storrs, 1985). Using simple programming techniques, it is possible to "trap" and save in data files the sequence of nodes visited by the user, along with the more specific user actions taken at individual nodes such as clicks on buttons, menu selections, or viewing graphic images, animations, or audio and video segments.

The data files can be analyzed using algorithms that extract the nature of the "subpaths" of the total path followed by the user. The types of subpaths users follow through hypermedia systems can include rings, loops, paths, and spikes (See Figure 1). As described by Canter, Rivers, and Storrs (1985), paths are movements between nodes in a linear sequence from one node to another. Spikes occur when a user moves through a number of nodes, and then returns along the path to the initial node. Loops and rings are similar in that the user moves through a set of nodes that eventually returns to the original node in a circular pattern. Rings are created when a user loops through several patterns that visit nodes that were previously accessed. The path that an individual user follows while interacting with a hypermedia system gives an indication of the nature of that interaction at different points in time. Of course, the types of paths a user might follow will be determined in part by the organizational structure of the system. Hypermedia systems organized hierarchically will tend to generate paths with many spikes, as the user moves down a "branch" of the tree and then back to the "root". A linear organization for the hypermedia system will tend to produce many paths. Rings or loops tend to indicate that a user is revisiting nodes, perhaps to search for information, or perhaps because of disorientation.

Figure 1. Types of user paths through hypermedia systems.



The frequencies of each type of path followed during an individual user's interaction provides a basis for comparison between individuals and groups. These frequencies can be recorded for each user, and common parametric statistical procedures can be employed to compare the mean number of each path type for groups of users in order to determine whether the frequencies were significantly different. This approach provides a means for analyzing individual users' interactions that can be more precise than merely determining the frequency that one node is accessed from another node (Misanchuk & Schwier, 1992). There is also the possibility of comparing groups of users that is not afforded by other methods that focus on individual user access patterns. In this way, alternative interface design strategies can be compared using quantitative methods that may reveal several advantages of one design over another.

This method was employed with data collected in a prior study (Nelson, 1991) to further characterize the interaction patterns of various users who possessed different levels of prior knowledge for the domain presented in a hypermedia system. Two groups of users with high and low prior knowledge of the content completed one of three tasks with a hypermedia document (browse, search, or study). The results indicated that prior knowledge influenced interaction patterns (e.g., there were more "spikes" for individuals with lower prior knowledge). In addition, the results of this analysis also confirmed a design assumption that was made, namely, that definitions and examples of unfamiliar terms needed to be provided to users with low prior knowledge, but that these definitions and examples would not be accessed by users with high prior knowledge. The large number of "spikes" followed by some users was the result of their access of definition and example nodes for some concepts in the document. It appears that this method of analysis of user interactions with hypermedia systems can be useful in testing design alternatives. Extensions of this technique might utilize similar algorithms embedded within the hypermedia system to detect in real time some of the various interaction patterns, and to provide system interventions or guidance based on such analyses.

Characterizing user interactions using directed graphs

The second method employs graph theory to construct a network representation of the paths taken by individual users through a hypermedia document, and to compare the networks as generated by the Pathfinder algorithm (Schvaneveldt et al., 1985). Pathfinder was originally developed to study the associative characteristics of human memory, and has been applied in a variety of research studies (Schvaneveldt, 1990). The algorithm is applied to proximity data that represents participants' ratings of the degree of relatedness between a set of concepts. The resulting proximity matrices are analyzed by Pathfinder to construct a network representation. Correlations can then be computed between individuals' networks to determine the degree to which the networks are similar.

When used to study navigation patterns in hypermedia, this method assumes that the more frequently a link is traversed by a user, the more direct is the association in the resulting Pathfinder network that represents the interaction pattern. To analyze the data, proximity matrices are constructed to represent the relative "proximity" of a node to every other node in the hypermedia document. In this case, proximity is defined as the number of times a node was visited through a link from another node. As shown in Figure 2, the raw data is used to construct the proximity matrix by analyzing the user's sequential moves between nodes. Each move from one node to another results in an increase in the frequency value of the corresponding cell in the matrix. So a move from node 1 to node 7 would increase the matrix cell at row 1-column 7 by one, and a move from node 7 to node 3 would increase the matrix cell at row 7-column 3 by one, and so on through the sequence of the raw data. After individual matrices have been developed for each user, group data can be derived by calculating the average value for each cell in the matrix (See Figure 2).

Figure 2. Deriving a proximity matrix from raw data, and averaging across a group of users.

1. A sequence of nodes ...

1,7,3,4,2,3,1,6,5,3,4,1,5,1,6,7,1

3. A number of proximity matrices...

2. ...produces a proximity matrix for each user

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7
Node 1	0						
Node 2	0	0					
Node 3	1	1	0				
Node 4	1	1	2	0			
Node 5	2	0	1	0	0		
Node 6	2	0	0	0	1	0	
Node 7	2	0	1	0	0	1	0

4. ...are averaged to produce a group proximity matrix.

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6	Node 7
Node 1	0						
Node 2	1.3	0					
Node 3	2.1	.7	0				
Node 4	2.3	1.1	2.1	0			
Node 5	3.5	0	1.6	0	0		
Node 6	3.4	0	0	0	1.2	0	
Node 7	3.1	0	1.2	0	0	1.5	0

Once the proximity matrices are established, the Pathfinder algorithm can extract the representative network from the average matrix, as shown in Figure 3. A computer-based tool for analyzing data using the Pathfinder algorithm is available (Interlink, 1990). The relatedness coefficients used to plot various Pathfinder solutions from different data sets can be correlated to determine the degree of similarity of the paths taken by individuals or groups. The correlation values indicate the degree to which different groups of users followed similar paths through the hypermedia document. This method was also applied to the data from the study cited above. Correlations between the groups suggested that characteristics of the task may have influenced the interaction patterns of users. At least for this data set, searching and browsing tasks produced patterns that were more similar than for the study task, as indicated in the comparatively high correlations. This method may also be extended by hypermedia authors to specify the initial organization of the nodes and links in a hypermedia document (McDonald, Paap & McDonald, 1990).

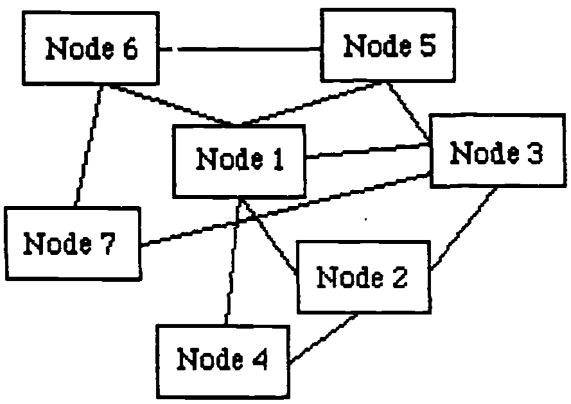
A Picture of the Users' Interaction

Another approach to visualizing the interaction path of an individual user is to construct an image based on the interaction data. The interaction that we wanted to represent was the amount of time spent on each screen, the direction of links, and the number of times that a screen was visited. In order to do this, each screen of information that was visited by the user is represented as a rectangle. The more time that is spent on a node, the larger the rectangle becomes. When a learner links from one piece of information to another, a line segment is drawn with an endpoint on the originating node and an arrowhead on the destination node.

Further, the more times a learner visits a node, the darker it becomes with a range of 4 (white, light gray, dark gray, black). The resulting image would then represent the interaction of that user.

Nelson's (1991) data were used in the Toolbook program to generate an image of the interaction each student had with the system. There were a total of 57 images produced (one for each subject). In the Nelson study, each subject was a student in an undergraduate educational psychology class. The system that they examined was a hypermedia program on the field of educational psychology. There were three groups. The Study group was told that they will have a test on the content in the program. The Browse group was told to evaluate the program because it might be used in later classes. The Index group was asked to find definitions to a list of words.

Figure 3. Pathfinder solution for hypothetical data.



Method

The 57 data files for the subjects in the Nelson (1991) study were entered into the Toolbook program to generate a map of each individual learner's interaction with the program. These 57 images were printed and copies were made. The images were given to three different groups: Gifted middle school students (n=6), teachers in an introductory educational computing course (n=6), and instructional technology doctoral students (n=6). The first two groups were given the 57 images and some paper clips and were instructed to place the images on a table and try to categorize the images into 3 to 5 groups. They were then asked to write a description of the procedure they followed to create the categories and to describe the categories. The third group did the same thing, except they were told what the images represented and each image indicated which group from the Nelson study the image was from.

The only performance data available from the Nelson study was the course grade each subject received. While this is a very indirect measure of the impact of the instructional package, it was the only one available. Grades in the sample were either A, B or C. Unfortunately, for a variety of reasons, only 38 of the 57 images could be associated with a grade. The categories generated by the groups in the current study were then used in a chi-squared analysis. One dimension was the grade received by the learner and the other dimension was the category generated by the subjects in this study. A total of 18 chi-squared tests were conducted.

Results

Results indicated that there was only one subject whose categorization strategy resulted in a statistically significant result in regards to the grade received in the course(see, Figure 4). The categories were: (W) "Has more dark squares than any other kind" (see, Figure 5); (X) "Has more white squares than any other kind" (see, Figure 6); (Y) "Has more polka dot (light gray) squares than any other kind;" and, (Z) "Two highest patterns were tied." Unfortunately, expected values are very low in the lower categories and would result in questionable conclusions. However, given the exploratory nature of this research methodology, it is worth taking a closer look.

Figure 4. Summary table and observed frequencies for the only significant categorization scheme based on grade in the course and created by N2.

Summary Table for Grade, N2

Num. Missing	0
DF	6
Chi Square	19.886
Chi Square P-Value	.0029
G-Squared	•
G-Squared P-Value	•
Contingency Coef.	.586
Cramer's V	.512

Observed Frequencies for Grade, N2

	W	X	Y	Z	Totals
A	12	9	0	2	23
B	5	7	0	1	13
C	0	1	1	0	2
Totals	17	17	1	3	38

It appears that the first category (W) has many people who received an A in the class. This first category can be described as a pattern where the user returned to most screens at least 3 times. Also, of interest is that the majority of the people who got a B in the course fall into category X. This category can be described as a pattern where the majority of the screens in the program were visited only once. This result points toward an interesting question for future research. That is, does the pattern where the learner returns to the same screen many times result in better learning? And, if this statement is true, can a system be designed that adjusts the level of user control based on this interaction pattern. There were not enough people who received a C or fell into the last two categories to conclude anything about them.

Figure 5. An example of category W created by N2.

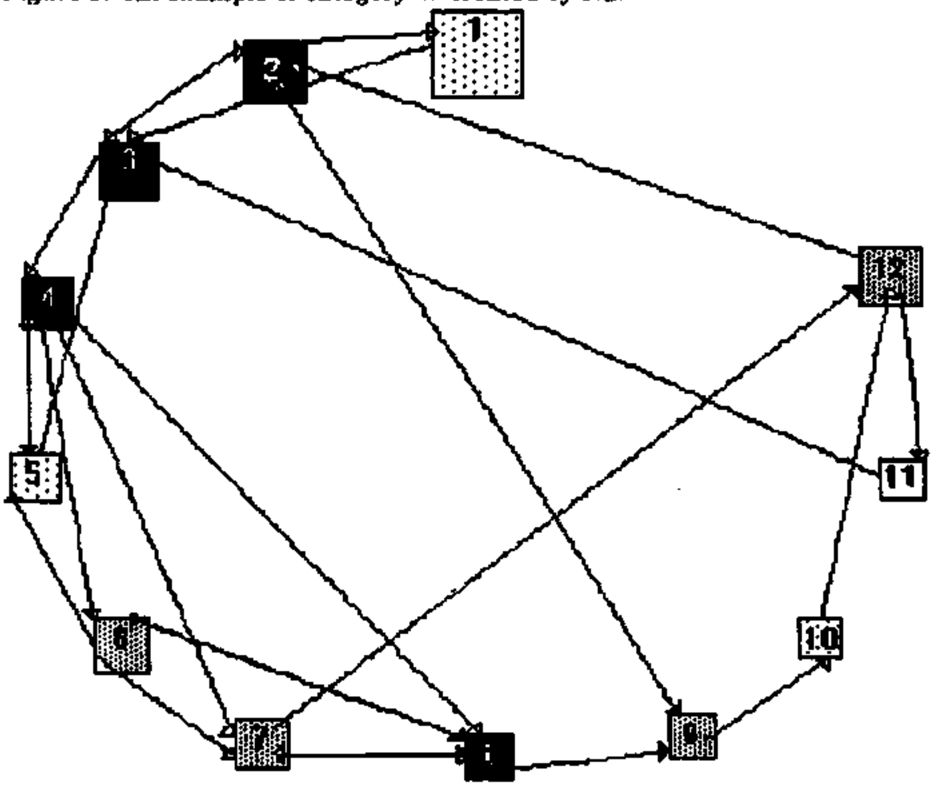


Figure 7. Summary table and observed frequencies for the only categorization scheme that was significant for grade as based on treatment group.

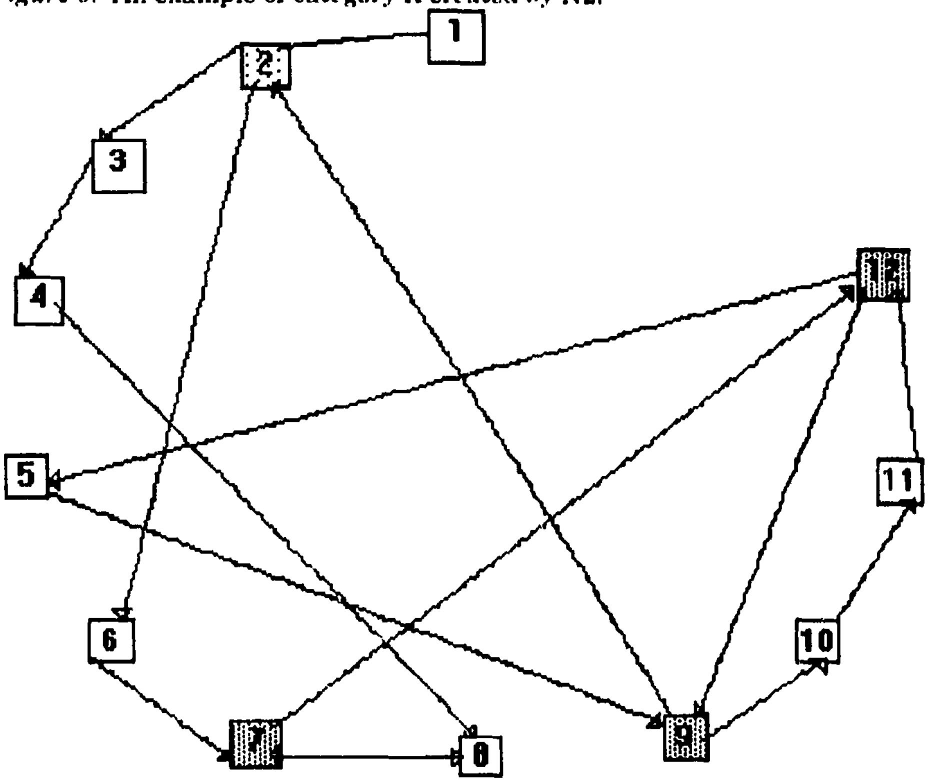
Summary Table for Group, N2

Num. Missing	0
DF	6
Chi Square	9.992
Chi Square P-Value	.1250
G-Squared	•
G-Squared P-Value	•
Contingency Coef.	.456
Cramer's V	.363

Observed Frequencies for Group, N2

	W	X	Y	Z	Totals
Browse	3	6	0	1	10
Index	3	8	1	1	13
Study	11	3	0	1	15
Totals	17	17	1	3	38

Figure 6. An example of category X created by N2.



A related question to the one described above is how do the categories generated by subject N2 relate to the experimental treatments in the original Nelson (1991) study? Figure 7 depicts the results of this analysis. While the result is not significant, a pattern similar to grade can be seen. That is, there are a large number of subjects that are both in the study treatment and fall into the pattern where the user returned to most screens at least 3 times (category W). Likewise, the pattern where the majority of the screens in the program were visited only once (category X) is well represented by the Browse and Index treatments. While it is premature to make any kind of definitive statement about whether these patterns are at all related to learning, it does hold some promise for a more rigorous experimental examination.

Chi-squared analyses were performed on the categories generated by the subjects in this study with the treatment groups in the Nelson study. The results indicated that all of the Instructional Technology doctoral students' categories were significantly related to the treatment groups. This is not surprising given that the doctoral students were aware of the groups and from which group each image came. There were also two subjects that were not informed of what the images represented that resulted in significant categories. These categories were generated by the teacher group in the current study and the results are depicted in Figures 8 and 9.

Figure 8. Summary table and observed frequencies for significant categorization scheme based on treatment group.

Summary Table for Group, N4

Num. Missing	0
DF	6
Chi Square	13.218
Chi Square P-Value	.0397
G-Squared	•
G-Squared P-Value	•
Contingency Coef.	.508
Cramer's V	.417

Observed Frequencies for Group, N4

	S	T	U	V	Totals
Browse	2	4	0	4	10
Index	2	6	2	3	13
Study	1	0	4	10	15
Totals	5	10	6	17	38

Figure 9. Summary table and observed frequencies for significant categorization scheme based on treatment group.

Summary Table for Group, N6

Num. Missing	1
DF	4
Chi Square	10.972
Chi Square P-Value	.0269
G-Squared	•
G-Squared P-Value	•
Contingency Coef.	.478
Cramer's V	.385

Observed Frequencies for Group, N6

	O	Q	R	Totals
Browse	3	2	4	9
Index	4	4	5	13
Study	0	1	14	15
Totals	7	7	23	37

For subject N4, categories T and V seem to define people in the treatment groups best. That is, category T does not include anyone from the study treatment group. Similarly, category V accounts for the majority of the study group (10 out of 17). The categorization scheme used by subject N4 is based on the shading of nodes (just as subject N2). In order to be included in category T, the picture should contain "no more than 2 different shades." Category V for subject N4 was that there were "no more than 4 different shades of boxes." Upon examining the nature of the images for the category T, we noticed that most all of these images had the 2 shades of light gray and white (all but 2 of them). This is not an interaction pattern that would indicate that these learners were returning to screens to re-examine information. On the other hand, the V category shows a pattern of behavior that certain screens are visited once, others twice, etc. While it is pure conjecture on our part, this would indicate that the users in this category were judging the value of the information and returning to screens that were important and not returning to screens that were not.

Subject N6 used a categorization scheme that was based on both frequency of returning to a screen (shade) and the number of screens visited (the number of nodes on the image). Categories O and Q can be collapsed into a single category where there were "no dark gray or black boxes and 6 or fewer boxes." Category R would be the opposite (the image contained dark gray or black boxes and it had more than 6 boxes). It is interesting to note that frequency of visiting screens is such an important attribute (it is an aspect of each of the categories described). Future research ought to examine this navigation pattern more closely.

Conclusions

The three methods for analyzing user interactions with hypermedia systems described above have been successfully employed to compare the patterns of navigation exhibited by groups of users in several studies. The last analysis seems to also provide some potential for further research more directly related to navigation patterns as they relate to learning. The analysis of peoples interactions with hypermedia systems is quite complex. The capability to visualize this interaction allows a researcher the ability to examine many different attributes simultaneously within the image. The results indicate that there appears to be merit to this type of analysis.

At this time, the methods in this paper appear promising for further research into usability studies of hypermedia systems, as well as more basic research into various theories of human-computer interaction. The latter research will also require additional methodologies in order to obtain the rich descriptions of interaction with hypermedia that is necessary to further develop theories and principles for the design of such systems.

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Title:

Producing Effective Graduate-Level Distance Education Courses for Interactive Television

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Technology has changed the way we view education and the delivery of instruction. Distance education is no exception when it comes to technology advancements and change. Distance education (DE) is described as an alternative delivery of instruction (Relaford, 1988); instruction that is delivered by a method other than through the traditional classroom setting. It can be defined as "formal instruction in which a majority of the teaching function occurs while educator and learner are at a distance from one another" (Verduin & Clark, 1991, p. 19). "Distance learning refers to the use of telecommunications (audio and video) to bring people together for the purpose of learning" (Brownell, 1992, p. 510).

Technology advancement has allowed DE delivery systems to provide students needed instructional opportunities that would otherwise pass them by (Barker, 1992). There are several types of DE delivery systems that promote distance learning (see appendix A). They include telephone audioconferencing, computer-based messaging, audiographic conferencing, interactive television, satellite broadcast, and others (Clark, 1989). Each of these systems involves specific technology that allows for the transfer of educational information. This information provides the learner with instructional elements that are necessary to help learning occur.

Research indicates that these systems are effective in producing learning. Each has advantages and disadvantages when used to deliver instruction. Our focus here is to examine the use of interactive television as the DE instructional delivery medium. A review of research and related literature on distance education delivered primarily through interactive television will help determine what practices in course design produce effective DE, what conditions of learning are associated with effective DE courses and what learner characteristics are most important in designing effective DE programs.

Interactive Television Effectiveness

Interactive television technology as a DE delivery system involves two-way communication between an originating classroom and remote classroom sites. Wilson (1991) states that such systems "provide immediate feedback and participation in interactive instructional processes through the use of alternative electronic communications."(p. 27) Video and audio signals are transmitted to and from the originating and remote sites via paths such as telephone lines, microwave systems, and satellite. This telecommunication technology provides enhanced DE instructional delivery because learners from every site can see and interact with the instructor during classroom meetings and instructional presentations. According to Moore and McLaughlin (1992) courses offered by such a system at the St. Cloud State University indicate that "students achieve at about the same rate and level as do students in on-campus sites. As a matter of fact, students at remote locations tend to do a bit better on their class examinations."(p. 75) Robinson (cited in Moore & Thompson et al, 1990) presented results from a five year study of the two-way Carroll Instructional Television Consortium. Data indicated that "student achievement levels are comparable to those found in live classrooms."(p. 68) Morehouse, Hoaglund & Schmidt et al (cited in Relaford, 1988) presented results on the effectiveness of interactive television from an analysis of the Minnesota system that indicated:

"Instructional television students enjoyed learning and achieved at a level similar to students in traditional classes. There was no evidence of statistically significant differences in achievement and/or in the rate of learning."(p. 27)

This and other research findings indicate that two-way interactive television is an effective delivery system foı promoting learning. Other factors also influence the learning experience resulting from the use of two-way interactive television.

Interactive Television Advantages

According to Alaska University (1989a) instructional television offers many potential advantages, including visual imagery, motion, motivation/Interest, persuasion, illustration of major points, summarization of key concepts, presenting otherwise unavailable experts or resources and others. It is particularly effective in delivering primary content and is most effective when combined with interactive activities.(p. 4)

Hudspeth & Brey (cited in Relaford, 1988) suggest that interactive two-way audio and video classes provide the best alternative to the traditional classroom and that they have these advantages:

* It provides a means to bring master teachers, upper level courses and graduate courses to smaller colleges.

* It is an excellent tool for providing choices.

* It is a means for providing enrichment and advanced offerings to students.

Barker (1990) includes these advantages for two-way interactive instruction:

* Two-way full-motion video is possible between all sites; students can see the teacher as well as other students at different sites, and the teacher can see all students at all sites.

* Most systems presently in operation are small networks that promote local control of the teacher and curriculum and maintain an overall class size.

* Open-line microphones allow for full teacher- student and student-to-student audio interaction. That is students can interact audibly not only with the teacher but also with students at other sites.

These advantages help interactive television, as an DE delivery medium, to be effective in aiding the learning process. However, learning occurs because information has been transmitted to and from the learner so that new knowledge is acquired. Because the information transferred to and from the student is important to the learning process, DE courses require the implementation of instructional design principles (Moore et al, 1990; Texas Education Agency, 1987) to insure proper course design and planning and a successful teaching/learning experience. DE instructional planning is complex and involves expertise in designing, planning and delivering of course materials, and evaluating the DE course so that appropriate changes can be made to improve future course delivery.

Instructional Design in Distance Education

The effectiveness of DE instructional delivery will depend upon the planning of the instructional materials and activities to be used in the delivery. The use of a systematic instructional design (ID) process will assure that the delivered instruction will be effective and successful in promoting learning. This systematic process of planning instruction will aid the educator or instructional designer in planning and developing such activities and instructional materials.

Dick and Carey (cited in Gagne, Briggs & Wager, 1988) describe an ID model that includes nine stages:

(1) identify instructional goals;
(2) conduct an instructional analysis;
(3) identify entry behaviors and learner characteristics;
(4) write performance objectives;
(5) develop criterion-referenced test items;
(6) develop an instructional strategy;
(7) develop and select instructional materials;
(8) design and conduct a formative evaluation with possible need for revision; and
(9) design and conduct a summative evaluation.

The Alaska University (1989b) suggests a four step ID model that includes design, development, evaluation and revision. The design stage includes:

* Determining the need for instruction.
* Analyzing the intended audience.
* Establishing instructional goals.

The development stage includes:

* Deriving specific objectives for goals.
* Creating a content outline.
* Reviewing existing materials.
* Organizing content.
* The selecting and developing of materials and methods.

The evaluation stage includes:

* Reviewing goals and objectives.
* Developing an evaluation strategy.
* Collecting and evaluating data.
* Determining recommended revisions based on the data analysis.

And finally, the revision stage allows for the development and implementation of a revised instructional plan.

Heinich, Molenda, and Russell (cited in Moller, 1991) provide the ASSURE model for planning programs that utilize DE technologies. It is primarily used by the individual instructor for planning daily classroom use of media. The ASSURE model has six steps:

1 - Analyze Learners
2 - State Objectives
3 - Select Media and Materials
4 - Utilize Materials
5 - Require Learner Performance
6 - Evaluate and Revise

Haynes and Dillon (1992) apply an instructional system design (ISD) model adapted from Gagne and Briggs that can help design instruction consisting of several interrelated activities. These include:

(1) the analysis of learner characteristics,
(2) the determination of instructional objectives,
(3) the selection of strategies,
(4) the design of media,
(5) the implementation of instruction, and
(6) the evaluation of the outcomes linked to the specific objectives and strategies.

ID models represent the framework that is used to guide the entire process of designing instructional systems (Heinich, Molenda, and Russell, 1989). Each of the ID models included here can aid in providing the framework necessary to plan effective instruction and activities. There are many other ID models. Appendix C contains a detailed description of an instructional design model adapted from the ASSURE model.

Environmental Characteristics of Distance Education

An understanding of the characteristics belonging to the distance education environment will aid the design and planning processes. Keegan (1990) cites five characteristics of distance education:

* The quasi-permanent separation of teacher and learner throughout the length of the learning process (this distinguishes it from conventional face-to-face education).

* The influence of an educational organization both in the planning and preparation of learning materials and in the provision of student support services (this distinguishes it from private study and teach-yourself programs).

* The use of technical media - print, audio, video, or computer - to unite teacher and learner and carry out the content of the course.

* The provision of two-way communication so that the student may benefit from or even initiate dialog (this distinguishes it from other uses of technology in education).

* The quasi-permanent absence of the learning group throughout the length of the learning process so that people are usually taught as individuals and not in groups, with the possibility of occasional meetings for both didactic and socialization purposes. (p. 44)

According to the Office of Technology Assessment (1989),

"Students, teachers, course material and presentation, and interaction are all affected; distance learning creates a new context within which the education process and student-teacher interaction take place. Old styles of teaching and learning may not be most appropriate or effective when mediated by telecommunications technologies....In designing distance courses or modules, teachers and instructional designers have had to find ways to restructure interactivity."(p. 93)

The Texas Education Agency (1987) states that "because of the intercession of distance and devices between the teacher and the student, new instructional techniques, varied uses of material and modification of class management may be appropriate."(p. 5)

The consideration of these characteristics during the design and planning stages will help the educator or instructional designer plan for the unique opportunities made available with the DE communication technology being used to deliver instruction.

Course Design and Planning

Design and assessment are key areas where distance educators and educational technologists can influencing how students go about their studies (Morgan, 1991, p. 10). Important considerations should include the delivery system, available resources, course content, the target learner audience, their learning styles, and their ability to engage in the learning process. Instructional experiences can be carefully designed and developed so that they can be used by a wide variety of learners possessing similar learner-related characteristics (Dwyer, 1990). The course planning process can involve many people who are specialists in certain fields. Members of such a planning team might include subject authors, instructional technologists, illustrators, media specialists, librarians, photo-librarians, and editors (Moore and Thompson et al, 1990, p. 4). Brinkley, Pavlechko & Thompson (1991) suggest a design team consisting of the course instructor, an instructional designer, a producer/director, a graphic artist and an on-air director. However, the individual instructor may be the entire planning team and provide the necessary course content that would be edited and published for a DE course. A realistic planning team for a typical distance education course might consist of the instructor, an instructional technologist (instructional designer), and a student or potential student of the course.

Development of course content can begin by representing it in a manner that enables the planning team to develop a ".ourse description, general aims, instructional goals, units and lessons/ modules to drive the content." (Brinkley, Pavlechko & Thompson, 1991, p. 51) Thus, the purpose of the planning team is to structure academic content in a form suitable for study by distant learners (Moore & Thompson et al, 1990). Instructional design principles can be utilized to provide for instructional strategies that fit the medium of delivery.

In regard to planning instruction, Wolcott (1993) cites three studies that indicate that college teachers' majors concerns include: selecting content and course materials, covering the course content, class processes, on-going planning activities, students' participation in class discussions, communicating with students, and recognizing student characteristics.

McGreal (1991) provides a set of guidelines to help the ordinary teacher produce instructional materials designed for distance education systems. They include:

> (1) The materials should be simple so that the teacher and students are clear about the goals of each lesson.
> (2) The materials should be highly structured so that the objectives of the lesson are achieved.
> (3) There should be many reviews of the material taught in previous lessons.
> (4) Evaluations should take place frequently to ensure that sufficient learning is occurring.
> (5) High interest content material should be found which can lower teacher anxiety, stimulate the students participating in the course, and develop a rapport with them.
> (6) The materials must be relevant to the particular needs of the students.
> (7) Extension activities should be made available for students who need more content to aid the learning process.
> (8) This material, although highly structured, must be clearly perceived by the teacher to be non-restrictive to his/her teaching style.
> (9) The material should be activity oriented in order to divert teachers away from lecturing to students and promote active student learning during class sessions.(pp. 8-9)

Parker and Monson (cited in Moore & Thompson et al, 1990) contend that specific techniques should be incorporated into the course development process. The techniques include humanizing, participation, message style and feedback.

"Humanizing refers to the creation of an accepting environment which breaks down the barrier of distance and generates feelings of rapport between teacher and students. Participation deals with the extent of interaction among participants in the interactive situation. Message style refers to ways of enhancing the interest and appeal of a presentation. Planning for short instructional segments, varying tone of voice and volume, and supplementing programs with visual aids maintain the interest and attention of the students. Feedback allows instructors to determine if their presentations were clear and effective. Both verbal and written feedback should be obtained, and can include questionnaires, interviews, or group reports." (p. 21)

Allen and Carl (1988) list seven characteristics necessary for the creation of a successful distance learning program (see Appendix D for more information). This model was adapted from guidelines found in "Guide to Distance Learning as an Alternative Delivery Procedure" published by the Texas Education Agency. The characteristics include:

(1) high standards are established for their teachers and mediators (student site contact persons; also called proctors, monitors, aides, etc.)
(2) consistently train and retrain staff
(3) carefully evaluate teaching sessions and/or the course packages before distribution by telecommunication or other means
(4) ensure that there are provisions for easy communications between students, instructors and proctors
(5) develop rigorous and valid testing programs which provide rapid response times and feedback loops
(6) package the course content
(7) provide ready accessibility to resources such as mediators and ample audiovisuals, print and other media for student use. (Texas Education Agency, 1987, pp. 4-5)

When the elements included here are considered during the design and planning stages, course effectiveness and efficiency will surely benefit. The design and production of course materials requires such considerations to produce effective delivery through DE technology. An example of the development process can be seen in the elements included in Brinkley, Pavlechko & Thompson's (1991) four element team approach. They include:

* Instruction
* Production
* Design
* On-Air Direction

Steps of the approach include:

* A faculty member is contracted to teach using distance education technology.
* A map of course content is given to the instructional designer. The designer will analyze the map and, if necessary, ask the faculty member for clarification.
The designer then gives the map to the production team (the map is an outline representing the content of the course).
* The design/production team members have an understanding of the course content and are prepared to discuss it with the faculty member.
* The design/production team asks the instructor questions about the content of the course (the course map) and the faculty member uses a computer program to plan the first lesson.
* The teacher designs a single lesson plan consisting of five parts and gives it to the instructional designer. The designer will discuss the lesson plan with the faculty member and, if necessary, ask him/her for clarification. The designer then givesthe lesson plan to the production team.

* The design/production team has an understanding of the lesson plan and the teaching styles and strategies the instructor will use for the distance education medium.

* Specific visuals for the first lesson plan are discussed. Specifics such as which slides and videotapes will be used are decided at this meeting with the faculty member, design and production team.

* An on-air script is produce by the producer and given to the on-air director. This step focuses on cues that the director needs when operating the controls that deliver the course to distant sites such as videotapes, slides and graphics.

* The faculty member reviews the media for the single lesson he/she has produced and makes any final changes to the media. The remaining lesson plans are then produced for the course.(pp. 50-54)

Cyrs and Smith (1991) provide design and production steps needed to produce interactive study guides for interactive television courses. Such guides are described as highly organized sets of "student notes, graphics pictures, graphs, charts and activities which are used in conjunction with a telelecture."(p. 37) The primary purpose of such guides is to focus the learner on key concepts associated with instructional content. Such guides allow the learners to concentrate "on the cognitive, analytical and critical thinking skills being demonstrated by the instructor."(ibid.)

Design steps for developing an interactive study guide include:

* Outline the content of one telelecture.

* Select a short instructional segment that can be shown as a word picture (a graphic representation of an idea, concept, data, geometric shapes, clip art, symbols, etc.).

* Identify the main concept and the supporting or sub-concepts (or examples of the concept) to be illustrated.

* Try to visualize the concept and sub-concepts by looking for ways to turn the words into pictures. If you can find clip art or other appropriate graphics use them and show relationships among the elements by using arrows and lines.

* Concepts that cannot be represented with graphic art can be placed in boxes or circles and arrows and lines can be used to indicate the element relationships.

* Leave out some of the key concept words and insert a blank line so that students will have an opportunity to fill in notes as you lecture.

* Proceed to design Word Pictures for all of the instructional segments in the lesson, being careful to indicate the proper sequence for presentation.(p. 38)

Wolcott (1993) describes the planning processes utilized by faculty members who are involved in distance teaching. Results from her study describe term planning, content, and the extended syllabus.

"...Participants (faculty) approached the task by planning at the course or term level. Planning took the form of a time-consuming, front-end activity rather than an on-going one...essentially packaging the course into an extensive syllabus....The faculty focused on selection and sequencing of content. In planning the course, the faculty were concerned with two dependent tasks: 1) defining the content, i.e., determining what to include, and 2) matching content with the time available in which to present it. These two tasks were embedded in the central planning activity, the development of the course syllabus. The faculty made their planning decisions tangible in the form of a course syllabus....The syllabus, in most cases, was far more extensive than the typical one- or two-page handout. Commonly referred to as the "expanded," "enhanced," or "extended" syllabus, these syllabi had as their base the traditional class syllabus that included a course description, course goals, readings and assignments, a topic outline, and grading policies. In addition to these standard items, the syllabi also contained handouts or hard copies of overhead transparencies, study questions, reprinted articles, and even extensive original essays."(pp. 28-29)

Although there are few studies that investigate the planning of distance teaching in higher education, the literature to date provides large amounts of information on the design and development of distance learning courses. Clearly, the designing of any DE course can be a complex, time consuming task. There are many pieces to fit together during the planning process that aid in the development of course production. Other considerations of course development include the specific elements associated with the distance learner.

Conditions of Learning

The preparation of instructional lessons and the delivery of such lessons to the distance learner involves understanding the learner's previously acquired knowledge and learning capabilities. Lessons should be prepared to meet the knowledge levels of the learners and provide the best method to transfer important information to them. Gagne' (cited in Gee, 1990) provides nine events of instruction that should be considered in the instructional delivery process. These events are designed so that each learner's natural cognitive processing is followed and new knowledge is acquired. Lesson material should be designed for the learners who are to participate in the instructional setting. Appendix C includes the nine events of instruction in detail. In targeting the adult learner, Knowles's (cited in Wilson, 1991) andragogical model makes the following assumptions:

* Adults' self-concept moves from one of dependent personality to self-directed human being.

* Adults accumulate a growing reservoir of experience that becomes a rich source of learning.

* Readiness to learn becomes increasingly oriented to their developmental tasks of their social roles.

* Shift in immediate application as their orientation of learning shifts from subject centeredness to performance centeredness.(p. 42)

Wilson (1991) concludes that students learn when all of the above conditions are considered plus the following conditions which are more specific to Distance Education:

* Self-pacing is allowed;
* Feedback is in the "fastest turn-around time that is feasible";
* Interaction with the institution is friendly and nonthreatening;
* Curriculum is structured to guide the student in linking instruction with previous knowledge and interests; and
* They are self-motivated.(p. 42)

The transfer of instruction via interactive television should be done in a manner that is effective and efficient in providing for the learners' needs. It should utilize all available resources to achieve this goal. The use of teaching methods can aid in the learning process. The message that is intended for the learner is transferred through this medium. Heinich, Molenda & Russell (1989) include eight methods to deliver the instructional message. They are presentation, demonstration, drill-and practice, tutorial, gaming, simulation, discovery, and problem solving. Joyce and Weil (1986) provide a variety of teaching models for delivering instruction. Determining which model or method is best used for instruction, depends on the learners involved and the content of the lesson. Information concerning learner characteristics and learning styles is important in planning and delivering instruction when using such methods.

Learner Characteristics and Learning Styles

The distance learner perceives and assimilates information delivered through the DE system. How that information is perceived, depends upon lesson content and structure, content delivery, and the learners' learning styles. Learning styles play an important role during this process. Gee (1990) identifies several learning styles. They include generalizing, exploratory, systematic, relationships, verbal, and visual.

Learning style inventory measurements are helpful in determining learning styles. The Canfield learning styles inventory (LSI) is one measurement instrument that determines learning styles. The Canfield LSI measures the conditions of learning, the content of learning, the mode of learning, and student expectations in a learning situation (Boylan & Kerstiens, Eds., 1989). According to Boylan & Kerstiens (ibid.), the Canfield LSI includes several specific elements associated with the four dimensions mentioned. Under the category of conditions of learning these student preferences are measured:

1. Affiliation - pleasant, friendly, and warm relations with other students or faculty;

2. Structure - orderly, logical, and well-defined goals, objectives, and study plans;

3. Achievement - independence, self-determined goals and objectives in relation to perceived skills and interests; and

4. Eminence - competition, knowledge of one's own performance in relation to other's, need for control or authority.

Under the category of Content, the instrument measures student preferences for working with various sorts of content. These content sub-categories include: numeric, qualitative, (working with words or language), inanimate (working with things), and working with people.

Canfield agrees with Gagne's notion of "Channel efficiency," the idea that in every individual, some channels of perceiving and processing information are more efficient than others (1967). As a result, his instrument also measures students' preferred mode of learning. The categories under this heading are: listening, reading, iconics (learning through illustrations, movies, slides, graphs, and pictures, etc.), and direct experience.

Finally, the Canfield LSI assesses student expectations of learning - i.e., their anticipated level of performance. The levels of anticipation include outstanding or superior performance, good or above-average performance, average or satisfactory performance, and below-average or unsatisfactory performance.

The instrument measures these categories through thirty items in which the students are asked to rank order their preferences among four choices.(pp. 15-16).

Reliability of the Canfield LSI instrument was established to be high and, in addition, validity showed "several statistically significant differences" among all pairs of groups tested (ibid.). Tamaoka (1985) generalizes that "by using Canfield's LSI, it may be possible to compare students' learning styles with teachers' instructional style." An additional instrument designed by Canfield provides an assessment of instructional style to correspond to his LSI. Brookfield (who cites Witken and Pratt in Wilson, 1991) has examined the relationship between cognitive styles and self-directed learning. Researchers have classified individual learners as Field Independent (FI) or Field Dependent (FD). FI learners are those who prefer "solitary situations and self-defined goals, strategies and reinforcement."(p. 43) FD learners are those who prefer "group situations, externally defined goals and reinforcement, and explicit instructions or definitions." (ibid.) The literature indicates that the FI learner is more likely to succeed at distance education (Wilson, 1991). Applying interactive television in a manner that provides learning opportunities for both FI and FD learners, will provide learning opportunities for both learning groups.

Identifying learner characteristics and the determination of learners' learning styles will help the instructor determine what instructional style(s) and delivery method(s) to implement. Course content can be delivered so that the students' academic success is high. Although existing research in distance education is inconclusive concerning the effect of learning style preferences on achievement, course design and assessment will play a critical role in determining what learning styles are best suited for the information and instruction delivered via interactive television technology.

Teacher Skills and Course Delivery

Distance education is a means by which learners can receive instruction that might not be available to them by traditional course delivery. DE systems that use two-way video and audio are utilized to provide the linking instructional medium to many remote learners. This interactive medium is an effective alternative to the traditional classroom setting. Learners are able to interact with the instructor and other learners at their site as well as with learners at participating remote sites. With this type of instructional delivery system, the teacher must be able to provide effective content delivery in a manner that uses the DE system such that the learner receives the maximum instructional benefits that are available.

For the novice distance teacher, familiarity with the ITV system becomes an essential requirement. Based on Thompson, Simonson & Hargrave (1992) make these recommendations for an interactive television training session:

* Provide teachers with an overview of the technology and how it works.

* Provide hands-on guided practice on the use of ITV technology.

* Incorporate the effective elements of instruction as major parts of the training session.

* Have periodic follow-up inservice and on-site coaching to ensure long term training benefits.

* Use with teachers who volunteer for ITV training.

After becoming familiar with an ITV system, teaching skills need to be adapted to fit the system. The DE teacher must provide the necessary interaction with the distance learners and present the course material in a manner that involves learners and produces learning. Seaman and Fellenz (cited in Wilson, 1991) define adult teaching as: "The activity through which the teacher or learning facilitator assists the adult student in acquiring new knowledge or skills."(p. 44)

The teacher is responsible for providing structure and feedback to the distance learners. Braucher (cited in Moore & Thompson et al, 1990) suggests that "developing a friendly atmosphere, accurately transmitting feelings by tone of voice, carefully selecting words, appropriately using silences, ... and thoughtfully integrating new students are skills which distinguish effective teachers in any setting or delivery situation."(p. 24)
Wilson (1991) identifies several skills for distance teachers from the literature: 1) imagines what the students need; 2) inspires the students; 3) encourages them; 4) likes people; 5) is alive; 6) provides feedback; 7) motivates students; 8) tolerant; 9) cooperative; 10) flexible; 11) innovative; 12) provides two-way written communication; and 13) establishes personal rapport.

Specifically, two-way interactive television (ITV) is an advanced means of providing distance education. It reflects many delivery characteristics of the traditional classroom setting. It is important to remember that there is a missing personalization with remote learners. According to Tykwinski and Poulin (cited in

Kolomeychuk & Peltz, 1991)

"The greatest challenge in interactive video instruction, or meetings, is overcoming the barriers of distance and technology that hinder that normal personal interaction. This interaction may be negatively affected by the novelty or fear of technology, number of participants or students and/or sites included in an event, decreased ability to receive non-verbal cues from participants, limited opportunity for after-meeting or after-class discussions, and preconceived notions about television viewing (e.g., a passive activity).

A high level of interaction is important in teaching and learning and in meetings in order to increase the attention and motivation levels. Interaction can also be used to determine whether the information and concepts being presented are properly received and interpreted. It is recommended that leaders, participants, instructors, and students become confident (through exposure and training) using the technology, limit the number of participants/sites, evaluate course and instructional design, establish interpersonal rapport, find activities that promote involvement, and establish new questioning strategies to promote interaction with the audiences."(p. 7)

The Office of Technology Assessment (1989, p. 93) states that "unless distance learning teachers pay close attention to the need to create an interactive environment appropriate to the technology, students can and will tune out." Johnstone (cited in ibid.) suggests:

"The best way to learn new information is to receive it while in an active, rather than passive, state of consciousness....One simple method the instructor can use to assist the learner...is to do something that is never done on broadcast television: to talk directly to the distant learner and require a response at the very beginning of the session." (p. 93)

The Alaska University (1989c) suggests the consideration of these strategies for teaching at a distance:

* Adapt instruction to meet the varied needs of the students, the content, and the limitations of the delivery system.

* Hold a pre-course audio (or ITV) conference to increase student familiarity and comfort with the system.

* Familiarize students with each other and with the instructor: develop/distribute student and instructor biographical sketches, make on-air introductions, have students state their names and locations when they address the group.

* Visit the different sites during the course , meeting individually with students.

* Maintain phone-in office hours so students can call collect.

* Develop skills to facilitate students' learning on their own and in concert with other students at a distance.

* Work together to minimize and rectify technological problems.(p. 3)

Other strategies include: a welcome letter, a clearly written and complete syllabus, course materials in student hands on time, quick return of student work, and a willing and obvious desire to meet student needs.(Alaska, 1990b, p. 4) Additionally, the Learn Alaska Network (cited in Office of Technology Assessment, 1989) identifies distance teachers' needs for assistance is such areas as:

* the amount of time needed to prepare and teach distance delivered courses,

* methods to establish and maintain effective communication with distant students,

* experiences with other faculty members,

* strategies for adding visual components to audio courses,

* planning and management of organizational details involved in distance delivery, and

* strategies to encourage group cohesion and student motivation.

Communication between teacher and student is important. There are several channels that can be used to communicate with the learners located at a distance. They include the telephone, the mail or postal system, computer messaging systems (bulletin boards and the like), and in the case of an ITV delivery system, the class meeting itself. The use of computers to supplement the communication between teacher and learner has distinct advantages. The use of such systems allows the students to move at their own pace and receive feedback from the teacher in a timely fashion.

Holmberg (1990) states:

"The possibility to use micro-computers, modems and telephone communication, so-called electronic mail, to attain immediate reception both of students' assignment papers etc. and of tutors' correction and comments will undoubtedly bring about considerable improvement..."(p. 16).

Computer-mediated communication (CMC) has the potential to favorably affect the course quality, attitudes, and motivational levels of students. The convenience of CMC enhances distance education effectiveness and provides flexibility and other advantages in the teacher-student and student-student communication processes (Boston, 1992).

Communication between teacher and student must occur in a manner that encourages personalization, motivation, and understanding. Effective DE instructional delivery needs as much personalization as is necessary to provide the distance learner with every possible opportunity to learn and feel comfortable with the DE technology. Existing research provides a list of guidelines for personalizing the ITV classroom. ITV teachers should:

* Emphasize and encourage active student participation.

* Meet face-to-face (if at all possible) with remote site groups prior to the first scheduled class.

* Schedule formal and informal face-to-face meetings with the class during the course term.

* Teach to the camera. This gives the remote student the impression of eye contact which is critical to personalization.

* Travel to, and teach from, each remote site if possible.

* Devise formative evaluation techniques in order to assess the success of the class as it is being taught. (Thompson, Simonson and Hargrave, 1992, p. 42)

The literature and existing research on teacher skills and course delivery includes an extensive amount of information on instructional delivery. Personalizing course delivery is seen as an essential need in the distance learning environment. Additional communication channels are important to providing for the distance learners' needs. Familiarity with the ITV system is important for both the distance teacher and learner. To ensure that course delivery is as effective as possible, teachers need to evaluate and assess course delivery.

Course Assessment

Course assessment must not be overlooked during the course design and planning stage. It is addressed here and uses the framework provided in previous sections. A primary purpose of course assessment is to determine if goals and objectives that have been set for the course have been achieved. This will help determine if the instructional methods chosen, and selected instructional media and materials are providing the means necessary to achieve such goals and objectives.

Assessment strategy will include formative and summative evaluation development. Formative evaluation will provide an on-going evaluation process that originates from the development of course materials and content delivery. Determination of problem areas within course materials and content delivery will indicate revision strategies that need to be implemented. Such strategies will ultimately increase the effectiveness of course materials and content delivery. Revisions that take place during the formative evaluation process can be implemented prior to course completion.

Summative evaluation will occur at the conclusion of the course. It will provide data on the effectiveness of the course and may include data collected during formative evaluations. Data gathered through the summative evaluation process will help in planning future courses. Summative evaluation will often include pre-testing, post-testing, and the gathering of other information that is obtained from tests and questionnaires. Other information can also be collected that provides information such as personal profiles of participating students.

The development of a course assessment strategy is the key to determining what changes need to be made to increase course effectiveness and efficiency. The Alaska University (1989b) suggest considering the evaluation of the following:

* Audience attitude and performance.

* Strengths and weaknesses of program.

* Effectiveness of teaching techniques and delivery systems.

* Instructor effectiveness.

* Degree to which course objectives were met.(p. 6)

Particular instruments can be developed and administered to distant and home site learners. Pre-test and post-test instruments will obviously determine if instructional delivery was effective in producing the desired learning outcomes and will be important to the summative evaluation process.

Questionnaires and tests can be developed to perform both formative and summative evaluation. It is important to remember that evaluation instruments have already been developed. Check to see if questions can be applied to the particulars of the course to evaluate.

Biner (1993) provides a four-step process for the development of an instrument to measure student attitudes toward televised courses. The steps include:

1 - Generating items related to course satisfaction.
   a. Instruction/Instructor Aspects
   b. Technological Aspects
   c. Course Management/Coordination Aspects

2 - Defining dimensions underlying items.

3 - Selecting content valid items.

4 - Writing and pre-testing the instrument.

Harrison et al (1991) determined that the three most consistently mentioned components of distance education programs were instruction, management, and logistics. Example elements associated with each of these components include:

Instruction

* instructional strategies such as the pacing of instruction, the use of work-related examples, the formation of study or support groups

* effectiveness of instructional materials

* the methods used for providing feedback, counseling, or motivation of learners

Management

* organizational structure

* communications between the program and clients, instructors, or students

* how available resources are used

* the policies and procedures of the distance education program.

Logistics

* the quality of the video

* the on-time delivery of instructional programs

* an efficient method of providing off-air, course-related materials

* the instructional environment at the receiving site(s)

Such elements can be included in the assessment instruments used in formative and summative evaluations. Appendix E contains several sample evaluation instruments that can be utilized to perform evaluations. Because assessment is so important in providing information needed to determine revision needs, such instruments should be developed during the course design and planning stage of the systematic planning process to ensure that assessment is effective and implemented on a timely schedule.

An Instructional Design Model for Distance Education Via ITV

Based on the literature and our own experience with distance education via interactive television, we suggest the following nine step model for designers of college level distance education courses:

1. Identify Course Goals
2. Analyze and Organize Content
3. Write Performance Objectives
4. Identify Learner Characteristics
5. Develop Lesson Plans
6. Develop and Select Instructional Materials
7. Design and Conduct Formative Evaluation
8. Modify Instructional Plan
9. Design and Conduct Summative Evaluation

This model is an adaptation of the Dick and Carey model discussed previously and is based on the unique characteristics of distance learning via ITV, and our own research. We think that it is well suited to the delivery of graduate level curses and takes into consideration the mature learner. This model has evolved through experience. It has been used successfully at Texas Tech for several years and we therefore offer it for your consideration. The model is implemented as follows:

To be practical in terms of planning and development time and cost effectiveness, distance education courses must be planned and conducted with resources similar to what is afforded traditional campus-based courses. First, a planning team should be established. Members of planning teams frequently include content experts, instructional designers, video production experts, graphic artists, media specialists, and others. However, as a practical matter, limited college and university budgets and resources usually limit the membership of the planning team. We suggest that planning team consisting of the teacher, an instructional technologist, and a student or potential student of the course. It is also possible that an experienced ITV teacher may constitute the entire planning team.

1. Identify Instructional Goals.

Goals are the broad statements of expected outcomes for the course. Identification of the instructional goals are primarily the responsibility of the course instructor. If the course is designed to meet a specific purpose (eg. certification or degree requirements) the basic content of the course may be predetermined. The goal statements will therefore reflect this. Usually, courses taught via ITV are also taught in traditional campus classrooms. The goals of the ITV course should be basically the same as campus-based courses. We have offered an introductory course in computer applications for educators both on campus and via ITV. Some sample goals for this course are as follows:

> 1. Demonstrate an understanding of basic computer terminology, hardware and software both as a classroom and personal productivity tool.
>
> 2. Evaluate, select and recommend educational software and prepare appropriate instructional design in order to integrate the use of small computers into specific content areas.
>
> 3. Explore developmental issues related to the creation of appropriate instructional software.

These goals appear on the course syllabus for both the regular on-campus classes and ITV classes.

2. Conduct Content Analysis

The teacher is a content specialist and therefore will be knowledgeable concerning the content of the course. Texts, accreditation association guidelines, and state curriculum guides may also be helpful. We divide the course into logical segments representing one class each and begin to develop a lesson plan for each class. The topics and content outline for each class are specified first. The instructional time for any college course must meet the minimum requirements of the college/university and the accreditation agency, usually 35-40 hrs each. However, allocation of class time may be different for ITV course than for on-campus courses. Some courses will require guided practice at remote sites, which are not part of televised lessons. This may be scheduled as a laboratory or may be conducted as part of regular instructional time.

3. Write Performance Objectives

Measurable objectives are written for each lesson. These are taken from the goal statements and are stated in terms of observable student behaviors. Measurable objectives help clarify exactly what is expected in the minds of both the teachers and the learners. Techniques of stating performance objectives are beyond the scope of this paper. A sample set of objectives for a lesson on integrated software for our educational computing course follows is given here as a sample:

Topic: Introduction to Integrated Software
Objectives:
Students will be able to:
1. Define integrated software.
2. List several examples of integrated software packages.
3. List examples of computer applications which are frequently included in integrated software.
4. List examples of products which may be produced with integrated software.
5. Discuss the relative advantages and limitations of integrated software packages as compared with stand-alone software.

If the teacher is not an instructional designer, the technologist should assist the course instructor in stating performance objectives for each class. The student member of the planning team can be asked to review the evolving lesson plans for suggestions. Clarity of goals and objective statements, terminology used, and suggestions on content to be included can be reviewed.

4. Identify Learner Characteristics

There are many ways to identify learner characteristics. We gather information at the first class meeting. This begins with introductions and completion of a brief student profile form. This includes such information as student's major course of study, reason for taking the course, previous experience relevant to the course, and place of employment. We also use both the Canfield Learning Styles Inventory and a teacher-made pre-test which is given at the first class meeting. The Canfield, which was discussed earlier, provides information on how the student learns best and suggests the kinds of activities which may be helpful to him or her. The pre-test provides information about how much the student already knows about the course goals and objectives. Since we deal with mature learners, we often ask for self-assessment. The information from these instruments is promptly sent to the instructor by FAX or data communications. The data is analyzed and detail is added to the lesson plans based on the information. For example, if most of the students are found to be field-independent learners, more activities which provide for independent study are included in the course. Student profile cards are also made which are referred to by the instructor as the course progresses. We use these to try to make assignments relevant to the student's interests, level of knowledge, and learning style.

5. Develop Lesson Plans

The basic instructional plan is the syllabus which is prepared first. However, the details of the instructional plan are contained in the lesson plans. The framework of each lesson plan was established in the content analysis and writing of performance objectives for each lesson. Now it is time to add detail to each lesson. With knowledge of the learners, the objectives and topics can be adjusted. Relevant examples can be developed. Activities can be planned. Requirements for media and materials can be determined. The technologist works with the teacher to plan activities which work best with the ITV medium. Lesson plans will be fully developed as the course is conducted. However, it is important to have long range plans. In addition to the basic need for good planning, the ITV staff will need to know what to expect and production of materials must be done in advance. We try to have final plans ready at least two weeks in advance of each class.

6. Develop and Select Instructional Materials

Earlier it was pointed out that ITV is an inherently visual medium. If a traditional lecture is poor technique in a regular class, it is deadly on ITV. Visuals, video demonstrations, and commercial media can be used to present the content in a manner which is more likely to maintain the students attention and help them understand and retain the information. Specifications for the media are developed in the instructional plan. Frequently, the teacher produces the media or the campus media service, ITV staff, or students may help.

7. Design and Conduct Formative Evaluation

As the course progresses, frequent feedback is obtained both informally and formally. Question and answer sessions are held during each class. Brief quizzes are given and student assignments are collected regularly. We specifically try to determine which methods and materials are preferred and to what degree objectives are being mastered.

8. Modify Instructional Plan

Modifications to the lesson plans are made as the course progresses based on feedback from the students. The student member of the planning team is also frequently used as a sounding board and to make suggestions. Material that was not mastered may be clarified by presenting it in another manner. Sometimes, new timely topics are added.

9. Design and Conduct Summative Evaluation

At the conclusion of the course, a post-test and a course evaluation are administered. The post-test is either the same as the pre-test or a more detailed version of it and provides detailed information concerning how well each objective was mastered. The course evaluation that we use is a standard course evaluation used at Texas Tech to which we have added several items concerning delivery of the course via ITV. This information is useful in evaluating the success of the course and for providing information for the next time the course is offered. The course planning team reviews and evaluates the data and makes recommendations for future courses.

Summary

Distance education delivery via ITV is clearly an effective means of providing instruction to learners at a distance. Interaction among course participants can vary over a wide range because of the capabilities of this delivery system. As a result, it is important for educators who use this technology for delivering instruction to know how to use the system, understand its capabilities, and know how to apply those capabilities to enhance instructional delivery. This in turn will provide the best possible learning outcomes for participating learners.

ITV technology provides many advantages as an instructional delivery system. Advantages, such as the ability to provide immediate feedback to learners and have interactive personal participation among all sites, enable this delivery format to be highly effective. Additionally, students benefit from this format by experiencing similar learning and achievement levels of students who receive instruction through the traditional classroom setting.

Other advantages of ITV that play an important role in providing effectiveness include the visual capabilities of the system, open-line audio transmission, and the sharing of many resources including master teachers.

Research indicates that instruction delivered via ITV requires structured planning and development. The use of instructional design principles to achieve effectiveness in course planning and instructional delivery is imperative. There are many instructional design models that can help the course designer accomplish the planning and development of DE courses. Although no one specific model has been determined to be the most effective in aiding the course designer, the use of such models has proven to be effective in producing interactive television instructional delivery effectiveness.

Course planning for ITV delivery requires the designer to know the characteristics associated with distance education systems, the available resources, how course content is to be delivered, and learner characteristics and learning styles. Planning teams can be utilized and the number of participants can vary from one to many.

Studies show that DE teachers are concerned with selecting course content and materials, covering the course content, class process, on-going planning activities, student participation, teacher-student communication, and student characteristics.

McGreal's (1991) guidelines to help the ordinary teacher produce instructional materials for distance education systems are helpful and are similar to those found in the literature. Also, Parker and Monson (cited in Moore & Thompson et al, 1990) reveal techniques important to course development that include humanizing, participation, message style and feedback. Interactive study guides are course materials that can also be developed to accommodate the ITV medium.

Specifically targeting conditions that will help students learn in the DE setting is important. Teaching methods and models will prove effective with the ITV medium. Knowing the characteristics and learning styles of the learners will help increase the effectiveness of the instruction development and delivery processes. Including delivery strategies that accommodate for both FI and FD learners will provide for a wider range of learners.

Existing research and literature provide these recommendations for training teachers about ITV:

* Provide teachers with an overview of the technology and how it works.

* Provide hands-on guided practice on the use of ITV technology.

* Incorporate the effective elements of instruction as major parts of the training session.

* Have periodic follow-up inservice and on-site coaching to ensure long term training benefits.

* Use with teachers who volunteer for ITV training. (Thompson, Simonson and Hargrave, 1992, p. 42)

* Establish the amount of time needed to prepare and teach distance delivered courses.

* Develop methods to establish and maintain effective communication with distant students.

* Provide experiences with other faculty members.

* Incorporate strategies for adding visual components to audio courses.
* Plan and manage of organizational details involved in distance delivery.

* Use strategies to encourage group cohesion and student motivation.

In delivering instruction through the ITV medium, existing research and literature provide effective teaching strategies and guidelines for personalizing the ITV classroom. Teachers should:

* Adapt instruction to meet the varied needs of the students, the content, and the limitations of the delivery system.

* Hold a pre-course audio (or ITV) conference to increase student familiarity and comfort with the system.

* Familiarize students with each other and with the instructor: develop/distribute student and instructor biographical sketches, make on-air

introductions, have students state their names and locations when they address the group.

* Maintain phone-in office hours so students can call collect.

* Develop skills to facilitate students' learning on their own and in concert with other students at a distance.

* Work with students to minimize and rectify technological problems.(p. 3)

* Emphasize and encourage active student participation.

* Teach to the camera. This gives the remote student the impression of eye contact which is critical to personalization.

* Travel to, and teach from, each remote site if possible.

* Devise formative evaluation techniques in order to assess the success of the class as it is being taught. (Thompson, Simonson and Hargrave, 1992, p. 42)

DE taught via ITV can be effective and rewarding. Proper course design, development, implementation, and evaluation will ensure that the DE learner receives the maximum benefits from the delivery medium. The research and literature provide information to help the DE teacher to understand DE technology and systems, and plan and deliver effective instruction. As a result, learning opportunities for DE learners will continue to improve as new strategies and advancement in technology enhance the delivery of instruction via ITV.

REFERENCES may be found in Appendix E

Title:

Opening the Black Box: Instructional Strategies Examined

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This paper will explore a conditions-based approach to development of micro-level organizational strategies for instruction. The paper draws upon ideas generated during development of the recently-published text, *Instructional Design* (Smith and Ragan, 1993) as well as subsequent work.

Reigeluth (1983) presents three components of instructional strategy: organizational, delivery, and management strategies. Organizational strategies refer to content presentation and sequence concerns, delivery strategies refer to media and grouping concerns and management strategies refer to matters of scheduling and resource allocation. Although all three components are of concern to instructional designers, organizational strategies are both the primary concern for this paper and are a component which has profound influence on the other components as well. Little prescription has been said to be available (the "black box") for organizational strategies: how will information be presented, what content will be explored, in what activities will learners engage? What will happen during instruction in what sequence or by what sequence-controlling event(s)?

Too often in instructional design literature, (or in common perceptions of the literature) when the focus of the design process is on the "develop instructional strategy," prescription is replaced with "just do it." In phases of the design process both before and after strategy development, instructional design technology has justified the term "technology." Principles and procedures abound to guide the designer in performing instructional analysis; the same can be said for development of assessments and for conducting summative and formative evaluation. But in strategy development, too often the principles which would guide one in making decisions have been clouded in mystery. It is a classic case of the "black box" in which both inputs and outputs are known, but the process itself appears to be unknown.

It is our contention that more is known that is of a prescriptive nature regarding the design of instructional strategies, specifically organizational strategies, than is generally acknowledged. The literature has been scat red and difficult to synthesize into a coherent whole. And. although the authors present an approach which itself is a synthesis, it is not a synthesis of *everything* out there on instructional strategies, since thus far a reconciliation of all potentially useful points of view has not been possible.

The approach to be discussed rests on what can be described as the "conditions model" of instruction. The conditions model reflects the idea that differences in learning tasks, primarily qualitative differences in cognitive processing required of different learning tasks, can suggest different ways by which instruction can either *supply* the processing needed or assist learners to *generate* the needed processing. The conditions model is most widely known in the work of R.M. Gagné (1985), but is also evident in work by many others including Merrill (1983), Reigeluth (1983), Landa (1974), and Tennyson (1986). Although there are questions about and limitations of the conditions model which we may not be able answer or rebut at present (e.g., concerns from the constructivist orientation about the feasibility of having stable enough "objectives" for learning to analysis and subsequent instruction based on those objectives), there is one important perceived limitation in this approach which we believe we have surmounted and which, in so doing, greatly expands the reasonableness and utility of the model. That limitation has been more perceived than real, in our view, yet it appears that ours may be the first sufficient explication to thoroughly counter the argument of this particular limitation. That limitation has been the notion that conditions-based models (and by association, the "instructional design" approach) prescribe only supplantive instruction or that the models are inherently biased toward supplantation.

It is easy to see how the idea that conditions models are associated with supplantive strategies, even though we believe this association to be largely the result of miscommunication and misunderstanding. A good example of what might lead a person to assume that the conditions models suggest supplantive strategies is seen in the wording of the "events of instruction" (Gagné. 1972):

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting stimulus material
5. Providing learning guidance
6. Eliciting performance
7. Providing feedback
8. Assessing performance
9. Enhancing retention and transfer

Gagné's explanations of the events of instruction occasionally suggest that he may have intended that the events could at times be other than "instruction-supplied" even though such suggestion is not present in the way the events are worded.

Regardless of Gagné's original intent, it is easy to view events of instruction from a position which is neutral with regard to the supplantive/generative question, placing the selection of strategy in that regard an element in the design process.

In the present author's recent text (Smith and Ragan, 1993), a revision of the events of instruction, which we label "expanded events of instruction," is presented in which both generative and supplantive interpretations are suggesting by the wording of each event.

		Supplantive Version	Generative Version
Introduction			
	1.	Gain attention to lesson	Activate attention
	2.	Inform learner of purpose	Establish purpose
	3.	Stimulate learner's attention	Arouse interest & motivation
	4.	Provide overview	Preview lesson
Body			
	5.	Stimulate recall	Recall prior knowledge
	6.	Present information	Process information
	7.	Gain & focus attention	Focus attention
	8.	Guide or suggest use of lng. strats.	Employ learning strategies
	9.	Elicit response	Engage in practice
	10.	Provide feedback	Evaluate feedback
Conclusion			
	11.	Provide summary & review	Generate summary & review
	12.	Enhance transfer	Transfer learning
	13.	Provide remotivation & closure	Remotivate and finish
Assessment			
	14.	Conduct assessment	Assess performance
	15.	Provide feedback and remediation	Evaluate feedback and seek remediation

Figure 1: Expanded Events of Instruction (adapted from Smith & Ragan, 1993)

We suggest that choice of instructional strategy form--from relatively supplantive to relatively generative--should be made on the basis of consideration of certain critical characteristics of the learning task, learners, and context for learning, specifically: time available for instruction, learner aptitudes, motivation, prior knowledge, availability of cognitive strategies, criticality of task, and future learning requirements. Thus, if time, learner characteristics, and so forth will allow it, the summarizing event, for example, may be generated by the learners rather than being supplied by instruction. A guideline we would propose is: make the instruction as generative as conditions allow. Here we follow a different path from those who recommend always employing a generative (exploratory, inquiry, inductive) strategy, and we take a different view from those who would always employ a supplantive one. A more extensive treatment of the generative-supplantive strategy dialogue can be seen in Smith (1985).

The neutrality of instructional events is maintained in the interest of reducing designers' assumptions or predispositions for one general form of instruction or another. Application of the expanded events should serve to reduce the frequency and validity of the criticism that instructional designers tend to develop a supplantive form of instruction, neglecting approaches which can sometimes be more desirable.

The second aspect of the expanded events concept is application to different types of learning. In the following we will describe strategy recommendations for six major types of learning: declarative knowledge, concept learning, procedural rule learning, relational rule learning, problem solving, attitude learning, and the learning of psychomotor skills. Recommendations which follow have been pulled together from many sources. First it should be acknowledged that the base of work by Gagné (1985) and Gagné and Briggs (1979) provided a point for expansion. Many of the following summary frames appear in Smith & Ragan (1993); some were developed for this paper. A few key sources are noted for each discussion and in the references section of this paper, and full references are provided in Smith and Ragan (1993).

Strategy Elements for Declarative Knowledge Learning

Introduction	
Deploy attention Arouse interest and motivation	• Use of novel, conflictual and paradoxical events, the interjection of personal/emotional elements, and making clear how the present learning relates to other learning tasks
Establish instructional purpose	• Relate instr. goals to personal goals or job reqmnts., make instrl. goals relevant, present goal in interesting format, remind lnrs. of relevant lng. strats., point out requirements for successful attainment of the obj., & let lnrs. know the form in which they need to remember.
Preview lesson	• Advance organizers or epitome can be useful form of preview, also outlines or maps.
Body	
Recall prior knowledge	• Advance organizers, use of metaphoric devices, and reviews of prerequisite concepts
Process information	• **Labels/names** **organization:** clustering and chunking **elaboration:** elaboration into sentences • **Facts/lists** **assoc** use of images **org:** expository and narrative structures, recognizing patterns, clustering and chunking, and elaboration. • **Organized discourse:** **assoc:** imagery, metaphoric devices **org:** analysis of expository and narrative structures, use of graphic organizers- frames, concept mapping **elaboration:** elaboration model
Focus attention	Underlining, listing, & reflecting; Questions: pre- & post-, embedded
Employ learning strategies	• Previously noted strategies (all but advance organizer) • Mnemonic techniques such as single use coding, pegwords, the method of loci, keywords, and the use of rhymes, stories, or jingles. • Rehearsal
Practice	• Role of practice, consider diff. needs for pract. for recall vs. recognition lng. tasks and for verbatim vs. paraphrased recall, consider needs for spaced practice, & the role of automaticity in declarative knowledge
Evaluate feedback	• Consider feedback needed for labels, facts, and lists (eval. correctness of associations of elements) as contrasted with the feedback needed for organized discourse ("understanding")
Conclusion	
Summarize and review	• Tuning cognitive structures, learner-generated summaries, interim summaries

Transfer knowledge	• Increase the number of possible connections in the learner's mental map, the role of application in a variety of settings, learners inference-making
Remotivate and close	• Show how learning can help student.
Assessment	
Assess performance	• Care required to b congruent with objective
Feedback and remediation	• Identify and clarify needs for learning

Propositional networks: Anderson, 1976; Schema: Minsky, 1975; Rummelhart & Ortony, 1977; Cognitive process of learning: E. Gagné, 1985; Illustrations in lng. org. discourse: Duchastel, 1978; Narrative structures & lng. org. discourse: Armbruster & Anderson, 1985; Graphic organizers: Holley & Dansereau, 1984; Focusing effect of questions: Bull, 1973; Attentional effect of questions: Schramm, 1964; Mnemonic techniques: Atkinson, 1975, Pressley, Levin, & Delaney, 1982; Generative summaries, Hidi, 1985

Strategy Elements for Concept Learning

Introduction	
Deploy attention Arouse interest and motivation	• Highlight concept label, use unusual picture or humorous story regarding concept, provide interesting information on origin or history of concept, and present first matched example and nonexample. Use inquiry approach.
Establish instructional purpose	• State explicitly in expository lesson. Delay statement in inquiry lesson.
Preview lesson	• Overview process of inquiry approach. Point out importance of examples and nonexamples and practice in lesson.
Body	
Recall prior knowledge	• Review concepts constituting critical attributes of concept. Use techniques such as informal questioning, formal pretest, advance organizer, or analogy
Process information	• Expose to best example and/or definition. Emphasize criterial attributes. Consider matched examples and nonexamples. Present concept in range of settings with diversity of non relevant attributes.
Focus attention	• Isolate criterial attributes in examples with highlighting such as boldface type, color, or a simplified drawing.
Employ learning strategies	• Generate concept maps, analogies, mnemonics or images.
Practice	• Identify examples from previously unencountered instances, which range in difficulty and settings. Explain categorizations. Generate examples.
Evaluate feedback	• Feedback contains attribute isolation.
Conclusion	
Summarize and review	• Restate criterial attributes. • Repeat or paraphrase key information.
Transfer knowledge	• Apply outside classroom. • Provide further examples.

Remotivate and close	• Show how learning can help student.
Assessment	
Assess performance	• Test ability to isolate criterial attributes in examples and point out their absence in nonexamples. • Test including range of common and non relevant attributes.
Feedback and remediation	• Provide score or other performance summary. • Identify problems of over- and under- generalization.

Concept learning: Klausmeier, 1980, Merrill & Tennyson, 1977; Wilson, 1987; Strategies for teaching concepts: Tennyson & Cocchiarella, 1986; Tessmer, Wilson & Driscoll, 1990; Use of examples: Ali, 1981, Use of analogies: Newby & Stepich, 1987; Concreteness of illustrations: Smith & Smith, 1991

Strategy Elements for Relational Rule Learning

Introduction	
Deploy attention	• Curiosity-evoking situation/problem
Establish instructional purpose	• Understand/apply principle, relationship between concepts
Arouse interest and motivation	• Curiosity-evoking situation
Preview lesson	• Inquiry=directions; expository=outline
Body	
Recall prior knowledge	• Review component concepts
Process information	• Present/induct relationship, state in principle form, demonstrate application
Focus attention	• Direction & size in change of one variable when other variable(s) changes
Employ learning strategies	• Mnemonic rule statement, diagram of relationship
Practice	• Predict, explain, control changes in concept(s) based on change of another; recognize situations where rule applies; determine whether rule correctly applied
Evaluate feedback	• Information on whether rule applicable, outcome of application
Conclusion	
Summarize and review	• Change in symbol system; restate principle
Transfer knowledge	• Point out how princ. will be incorporated into prob. solving; identify life situations
Remotivate and close	• Relevance to daily lives or current probs.
Assessment	
Assess performance	• Recognize if principle applicable, apply principle to predict, explain, control
Feedback and remediation	• Identify misconceptions, over- or under- generalization

Relational rule learning: Gagné, 1985; Anderson, (1985); Strategies for teaching relational rules: Tennyson & Tennyson, 1975; Joyce & Weil, 1986

Strategy Elements for Procedural Rule Learning

Introduction	
Deploy attention	• Ask question, demonstrate procedure, describe efficiency
Establish instructional purpose	• Describe procedure to be learned and range of applicability
Arouse interest and motivation	• Emphasize efficiency & reliability of procedure
Preview lesson	• Preview procedure in chunks
Body	
Recall prior knowledge	• Review component comcepts, sub procedures, or related principle
Process information	• Simplify complex procedures, situations that require proced., steps in procedure order of steps, how to eval. corr. of applic. May elab. over several iterations
Focus attention	• Critical char's of situations requiring procedure, key cues to transitioning between steps, keywords for each step, cues for correct completion of procedure.
Employ learning strategies	• Job aid, mnemonic for order of steps
Practice	• Identify situations requiring procedure, order of steps, completion of steps, correct completion of procedure
Evaluate feedback	• Correct answer w/ explan., checklist or rating scale, video feedback
Conclusion	
Summarize and review	• Major steps in proced., rel. to principle, appropriate situations for application
Transfer knowledge	• To prob. solving, more complex proced's.
Remotivate and close	• Emphasize utility of proced. in terms of reliability and efficiency
Assessment	
Assess performance	• Identify situation to which procedure applies, correct order and completion of steps, recognition of correctly completed procedure
Feedback and remediation	• Identify common errors and misconceptions

Procedural rule learning: Gagné, 1985; Anderson, 1985; Teaching procedures: Gilbert, 1978, Landa, 1974; Marcone & Reigeluth, 1988; Schmidt & Gerlach, 1990; Wilson, 1985.

Strategy Elements for Problem-Solving Learning

Introduction	
Deploy attention Arouse interest and motivation	• Present a challenging and interesting problem that is represented in a novel manner.
Establish instructional purpose	• State class of problem that learners will learn to solve. • Delay statement in inquiry lesson.
Preview lesson	• Point out that problems will become increasingly complex throughout lesson.
Body	
Recall prior knowledge	• Explicitly review relevant prior knowledge: rules, declarative knowledge, or strategies. • Suggest ways that learners to reorganize knowledge in a more conducive form. • Attend to similarities and differences to other problem-solving learning.
Process information	• Encounter simplified, prototypical versions of problem first. • Verbalize task requirements. • Provide model think-alouds. • Decompose problem into subgoals.
Focus attention	• Isolate critical attributes in given state and goal state.
Employ learning strategies	• Generate networks, analogies. • Monitor success of solutions. • Ask guiding questions and provide hints. • Represent problem in alternate forms. • Use print or other media as a form of external storage.
Practice	• Practice identifying and clarifying given and goal states. • Practice decomposing problem. • Practice evaluating adequacy of a provided solution. • Practice with well-defined problems first.
Evaluate feedback	• Model solution of process or provide models of solution. • Given hints or ask questions. • Provide information on efficiency as well as effectiveness of solution
Conclusion	
Summarize and review	• Restate criterial attributes of problem class. • Summarize effective strategies. • Suggest ways of organizing knowledge for storage and retrieval.
Transfer knowledge	• Find similar problems outside classroom. • Explicitly state when strategies may transfer to other problem types.
Remotivate and close	• Review the importance and breadth of what has been learned.
Assessment	
Assess performance	• Test ability to solve similar, but novel problems, both well-defined and poorly defined. • Test ability to isolate criterial attributes goal and given states. • Test ability to evaluate others' solutions. • Test ability to justify solutions.

Feedback and remediation	• Identify whether problems are in pattern recognition, decomposition, explaining solution, etc.

Domain-specific problem solving: Dunker, 1945; Gagné, 1980, 1985; Anderson, 1985; de Jong & Ferguson-Hessler, 1986, Alexander & Judy, 1988; Newell & Simon, 1972; Mental models: Johnson-Laird, 1983; Teaching of problem solving: Derry, Hawkes, & Tsai, 1987, Glaser, 1989; Mayer, 1985; Foshay, 1991

Strategy Elements for Cognitive Strategy Learning

Introduction	
Deploy attention Arouse interest and motivation Establish instructional purpose	• Experience task which requires the strategy • Discuss role of strategic thinking in learning
Preview lesson	• Demonstrate entire strategy model
Body	
Recall prior knowledge	• Recall previously learned strategies or tasks which seem similar
Process information	• Experience situations for which application of the strategy is appropriate and inappropriate • Model demo. strategy with think-aloud
Focus attention	• Critical attributes of tasks to which strategy is approp. • Cues that indicate successful application of strat.
Employ learning strategies	• Thinking aloud about cognition and monitoring effects of the strategy
Practice	• Identify contexts/tasks to which strategy is appropriate and explain why • Apply strategy to increasingly difficult tasks • Reciprocal practice
Evaluate feedback	• Peer evaluation • Group feedback - model appropriate application, examine artifacts of strategy use

Conclusion	
Summarize and review	• Summarize steps & review tasks to which strategy is appropriate
Transfer knowledge	• Move from detached to embedded with prompts, withdraw prompts • Compare strat. to others learned later
Remotivate and close	• Importance of effort coupled with strategy use
Assessment	
Assess performance	• Directly observe • Examine artifacts of strategy use

Feedback and remediation	• Was appropriate strategy selected? • Was strategy applied correctly? • Was success of strategy monitored and "fix up" strategies employed

Cognitive strategies: Derry & Murphy, 1986; Weinstein, 1982; Gagné & Driscoll, 1988; Davidson, 1988; Events for cognitive strategy instruction: Davidson & Smith, 1990; Deshler, Alley, Warner, & Schumaker, 1981; E. Gagné, 1985; Meichenbaum, 1977; Pressley, Snyder, & Gargilia-Bull, 1987; Weinstein, 1981

Strategy Elements for Attitude Learning

Introduction	
Deploy attention Arouse interest and motivation	• Engaging situation • Identification with characters or situation
Establish instructional purpose	• May be direct or indirect but to withhold for whole lesson is manipulative
Preview lesson	• May be indirect or withheld
Body	
Recall prior knowledge	• Present persuasion before expression of old attitude
Process information	• Persuasion, discussion, role-play, simulation
Focus attention	• Use of respected role model if persuasive tech. used --role model seen to receive valued reward
Employ learning strategies	• Use of acronyms, mnemonics, slogans for cognitive component as appropriate
Practice	• Practice cognitive, behavioral, & affective --know what to do, do it, know how it feels
Evaluate feedback	• Emphasize natural consequences • Include cognitive, behavioral, & affective aspects
Conclusion	
Summarize and review	• Clear restatement of desired behavior --purpose of instruction should be clear
Transfer knowledge	• Discuss applications, situations • Role play, simulations
Remotivate and close	• Realize how new learning can be used
Assessment	
Assess performance	• Ideal: behavior in actual free choice situation • Practical: role play or simulation of situations
Feedback and remediation	• Emphasize natural consequences • Include cognitive, behavioral, & affective aspects

Attitude learning: Martin & Briggs, 1986; Brandhorst, 1978; Zimbardo & Leippe, 1991; Attitude instruction: Fleming & Levie, 1978; Kiesler, Collins & Miller, 1969; Martin & Briggs, 1986.

Strategy Elements in Psychomotor Skill Learning

Introduction	
Deploy attention Arouse interest and motivation	• Focus on task • How new skill will help (may be implicit from preview or may need context of larger skill)
Establish instructional purpose	• What skill to be learned now should be clear
Preview lesson	• Overview what will be learned and how
Body	
Recall prior knowledge	• Point out the known skills that new skill uses
Process information	• Explanation then demonstration or • Explanation and demonstration together • Always organize by steps (subroutines) of the skill
Focus attention	• Learner activity during practice • Special attention for critical skills (dangerous, etc.)
Employ learning strategies	• Visualization of performance, mnemonics, analogies
Practice	• Distribution (whole/part) Scheduling (mass/spaced) • Sufficient for automaticity and desired skill level
Evaluate feedback	• External: suggestions, comments • Internal: proprioceptive, sensory
Conclusion	
Summarize and review	• Include re-cap of the steps in consolidating and clarifying fashion
Transfer knowledge	• Extended practice - maintenance of proficiency -- fundamental in many skills
Remotivate and close	• How apply in future; when use
Assessment	
Assess performance	• Observation of performance, performance rating
Feedback and remediation	• Learner needs clear idea of how well s/he can perform the skill and what to do next

Psychomotor learning: Fitts & Posner, 1967; Miller, Galanter, & Pribram, 1960; Oxendine, 1984, Robb, 1972; Singer, 1982; Instructional considerations: Practice: Harrison & Blakemore, 1989; Rothstein, Catelli, Dodds, & Manahan, 1981; Feedback: Ho & Shea, 1978; Magil, 1985; Newell, 1974; Rogers, 1974; Smoll, 1972

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Title:

Evaluating the Impact of Instructional Multimedia: Workable Techniques

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A variety of conditions and attitudes have made it difficult to develop and use evaluation schemes for "new media." Below we list four issues which pose obstacles to effective evaluation.

- **Continuous change**: A continuous blizzard of technological innovations often blinds designers of instructional multimedia to the fundamental questions to be answered by formative evaluation in the course of development. As a result, "evaluative activities" are put aside in order to expend effort on just getting the multimedia system to work smoothly in its technological environment, and on insuring that the system is compatible with the latest software.

- **Technology focus**: The delivery of multimedia programs can require sophisticated, non-standard, andoften costly hardware and software. Thus the discussion of Multimedia remains focused on resolving hardware/software issues: *who* can tell us *what* to buy, *how* to hook it up, and *how* to keep it working. The necessary concurrent discussion of learning or intellectual activity to be supported by multimedia tools pales by comparison.

- **Evaluation in isolation**: Evaluation is frequently labeled a "phase" unto itself, residing outside of the central development activities of analysis, design, and implementation. Frequently, the only people involved in the evaluation are the prototypical user and the development team, ignoring the interest and vested interests of a much wider group of stakeholders, further isolating the process by keeping it out of a real-world environment. Evlauation is conceived of as a measuring of outcomes and products, requiring statistically valid instruments and experimental groups, and takes place long after key decisions have already been made based on perceived value and usability. Thought of in this way, evaluation seems impractical.

- **"Hyped Media"**: A variety of claims are made as to the superiority of instructional multimedia to more traditional instructional media and methods. Among them are higher grades, improved critical thinking, accommodation of different learning and cognitive styles, and improvement of teaching. A coherent approach to confirming these claims has yet to be described and implemented.

In this presentation we propose a framework for the formative evaluation of multimedia, describe the techniques that have worked best in our software development efforts at Indiana University, and provide examples of the variety of ways in which we used evaluation results. Our emphasis is on what is workable and possible to do given the traditonally limited resources of the instructional designer in an academic setting. Our aim is get the instructional developer to use a variety of evaluation techniques more frequently and with greater confidence.

Our approach

The familiar social science experimental method has long been the accepted approach to evaluating the effects of mediated treatments on learning. Scriven (1987) lists these steps. In order to evaluate a program, you

1. Identify the goals of the program
2. Convert them into behavioral objectives
3. Identify tests (or construct them) that will measure these objectives
4. Run these tests on the target populations
5. Crunch the data
6. Report whether or not, or to what degree, the goals have been met

Characterizing this approach as the "naive social science model," Scriven continues

> There is a standard set of about fourteen questions that need to be investigated in most evaluations, of which only one is the traditional investigation of alleged or hypothesized effects so familiar in social science research. The only points that need to be made are that these questions, be they concerned with cost or alternatives or ethics or unexpected effects or historical background, cannot be ignored; and that a systematic approach to them is possible, with about the same chances of getting an answer as we can expect in the usual scientific or criminological hunt for explanations and theories. (p. 65)

In contrast, we seek to arrive at the answers to these questions from within the development process by focusing primarily on a single question: to what degree does this instructional multimedia program support the user's activities/tasks in the user's task environment? For if the product is not used then it doesn't matter whether it creates potential for or enables more or better learning. Furthermore, the desired learning is most likely to take place far from the machine, as the user reflects, applies, and synthesizes. It is therefore the process, or the quality of the mediation, not the product that should be the focus of instructional multimedia evaluation (Hutchings, 1992; Marchionini, 1990).

Our views on an appropriate evaluation model for multimedia do not, however, exist in a simple bi-polar opposition to what Scriven describes as the "naive social science model." Rather, our approach can be seen as an eclectic one moving across a continuum from a management-oriented model (related to the social science objectives-oriented approach) to the naturalistic-participant oriented approach at the opposite end (Worthen and Sanders, 1987). (See Appendix A). According to Worthen and Sanders, the management-oriented approach focuses on user needs, de-bugging, and evaluation at all stages of development. The naturalistic approach is helpful for examining innovations-in-use, for portraying the complexities of and educational activity, and for responding to an audience's needs. From our experience of both success and failure in the development of multimedia programs we have seen the following key characteristics emerge in our approach to evaluation:

- a focus on user satisfaction (usability and valuing)
- integration of evaluation into the design process
- use of a variety of techniques
- inclusion of a range of stakeholders

A focus on user satisfaction
What do we mean by user satisfaction and usability? What attracts our faculty to using multimedia is the technological reality of access to a variety of media via the computer. The ability to draw together a huge volume of information in a variety of formats, makes it possible to create and place at the students' and teacher's disposal elaborate

learning/teaching environments not possible only 10 years ago. Thus, the issues of access and control are paramount; that is, the program must facilitate moving about, finding things, and control appropriate to the task and level of user. Romiszowski suggests that when the purpose of the program is to provide access or act as a tool, the appropriate evaluation approach is to measure user satisfaction (Romiszowski, 1990).

To the definition of user satisfaction we have added another dimension: valuing. This aspect is based on the simple idea that a tool viewed as relevant, critical, and of wide applicability is a tool that the user will come to rely on. The user's "valuing statements" comprise a face validity of the evaluated program. Therefore, in all of our evaluation efforts we look for valuing statements.

Integration of evaluation into the design process

Evaluation occurs simultaneously with the analysis, design, and implementation. Within the large scale development project there are many small scale design processes which go through a full problem solving process for purposes of exploring options and developing a fuller understanding of the requirements. The successive phases of development–each with concurrent problem analysis, development and evaluation–become increasingly concrete (Goodrum, Dorsey, & Schwen, 1994).

Evaluation could be said to lead the process. The creation of prototype versions of proposed solutions are for the purpose of evaluation and refinement of specifications. This allows users to have a realistic experience for basing assessments and revisions. Conceptual prototypes allow for early user reaction, feedback, and projection of consequences. Working prototypes allow for hands-on use in the context of the task. If the evaluation process begins early then parts of a design or even an entire design can be discarded before time investment and escalating commitment prevent such corrective action. The use of alternative prototypes in the process helps keep designers and users from locking into a design too early. Frequent user evaluation helps insure usability and provides new ideas for design, content, and evaluative categories.

Inclusion of a range of stakeholders

By including a range of stakeholders early in evaluative activities you collect ideas, gain buy-in and commitment, and avoid unforeseen technical and administrative problems. The key stakeholders most often missing from the iterative design cycle are those involved in implementation and delivery, for example, those responsible for the local area networks which must have the capacity and flexibility to get the multimedia program to the user. The developer may need to consciously expand his or her idea of what a stakeholder is. To determine stakeholders, consider who or what could block the user's access and ablity to work with the program. Another way to find all the stakeholders is to think of everyone having a vested interest, and let the non-stakeholders self-select out of the group.

Use of a variety of techniques

Examining a process requires gathering snap-shots at various stages along the way, calling for a concert of methods, each of which adds "color" to the description. The techniques we have used that have yielded the most usable data have their roots in qualitative inquiry. They are:

- Observation
- Self-report
- Interview

- Peer evaluation (showing and telling others)

The stage of development, the purpose of the program, the target user and other stakeholders, help determine the type of method used and degree of formality in conducting the evaluation and analyzing the results. Another way to approach the choice is to ask (Knuscen, Tanner, and Kirby, 1991):

- For what reasons are we doing an evaluation?
- What will we do with the results?
- What resources do we have?

Our Experience
The nature of our multimedia development has been a) creation of presentation packages for faculty clients to use in developing multi-media lectures and b) creation of multimedia programs for students to use in networked computer clusters. The following techniques have proven beneficial to our evaluation process, especially when used together on the same multimedia project.

Client questions. Throughout the development process we ask the client to compare the "old" way with the "new way" of doing things. What was wrong with the "old way" of teaching a topic? Does the innovation help? How does it help? Could you use this in other courses? Do you think that you could take on more of the development yourself? Client questions like these keep the developer and client in a critical appraising mode focused on usability, worth, and value. (See Appendix B.)

Mock-ups. Paper mock-ups may be used at a variety of points in the development process. They are, in a sense, like a structured interview, if presented as a question rather than a *fait accompli*. At the beginning of the process they are an inexpensive and simple way to test ideas for fit with the client's or user's requirements. They can provide data on usability before committing to a design. We have also use paper mock-ups in mid-development when a project has foundered or been dormant. Removing the program from the "high tech" environment helps refocus everyone on task and usability, and the underlying reason for creating the product. It may also invite greater participation from those not at ease with computers and from those who may be new to the project if it is being picked up again after a period of time. The paper mock up signals an openness to critical evaluation. (See Appendix C.)

Observed initial use. This may be done as formally or informally as resources, data needs and stage of development require. After 4 months of development on one program we conducted a field test in two stages: a pre-field test review conducted by instructional developers, two students, and a faculty member; and a full field test with 20 students using the program in a network cluster. The full field test involved detailed observation of two students and a survey of the whole class. The tests identified current and potential problems, highlighted the program's positive points, provided design ideas, and involved three diferent groups of stakeholders. It di d require more coordination than some of the other methods, however, and preparation of the evaluators. (See Appendix D.)

Field trial. To be effective, the field trial must take place under actual conditions that test the limits of the products caabilities. Since a field trial is conducted during actual use, care should be taken to provide backup and support in case the system fails. Observations may be highly structured or subjective evaluation of an expert (See Appendix E). The structure and nature of the observations again depend on what data is needed and how the data will be used. For example, are you still looking for design ideas, are you firming up a design to bring the process to closure, or do you want to know if the progam is usable in order to seek more resources?

Minute paper. Having the users/consumers respond in writing to an open-ended question can help you adjust your program in mid-course. The time limit forces the writer to divulge only those issues of primary concern. The short length makes it possible to quickly review responses and tabulate results. The openness allows you to pinpoint problems you may not have considered. (See Appendix F.)

Classroom artifacts. Student and faculty client questions, criticisms, compliments, value statements, problem statements are all evaluative in nature. They point directly and indirectly to places where the program either performed well or fell short. Electronic mail now helps keep a record of them. We encourage our faculty clients to keep a record of these artifacts as well as keep a record of mail received from faculty. Setting up a "help" phone service during specified hours can also help capture problems, and provide evaluative data.

Focus group. The focus group, conducted by a person perceived as impartial and open, is an efficient way to interview a number of users at the same time. We have had success with both a highly structured format in which a list of questions was prepared in advance, and an informal format in which small groups were asked one or two open-ended questions. The more informal focus groups helped in defining what issues would become important later in the process. The structured focus group was conducted at a later stage of development, at a point when the important issues had been more clearly identified through prior evaluation. (See Appendix G).

Survey. A survey conducted during later stages of development may complement the structured focus group. From our experience we have identified some critical survey categories:

- How does the student value the learning experience?
- Was the experience relevant to the course and at the same time widely applicable?
- Was the program useful in completing the assigned task?
- How does the student compare the activity with activities in other courses?

The purpose of the survey is to gather data for fine tuning performance and to project the "bottom line" results of using the program. (See Appendix H).

Peer Evaluation. Demonstrating or talking to peers about their multimedia programs helps clients remain in the critical, evaluative mode established at the beginning and maintained during the design process. Peer questions are opportunities for reflection, generate new ideas, open up new partnerships. Peer evaluation may take place among other stakeholders as well, with the same effect of informing current and future design, and identifying other criteria by which the program might be judged. (See Appendix I).

Summary

Our approach to the evaluation of multimedia contrasts sharply to the objectives-oriented social science evaluation model. Rather than look to one method for answers to all of our evaluation questions we have borrowed heavily from naturalistic and participant-oriented evaluation approaches to obtain the answers. Our underlying philosophy toward evaluation in multimedia development process, based on our actual practice can be summed up this way:

- Find out if your multimedia helps the users do what they want to do.
- Evaluating *usability* gets you most (80%?) of what you need.
- Evaluation is a concurrent process through all stages of development.

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	Management -oriented	Consumer-oriented	Naturalistic and Participant-oriented
Purpose	Providing useful information to aid in making decisions	Providing information about educational products to aid decisions about educational purchases or adoptions	Understanding and portraying the complexities of an educational activity, responding to an audience's requirements for information
Characteristics	Serving rational decision-making, evaluating at all stages of program development	Using criterion checklists to analyze products, product testing, informing consumers	Reflecting multiple realities, use of ind[illegible]ive reasoning and d[illegible], firsthand experience on site

Criteria	Utility, feasibility, propriety, and technical soundness	Freedom from bias, technical soundness, defensible criteria used to draw conclusions and make recommendations; evidence of need and effectiveness are required	Credibility, fit, auditability, confirmability
Benefits	Comprehensiveness, sensitivity to informaiton needs of those in a leadership position, systematic approach to evaluation, use of evaluation throughout the process of development, well-operationalized with detailed guidelines for implementation, use of a wide variety of information	Emphasis on consumer information needs, influence on product developers, concern with cost-effectiveness and utility, availability of checklists	Focus on description and judgment, concern with context, openness to evolve evaluation plan, pluralistic, use of a wide variety of information, emphasis on understanding
Limitations	Emphasis on organizational efficiency and production	Cost and lack of sponsorship, may suppress creativity or innovation, not open to debate or cross-examination	Nondirective, tendency to be attracted by the bizarre or atypical, potentiall high labor intensity and cost, hypothesis generating, potential for failure to reach closure

Adapted from Worthen, B. R. and Sanders, J. R. (1987). *Educational evaluation:Alternative approaches and practical guidelines.* New York: Longman

Client Questions

1. What's one of the things you'll be teaching today?
   (looking for a lecture part or even a specific point that we can make sure we capture and hilite)

2. How did you teach this in the past?
   (what were the frustration or limitation of teaching it that way. i.e., what was wrong with that way of teaching it)

3. How will you be using the technology to help you teach this in your class?

4. How difficult was this to create?
   (and what kind of help did you need?)
   (do you see yourself doing more and more of this on your own?)

5. Is this a better way of teaching? Why? (or why not)

6. What other courses or areas in your field would this be useful for?

Insert Graphic entitled "Mock-ups" here.

Insert Graphic entitled "Observed Initial Use" here.

Field Trial

This is an example of another style of observation, performed at a later point in development than the Observed First Use example in this packet.

M conducted the class like a two-person dance. He used the Komo program to display text mostly. It was an outline he traversed to give students an idea of where they were. It seemed to work reasonably well because he didn't go too deep in the hierarchy. He has someone in the back controlling two slide show projectors. Frequently the images from the slides and Komo overlap. Often, the person controlling the slide projectors moves the images to keep them from falling on the text M is projecting. Frequently, the tool palette from the program can be seen over the slides. M's irreverence is plain--he doesn't seem to care much if the slides overlap the tool palette or not. The person in the back swings the slides back and forth trying to find an empty space for them as M turns Komo on and off. There is no "grid"--there is no place where text always comes up and pictures always come. The presentation is like M--fluid, ever changing, refusing to be categorized and yet paradoxically, existing within the framework of a highly structured outline....

...He wants to be able to access things quickly in any way he wants. The interface is extremely important to him. I can imagine him wanting something with a fluid picture-showing capability. He presses "next slide" on his computer. Up pop two pictures. He points to one of them with his finger on a stylus and drags it off the screen. He pops up some text. He presses "clean up" and all of a sudden, everything fits." He presses another button and the two pictures blow up to fill the screen. Another button and the pictures disappear.

Minute Paper

This question was placed on an overhead projector. Students wrote brief answers to the question which the instructional consulting staff then reviewed to get a "reading" on how things were going at mid-semester. The purpose was to spot problems and fix them before the end of the semester.

> **What is the effect of the technology used in this course on your learning?**

Insert graphic entitled "Focus Groups" here.
Insert graphic entitled "Survey" here.

Peer Evaluation

A faculty developer of a large multimedia project answers questions from her peers as she demonstrates her program. The following is a rough transcript from the video recording of her demonstration.

Faculty developer: An advantage of this format ...it really does give student access to a much wider array data than ever before and more accessible we've started tools to help them make those connections in their own minds in different sorts of ways graphics, text, video give each student a little bit of something

...what we're trying to improve upon is the interactivity...

Faculty developer stops her demonstration.

Any questions?

Peer question: Do students type their answers out?
Delivery issues discussed

Peer question: How do you get them started without being overwhelmed?
Faculty developer: Simple questions and self-help tutorial. Different students got started in different ways.

Disadvantage: lots of data
Advantage: open ended

If you ask the right questions...The trick is the interface of the questions you ask.
I've challenged graduate students with this data set.

I wanted them to use this as a tool and a learning resource as much as I wanted them to see use it as a text so I didn't allow them to print it out.

Peer question: You're not involved with authoring? the programming?

Faculty developer: The programmers created a miniature set of authoring tools that have allowed me to -- created a template -- I create the images and can very quickly...

I put it together mostly, I haven't done the scripting. (Faculty developer goes into stack and adds to it. She opens a palette to choose a card format, then she brings in a picture, types in the text)

That's how I put it together. It's been very easy to put it together. I know a lot more about hypercard than I ever did.
a cut and paste and a content problem for me

Peer comment: Very flexible architecture overall.

Faculty developer: Next: use this as a presentation tool
Astound -- allow you to select a few elements -- I'll be working on that next semester

Peer question on copyright issues.
Faculty developer: Copyright issues -- got to mail out the letters! I've tried to replace

copyrighted material with my own material
any color stuff is mine.

I like to doodle, so I can always create something myself.

Prototype on a CD

At each stage we've gotten student evaluate information
I've been astonished how resilient the students are.

Title:

Utilizing Intrinsic Motivation in the Design of Instruction

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The study of motivation has long been a neglected area in instructional technology. The emphasis on promoting effectiveness and efficiency in instructional design often excludes concerns about the appeal of instruction. Traditionally handicapped by the lack of theory and lack of measurements dealing with motivation, instructional designers have assumed that good quality instruction will in itself be motivating (Keller, 1983).

However, research in the field of intrinsic motivation over the last decade has yielded insights which can be applied to problems in instructional design. This research has resulted in the development of Flow Theory, a model which explains the structure of optimal experiences and the dynamics of intrinsic motivation.

This paper will provide a synthesis of Csikszentmihalyi's Flow Theory of intrinsic motivation with Keller's Motivational Design Theory of Instruction. The conceptual integration of these two theories will be the basis for presenting prescriptions aimed at increasing the level of intrinsic motivation in instruction.

Theoretical framework

The flow phenomenon is best described in terms of its two parameters, challenge and skills. When these two factors are in balance, people feel that they have the skills necessary to achieve a challenging, but realistic, goal (Csikszentmihalyi, 1982). A challenge is perceived as an activity that has clear goals and requires an investment of effort in order for the goal to be achieved. Skills are those efforts that an individual needs to apply towards the achievement of the goal. Implicit in this model is the characteristic of feedback, which allows an individual to track his or her efforts in achieving the goal.

Csikszentmihalyi (1993) states that flow-like activities have four main characteristics:

> (1) they have concrete goals and manageable rules, (2) they make it possible to adjust opportunities for action to our capabilities, (3) they provide clear information about how well we are doing, and (4) they screen out distractions and make concentration possible. (p. xiv)

Flow experiences are informative in nature, that is, they are clearly bounded by rules and goals, yet are flexible enough to allow an individual to exert effort and experience the results of those efforts.

The emotional effects of attempting to achieve any goal can be classified according to the ratio of challenge to skill an individual applies to the task. These ratios are termed "channels" and are grouped into classes and defined by Csikszentmihalyi & Csikszentmihalyi (1988), as: flow, in which the level of challenge is equal or slightly above the level of skill required to achieve the task; anxiety, in which the level of challenge is greater than the amount of skill necessary for the task; apathy, in which both the level of challenge and the level of skill is low; and boredom, in which the level of challenge is lower than the amount of skill an individual can bring to the task (see figure 1).

Flow is perceived as a positive experience because the mastery of an achievable challenge stretches an individual's capabilities by promoting the development of new skills and increasing self-esteem and personal complexity (Csikszentmihalyi & LeFevre, 1989). In addition, remaining in the state of flow requires further increases in the complexity of the challenge, thereby promoting growth.

While in a state of flow, people often report feeling more active, alert, concentrated, happy, satisfied, and creative (Csikszentmihalyi & LeFevre, 1989). Flow produces a sense of focused concentration described as the "merging of activity and awareness" which Csikszentmihalyi claims "produces harmony within the self" (Csikszentmihalyi & Csikszentmihalyi, 1988).

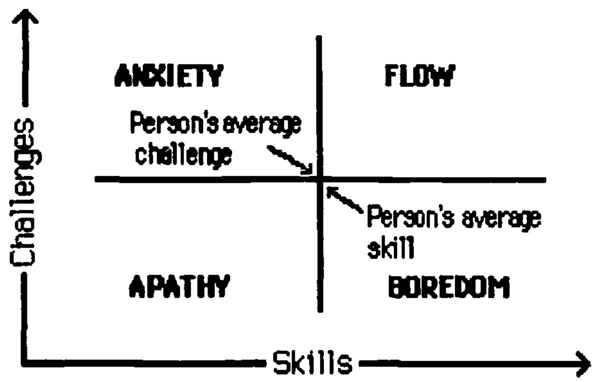

Figure 1: The "four-channel" flow model. (Adapted from Massimini and Carli, 1986, as cited in Csikszentmihalyi & Csikszentmihalyi, 1988.)

In terms of instructional design, flow theory emphasizes the importance of three design variables, goals, means and feedback. Instructional designers promote the use of instructional objectives as the backbone of the development process. The emphasis in flow theory on the importance of clear goals reinforces this basic prescription. In addition, the importance in flow theory of communicating clear means to achieve goals is the main purpose of the many instructional design theories and models that have developed in our field. And the emphasis on clear feedback in flow theory has also been an issue in instructional design since the days of Skinner and the development of programmed instruction.

These three environmental characteristics of flow provide a theoretical congruence between Csikszentmihalyi's theory and the practice of instructional design. Flow theory can provide instructional designers with a clearer understanding of the motivational aspects of instruction while also providing us with a set of criteria for evaluating the appeal of instruction.

The first, and perhaps only ID theory to explicitly address the use of motivation is John Keller's motivational design theory (Reigeluth, 1987). This theory is integrative in nature and is intended to be used in conjunction with other instructional design theories. The theory has both a descriptive component, the "Motivational Design" theory, and a prescriptive component, known as the ARCS (Attention, Relevance, Confidence, and Satisfaction) model of instructional strategies (Keller & Kopp, 1987).

In analyzing and synthesizing the research on motivation in education Keller has identified three major categories which form the backbone of his theory: effort, performance, and consequences. In addition, each of these categories has both personal and environmental factors which affect them.

This synthesis has a basic assumption: that the intrinsic motivational theory of flow should be thought of as a subset of Keller's larger theory of motivation. The goal was to incorporate flow theory within the three-categories framework of Keller's theory.

From this perspective then, Keller's category of effort corresponds to the challenge parameter of the flow model. This is based upon the assumption that an individual's amount of effort is at least partially a function of their perception of the challenge.

The performance category of Keller's theory corresponds to the skills parameter of flow, if we assume that an individual's performance is dependent upon an adequate level of

692

skills to meet the challenge.

Finally, the consequences category of Keller's theory would correspond to the function of feedback in the flow model. Feedback is used in the Flow model to adjust the balance of challenge and skills to create optimal experiences. Interpreted from Keller's framework, the consequences of an individual's performance functions as a feedback mechanism, therefore allowing the individual to evaluate performance and modify behavior if necessary (see figure 2).

In addition, personal and environmental factors have been derived from Flow Theory which correspond to these elements in Keller's theory.

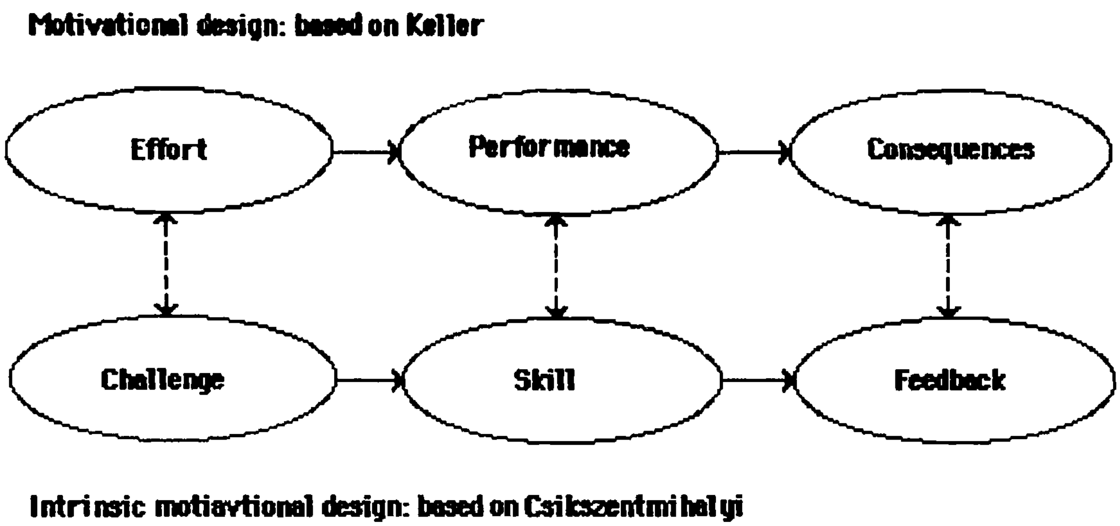

Figure 2: The conceptual fit between Keller's and Csikszentmihalyi's theories, showing intrinsic motivation as a subset of motivation

This synthesis provides a number of advantages to the instructional designer. First, it provides a unified conceptual framework for the motivational design of instruction, which not only takes advantage of the latest research in intrinsic motivation but also fits within our own conceptual frame of reference. Second, it can help clarify the issues in intrinsic motivation by defining the chief parameters and relationships within the theory. Third, as with Keller's theory, it leads to predictions about the relationships between intrinsic motivation, learning, and performance. And finally, it can be used as a basis for developing prescriptions for the design of intrinsic motivation in instruction.

Methodology

As an initial attempt to derive these prescriptions, an extensive literature review was conducted on the topic of intrinsic motivation. This literature review covered a wide variety of authors, operating from a number of theoretical viewpoints. Their recommendations were interpreted from the viewpoint of flow theory, and specific prescriptions were derived which fit into the framework of the theory.

The prescriptions are grouped into three major categories which correspond to the three variables presented in the synthesis: challenges (incorporating goals), means (including skills), and feedback.

Challenge Strategies

The first set of strategies listed under C1: "Challenges/Skills" (see table 1) are based upon Csikszentmihalyi's (1990) identification of the first major element of flow. It is important for the designer/teacher/manager to clearly identify the goals, means, and boundaries of the activity. These provide the "rules of the game" that students will be operating under. It is these very constraints that can be liberating for a learner because they reduce ambiguity and doubt. Once the challenge has been set however, learners should be given the maximum amount of freedom to explore within the boundaries of the activity. The idea is to clearly define goals and final outcomes, but not to micromanage the process for each individual.

The strategies under C2 deal with the need to design challenges that are optimal in nature, that is, activities that are difficult, but achievable by the target group (Reeve, 1992). Since individual differences may vary considerably, challenging activities should be designed with a variety of difficulty levels so that individual learners can enter them at an appropriate level. Furthermore, the activity must contain an element of accelerating difficulty to compensate for the growth in the learner's skills (Csikszentmihalyi,1990). Feedback that is directly linked to performance is another useful element in designing optimal challenges because it allows the learners to systematically judge their progress and fosters an increased sense of competence (Deci & Ryan, 1985).

Table 1: Challenge Strategies

C1. Challenge/Skills

C1.1 Create challenging activities that require the application of of skills.
C1.2 Clearly communicate the goals of the activity, and the rules bounding the activity.
C1.3 Clearly communicate the means to reach the goal by identifying pre-
requisite skills.

C2. Optimal Challenges

C2.1 Create challenging activities that are optimal in nature.
C2.2 Create activities with varying degrees of difficulty.
C2.3 Create activities with accelerating difficulty levels.
C2.4 Utilize clear and informative feedback to communicate performance.

C3. Goal Setting

C3.1 Create goals for the activity which are interesting, challenging, and
clearly
communicated.
C3.2 Create activities that allow for goal setting.
C3.3 Utilize short-term goals for individuals whose initial intrinsic
motivation
is low.
C3.4 Utilize long-term goals for individuals whose initial intrinsic

motivation is high.

Goal setting is the concern of the strategies listed under C3. Within the boundaries of the activity, personal goal setting should be encouraged. However, guidance as to the type of goals should be provided based upon the learner's initial level of intrinsic motivation (Vallerand et al., 1987). Learners with high levels of intrinsic motivation should be encouraged to set their own goals, particularly long term goals; learners with low levels of intrinsic motivation may require a series of short term goals and/or extrinsic rewards.

Means Strategies

The second category of strategies deals with the means of achieving the goals set up by the first set of prescriptions. This category has been broadened from Csikszentmihalyi's emphasis on individual skill development to also include environmental aspects which help create a supportive, informational context (see table 2).

According to cognitive evaluation theory (Deci & Ryan, 1985; Vallerand, et al., 1987) an informational context is necessary to promote intrinsic motivation. The strategies under M1 deal with approaches toward developing an informative learning environment. These strategies are used to encourage the development of individual initiative, because intrinsic motivation depends upon a perception personal control and a sense of achievement (Reeve, 1992; Burger, 1985).

The M2 strategies address environmental parameters that encourage the development of learners' skill levels. These are based upon Csikszentmihalyi's seventh element of flow (1990) along with Gagné's (1965) emphasis on the identification of prerequisite skills and knowledge as the basis for instructional design. Strategy M2.3 relates to those metacognitive skills derived from the principles of flow theory (Csikszentmihalyi,1990).

Table 2: Means Strategies

M1. Informational Context

M1.1 Create an informational, rather than a controlling, context for the activity.
M1.2 Within the parameters of the activity, encourage self-determination by maximizing personal choice on the selection of goals.
M1.3 Support feelings of autonomy and freedom, and encourage a task-orientation by allowing learners to direct their own practice and to meet their own standards of excellence.

M2. Skills

M2.1 Construct activities that allow for the development of skills that reduce the margin of error.
M2.2 Teach and practice all necessary pre-requisite skills.
M2.3 Encourage learners to monitor their own feelings of anxiety, apathy and boredom, and to use these feelings as feedback for adjusting the challenge level of the activity.

Feedback Strategies

The strategies dealing with feedback under section F1 are intended to be general heuristics dealing with the overall feedback function (see table 3). Strategies F1.3 through F1.5 are based upon recommendations made by Vallerand et al. (1987). The recommendation on the use of extrinsic rewards for low initial intrinsic motivation is from Reeve (1992).

Positive verbal feedback, if it is used in a context of self-determination, can enhance perceived competence, while negative feedback often decreases competence if it is perceived in a controlling manner. These recommendations are derived from Deci & Ryan (1985).

The concept of naturally occurring feedback, and the two specific forms of it recommended in strategies F3.2 and F3.3, are again based upon Deci & Ryan (1985).

The prescriptions on both direct and indirect competition are also from Deci & Ryan, (1985). It should be noted that all forms of competition should be used carefully. Direct competition should be used only for extrinsic purposes, if at all, as it tends to have a de-motivating effect on those who persistently lose.

Application

Some instructional strategies which seem to naturally incorporate some of these prescriptions include hypermedia applications, simulations and games, and adaptive instructional systems.

A high level of self-determination and personal choice is a key feature of hypermedia systems, and in terms of intrinsic motivation, it is their strongest characteristic. Of the various types of applications being reviewed, hypermedia provides the greatest amount of choice, however, these systems also require the users to set their own goals and define their own feedback. The only goal inherent in these systems is the search and retrieval of information. Their use in a broader educational context requires that goals be defined either by the teacher or by the learner. The same problem can be seen in relation to the feedback function, which consists largely of answering the question "Did I find the information I was seeking?". However, the exploratory nature of most hypermedia systems allow learners to seek out increasingly difficult levels of material. When used appropriately, these systems can provide a challenge which is optimal in nature.

Table 3: Feedback Strategies

F1. General

F1.1 Feedback should be concrete, immediate, and logically related to the goal.

F1.2 Utilize feedback for informational, rather than controlling purposes.

F1.3 Offer feedback and advice, but don't impose it.

F1.4 Create appropriate pacing of feedback for each individual.

F1.5 Provide a supportive context by de-emphasizing pressure to perform or compete.

F1.6 Utilize extrinsic rewards only if there is low initial intrinsic motivation.

F2. Verbal Feedback

F2.1 Utilize creditable and informative verbal feedback to promote the perception of competence.

F2.2 Avoid negative verbal feedback which can be perceived as a judgement of incompetence.

F3. Naturally Occurring Feedback

F3.1 Design activities that incorporate feedback which is naturally obtained during the process of achieving the goal.

F3.2 Utilize self-evaluation feedback whenever possible.

F3.3 When concentrating on pre-requisite skills, compare performance against a standard.

F4. Competition

F4.1 Utilize indirect competition if it can be perceived as being informational.

F4.2 Avoid the use of direct competition if it is perceived as controlling.

Games and simulation incorporate to a great degree the principles of intrinsic motivation. By their very nature, games and simulations require a clearly defined goal, and the rules for play or operation must be clearly defined. The challenge inherent in a game or simulation can be made optimal by merely changing the variables or the rules to make the activity more difficult as play progresses.

Skill development within the simulation game is provide by practice and strategy development. There is often a high degree of self-determination and personal choice within the boundaries of the activity, with a strong orientation toward the task, that is, the desire to win the game.

Feedback from a simulation game is almost always concrete and immediate, and is always naturally occurring within the context of the activity. There is also a strong element of competition, which can be both direct and indirect in nature. This helps create an atmosphere that is informative in nature, in which performance is evaluated directly in terms of the task.

However, for educational purposes, games and simulations must be integrated into a course with supporting instruction both prior to and after the activity. Standing alone, they may provide entertainment, but they do not ensure the the acquisition of specific knowledge or skill.

Adaptive Instructional Systems hold out much promise in their ability to incorporate the principles of intrinsic motivation into instruction. As can be seen from the research reviewed, intrinsic motivation depends upon a fine balance between clearly defining and structuring the learning activity and allowing the learner a high degree of self-determination and personal choice.

The purpose of an adaptive system is to adapt the style, sequence or content of the instruction to the learners' individual differences. These differences include aptitude, prior knowledge, cognitive styles, and personality characteristics, such as motivation, levels of anxiety, locus of control and risk taking. Research has shown that aptitude, particularly intelligence, and prior knowledge are the two strongest predictors of performance in instruction. Among personality characteristics, motivation is the difference that most affects learning (Jonassen, 1988; Carrier & Jonassen, 1988).

An adaptive system that could accurately adjust the difficulty level of the instruction for a particular learner as they were using it would be able to maintain an optimal level of challenge. The degree of flow experienced by a learner could be maximized in a system which queried the emotional state of a learner during use (i.e. whether a user felt bored, anxious, etc.), or which analyzed and used content-centered responses to gain information about the user's motivational state. This information could then be used by the system as the basis for further adapting the instruction.

Conclusion

It should also be noted that these prescriptions are preliminary and require further research and development. A process of expert review, brainstorming, and refinement of strategies, as recommended by Keller (1987a), should be employed to further extend this model. In addition, the author is currently conducting a research study to gather empirical evidence in support of these prescriptions.

The significance of this approach is that it attempts to begin an investigation into an aspect of education and training which is critical but often neglected. Motivation, it can be argued, is one of the most important factors in education. A highly motivated student will strive to overcome many limitations in order to achieve his or her goals. An unmotivated student, however, will achieve little in even the most resource rich environment. Initial motivation of an individual towards a topic depends upon many personal and psychological factors. However, continued engagement in the topic can depend, to a large extent, on how that activity is structured. Flow theory identifies those structural variables which can be manipulated by an instructional designer to increase the likelihood that a learner will be motivated on an intrinsic level.

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Title:

Design 2000: Theory-Based Design Models of the Future

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Instructional design was born in the twentieth century, emerging from the theoretical roots of other disciplines. The foundations of macro-design processes are in general systems theory and are apparent in the instructional systems design (ISD) models, as exemplified by the Dick and Carey (1990) model. The micro-design strategies are based primarily upon learning and instructional theory as exemplified by Gagne's Events of Instruction. Designers use both macro- and micro-models[1] to provide direction for their work and, as Duffy and Jonassen (1991) have noted, design endeavors are always theory-dependent even though the designers may not be explicitly aware of the application. The task of this paper is not to describe theory changes in the field, but rather to anticipate the nature of the influence theory will have upon the design models of the twenty-first century, based upon the emerging theoretical developments of today.

Efforts will be made to distinguish between model enhancements which are generated primarily from new theory and research, as opposed to model enhancements which are the product of changing practitioner traditions, such as those prompted by emerging constraints in the workplace, or the impact of the new technologies. Admittedly, this demarcation is not always clear since practice and theory are often interrelated, and ISD models themselves are typically a result of the combination of abstract theoretical principles and analyses of practitioner experience. At times, this blurring of theoretical and practical innovations is evidenced by emerging models which seems to represent the impact of new *thinking*, rather than actual theory.

The anticipated model changes discussed in this paper are the result of the disparate theoretical thinking in areas such as chaos theory, constructivism, situated learning, cognitive learning theory and general systems theory. In addition, examples of new ideas which bridge theory and practice will also be addressed. Such topics include designer decision making research, performance technology, and the quality movement.

<u>ISD Models of the Year 2000</u>

In spite of the criticism in some quarters of traditional ISD models (see Richey, 1993 for a review of such criticism), it is difficult to imagine that they will not continue to be a driving force among practitioners in the next decade. It is likely, however, that they will change. These trends appear to be directed generally toward altering the traditional linearity of the design process, and specifically toward the expansion of front-end analyses, and the formative and summative evaluation procedures. The fact that these aspects of the design process are topics of discussion is not unusual; the nature of the discussion is unusual, because of the current efforts to reduce design cycle time to accommodate time and money constraints (Dick, 1993a; Gustafson, 1993). Needs assessment and evaluation procedures are typically the first design elements to be sacrificed by practitioners, and the linear structure facilitates the use of rapid prototyping and other techniques used to reduce cycle time. Nonetheless, these are the areas impacted most by current theoretical trends.

<u>Nonlinear Design Models of the Future.</u> While most current ISD models are not explicitly constructed for use only in a linear fashion, it is nonetheless the typical pattern of use. Criticism of this practice is becoming more widespread, and it is sustained by the

[1] In some parts of the literature the terms "macro-design" and "micro-design" refer to the size of the instructional unit, with macro referring to program or curriculum design and micro referring to lessons or modules. This is *not* the orientation here: rather I am distinguishing between overall design and development processes, and strategy selection and sequencing.

growing interest in chaos theory, cognitive advancements, and a new look at general systems theory. Quite briefly, chaos theory posits the existence of order within apparently chaotic or seemingly random systems (You, 1993). Chaos theory, especially when examined in detail, can have great implications for instructional design. You (1993) discusses the notion of linearity within the ISD process and the support chaos theory gives to changing from linear to nonlinear design models. He asserts that *non*linear ISD models:

> assume a more holistic orientation, rather than one of mutual causality;
> are able to better accommodate those factors in a given situation which can interfere with the prescribed design processes; and
> reflect the dynamic and unpredictable aspects of the learning process.

Due to this nonlinear process, the while (i.e. the final instructional product) becomes more than the sum of its parts. This position stems from a view of current linear models as reductionist in nature, implying a cause and effect relationship between the various stages in the ISD process. In other words, the output of one phase becomes the input of the next.

Support for nonlinear design models also is appearing from traditional sources of design theory -- from cognitive psychology and general systems theory. Tennyson (in press) sees emerging design models (ISD^4, or fourth generation instructional design) as a reflection of the cognitive science movement. Specifically, this new form of ISD is "a dynamic, problem solving approach...controlled by contextual or situational problem solving evaluations" (p. 10). This new ISD is a flexible, dynamic process with its various component activities "connected by context rather than by predefined ID processes" (p. 11). The activity domains (analysis, design, production, implementation, and maintenance) are based upon a situational evaluation. The domains are viewed as overlapping activities, activities which can be continually adjusted as new conditions arise.

The notion of instructional design as an activity with many component processes which are completed in an iterative, overlapping, or even concurrent fashion is not inconsistent with the original presentations of general systems theory. Systems were viewed as existing within and interacting with an environment. Systems were viewed as a whole. Systems were viewed as dynamic. Currently, these attributes are being reexamined in terms of *systemic* design, as opposed to *systematic* design. The use of the word "systematic" implies using specified design procedures, while the word "systemic" implies concurrent consideration of the many aspects of a situation which can affect the learning process (Richey, 1992). There is more emphasis on design as creative problem solving (Romiszowski, 1981), flexibility, and adaptability in systemic design. Not only does the systemic approach imply the consideration of a wider range of variables in the design process, it also implies the use of a nonlinear orientation. It prevents the use of piecemeal solutions to education and training problems.

<u>The Role of Analysis in Design Models of the Future.</u> The role and importance of instructional context has been expanding, bolstered not only by the theoretical emphasis on environment in systems theory, but also by the current impact of constructivism, cognitive psychology, and performance technology. While such theory also is influencing the development of particular analysis techniques (such as cognitive task analysis), the emphasis here is upon anticipated changes in the ISD models themselves, especially with respect to the various forms of front-end analysis.

Seels (1989) indicates that the "constructivist paradigm states that learning occurs because personal knowledge is constructed by an active and self-regulated learner who resolves conflicts between ideas and reflects on theoretical explanations" (p. 13). Constructivism further holds that meaning is based upon experience and the context in which that experience takes place (Duffy and Jonassen, 1991). The constructivist influence is permeating much thinking on instructional design, and is part of the growing emphasis on the importance of learner characteristics in the design task. Rather than concentrating primarily upon the learner's prerequisite skills, learner's experiential background, attitudes, and interests are also being addressed. Such considerations become one feature of the newer, expanded needs assessment orientation.

In addition to this broader consideration of learner characteristics, new pre-design analysis procedures are also breaking away from the old almost total emphasis on subject matter by addressing the nature of the environment as well. For example, Tessmer and Harris (1992) proposed an analysis which addressed the learning environment and the support environment. Richey (1992) has demonstrated the critical role of not only a variety of learner characteristics, but the learner's perceptions of the organizational climate in training design. Richey and Tessmer (in press) have now merged these two approaches in a comprehensive model of contextual analysis which includes consideration of three temporal environments in the front-end analyses: pre-instructional, instructional, and post-instructional. Each environment is analyzed to determine the essential physical and psycho-social factors from the immediate and surrounding environment that influence learning and transfer of training.

Contextual analysis is also prompted by the increasingly wide-spread influence of performance technology. Here, the orientation is toward solving organizational performance problems, with education and training seen as only one possible solution. The characteristics of the environment are critical during the front-end analysis which is viewed more of a problem analysis directed toward the larger organizational setting, as opposed to a needs assessment directed primarily toward learner knowledge and skill deficiencies.

The Role of Evaluation in the Design Models of the Future. Interestingly, most current ISD models do not include a comprehensive notion of evaluation. The majority of models reviewed by Andrews and Goodson (1991) addressed only formative evaluation of products and programs and needs assessment, but did not specifically include a summative evaluation phase. Notable exceptions are the design models of Dick and Carey (1990) and Seels and Glasgow (1990). It is anticipated that not only will the models of the twenty-first century address both formative and summative evaluation, but that the nature of such evaluation will be expanded from what typically occurs today. These new approaches will occur to some extent by those concerns with context that are now beginning to impact the analysis stage of design.

These context considerations have been generated by the conceptual influence of both performance technology and the total quality management (TQM) movements. Essentially, both movements are concerned with the corporate "bottom line" and satisfying the requirements of the customer, and such emphases negate traditional assessment and evaluation procedures which are limited to examining short-term learner outcomes. Instead, they stress what Kirkpatrick (1983) has previously labeled as Level 3 and 4 evaluations. Here assessments are made of the application of knowledge and skills and upon subsequent organizational impact, rather than learner reactions to instruction and knowledge acquisition. Level 3 and Level 4 summative evaluations are likely to be demanded, especially in the workplace, but it is not unlikely that school environments will also require such data. Moreover, it is being suggested that designers also use Level 3 and Level 4 techniques when conducting formative evaluations as well as summative (Dick and King, in press).

The concerns with retention and transfer of training also are evident in the addition of confirmative evaluation processes to a typical ISD model as has been suggested by Hellebrandt and Russell (1993). The object of this endeavor is to determine the continuing competence of learners or the continuing effectiveness of instructional materials. Not unrelated to Level 3 evaluation, confirmative evaluation complements the thrusts of situated cognition and anchored learning which address the importance of embedding learning activities in realistic contexts as a means of promoting transfer of training (Streibel, 1991).

Micro-Design Models of the Year 2000

In addition to those enhancements of the typical macro-design model, micro-models which guide the selection and sequencing of instructional strategies are also likely to change in the twenty-first century. Two key micro-model issues which have been stimulated by emerging theoretical developments will be discussed here -- the nature of learner control, and the transfer of training.

The Nature of Learner Control in Design Models of the Future. At the heart of constructivism is the issue of learner control. The true constructivist believes that meaning and reality are functions of individual interpretation (Jonassen, 1991; Lebow, 1993). An extension of this orientation to instructional design then implies that:

instructional goals and objectives would be negotiated rather than imposed upon the learner;
sequences of learning activities would be flexible rather than prescribed;
learning strategies would not be dictated by the design; and
evaluation would be less criterion-referenced (Jonassen, 1991).

Aspects of this orientation are not entirely unrelated to the conclusions of both cognitive-based designers (Wilson and Cole, 1991), as well as to some who have struggled to develop instruction using the full capabilities of the new technologies. For example, Hannafin (1992) speaks of the possibilities the interactive technologies offer for student-centered learning. In these situations, the designs "focused on supporting student-initiated lesson navigation, providing an organizing theme or context for lesson activities, and embedding aids and support in the form of help, elaboration, and other resources that can be selected by the student to improve understanding" (Hannafin, 1992, p. 54).

Such environments are far less structured than is typical of those designed using systematic procedures on both a macro- and micro-level. While this is compatible with the newer technology-based instruction, such as a hypertext lesson, it is not nearly so compatible with environments demanding accountability. For example, the TQM movement is predicated upon organizational objectives (i.e. a vision or mission statement), policies, and procedures that specify the manner in which the objectives will be achieved (Caplan, 1993). Likewise, performance technology relies upon a high degree of structure to meet, evaluate, and report the impact of instruction upon the solution of organizational problems. Such orientations are not alien to many instructional designers who adhere to traditional systems thinking (Dick, 1993b), but they do not seem to facilitate the types of learning environments proposed by Hannafin, Jonassen, or Lebow.

This philosophical dichotomy transcends other aspects of micro-design. Another key example is that of message design. Berry (in press) describes the radical shifts in future message design, stimulated by learner centered design and situated cognition, in which instructional environments will facilitate learners as they explore areas of knowledge and develop their own versions of that knowledge. "The development of such systems is predicated on a shift from design of 'stimulus messages' to interface design" (Berry, in press, p. 8). This is a radical departure for traditional message design, and the dimensions of such change are compounded by the implications of the new technologies, technologies that not only provide for nearly full fidelity and a wider array of formats, but also for the design of message environments and experiences.

Transfer of Training Strategies in Design Models of the Future. Transfer of training is critical in most education and training environments, and to many, serves as a criterion for effective instruction. Consequently, it serves as a logical focus of analyses of strategy selection and sequencing. Current transfer discussions have emerged to a great extent from an examination of situated learning and its applications in instructional design. The issue centers on the relative effectiveness of using either situated, authentic tasks or generalized principles in instruction as a means of promoting transfer. Winn (1993) argues that traditional instructional design (ID) and situated learning (SL) are compatible if compromises are made:

> For ID this means primarily re-integrating design with instructional delivery so that the interaction between student and instruction becomes more adaptive to situations that vary from one problem to the next. It also means the development of learning environments in which students construct knowledge for themselves. For their part, proponents of SL need to develop effective ways for bringing authentic activity into the classr... , or for better articulating school-based and community-based activity (p. ..).

These compromises highlight the instructional strategy changes that are suggested by situated learning, changes which alter the common use of generic prescriptions. While these changes are not inconsistent with the recommendations which have been made in other quarters with respect to learner control, they are not uniformly accepted. Tripp (1993), for example, continues to question the ability of "situated" instructional activities to promote transfer. For example, while supporting the importance of showing the relevance of content, he cites the barriers created for many learners by the complexities of the "real world" when they are introduced into instruction.

Other lines of current thinking also provide direction for promoting transfer. The emphasis upon contextual variables in constructivism and performance technology also speaks to transfer of training. Richey and Tessmer's (in press) contextual analysis model speaks to environmental cues and incentives which impact transfer, as well as opportunities for content use and application in diverse settings. Such data suggests modifications in both learning activities and supporting instructional management systems.

<u>Summary</u>

The stimulation currently provided by the rich intellectual activity in the realm of instructional design is creating the likelihood of change, not only in the generic procedural models traditionally used to guide ISD projects, but also in the types of the strategies used to achieve learning goals. Some of these changes are obvious now; others will become more common as we approach the new century. As the design generations evolve, it is possible that the high degree of procedural unanimity the field has previously enjoyed may be replaced by more diversity. For example, there may be macro-design models which do not advocate the specification of goals and objectives. There may be micro-design models which do not advocate sequencing using the traditional hierarchical approach based upon Gagne's Cumulative Learning Theory. This diversity, while admittedly unsettling to many of us, is also exciting, and offers a promise of not only new models, but new challenges to practitioners and researchers alike.

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Title:

Developmental Research: The Definition and Scope

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Developmental Research: The Definition and Scope[1]

The field of Instructional Technology has traditionally involved a unique blend of theory and practice. This blend is most obvious in developmental research which involves the production of knowledge based upon situation-specific problem solving. Developmental *research*, as opposed to simple instructional development, has been defined as "the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness" (Seels and Richey, in press). In its simplest form, developmental research could be either:

> a situation in which someone is *performing* instructional design, development, or evaluation activities and *studying* the process at the same time; **or**
>
> the study of the impact of someone else's instructional design and development efforts; **or**
>
> the study of the instructional design, development, and evaluation process as a whole, or of particular process components.

In each case the distinction is made between performing a process and studying that process. Reports of developmental research may take the form of a case study, an evaluation report, a retrospective analysis, or even that of a typical experimental research report. Today, even amid the calls for increased use of alternative research methodologies, the notion of instructional development as a research methodology is unclear, not only to the broader community of educational researchers, but to many Instructional Technology researchers as well.

The Background of Developmental Research

The field of Instructional Technology as it exists today emerged from a convergence of the fields of audiovisual education and instructional psychology. In audiovisual education the emphasis was upon the role of media as an enhancement of the teaching/learning process and an aid in the communication process, and there was much interest in materials production. On the other hand, in instructional psychology the nature of the learner and the learning process took precedence over the nature of the delivery methodology, and there was much interest in instructional design. Complementing the instructional psychology roots was the application of systems theory to instruction which resulted in the instructional systems design movement (Seels and Richey, in press). This conceptual and professional merger came to fruition in the 1960's and 1970's. During this period instructional design and development came to assume the role of the "linking science" that John Dewey had called for at the turn of the century (Reigeluth, 1983).

Not surprisingly, it was during this same period that development emerged as a research endeavor. This change was exemplified by the shift in topics between the First and

[1]This paper is excerpted from "Developmental Research" a chapter by Rita Richey, Philip Doughty, and Wayne Nelson which will be published in the forthcoming Handbook of Research on Educational Communications and Technology edited by David H. Jonassen.

Second Handbooks of Research on Teaching (Gage, 1963; Travers, 1973). In the 1963 handbook, media was addressed as an area of research, and all research methodologies considered were quantitative. In the 1973 handbook, media continued to be included as a research area, but the research methodologies were varied, including Eva Baker's chapter on "The Technology of Instructional Development". This chapter describes in detail the process of systematic product design, development, and evaluation. Of significance is the fact that the entire methodology section was titled "Methods and Techniques of Research *and Development*".

This was a period in which federal support of educational research mushroomed. Regional research and development laboratories were established and the ERIC system was devised for dissemination. Clifford (1973) estimated that appropriations for educational "research and development for 1966 through 1968 alone equaled three-fourths of all funds ever made available" (p. 1). Research-based product and program development had become firmly established as part of the scientific movement in education. At this time, Wittrock (1967) hailed the use of empirical measurement and experimentation to explain product effectiveness. Such activities "could change the development of products into research with empirical results and theory generalizable to new problems" (p. 148).

Hilgard (1964) characterized research as a continuum from basic research on topics not directly relevant to learning through the advocacy and adoption stages of technological development. Saettler (1990) maintained that the last three of Hilgard's research categories were directly within the domain of Instructional Technology. These included laboratory, classroom and special teacher research; tryout in "normal" classrooms; and advocacy and adoption. Note that these are portrayed as types of research, rather than applications of research, and they are all encompassed within the framework of developmental research.

While Instructional Technology is not the only field concerned with learning in applied settings, few would dispute the critical role played by these three types of research in our field. Moreover, our uniqueness among educational fields is not only our concern with technology, but rather our emphasis upon the design, development, and use of processes and resources for learning (Seels and Richey, in press). Given this definition of the field, developmental research is critically important to the evolution of the field's theory base.

The Character of Developmental Research

The distinctions between "doing" and "studying" design and development provide further clarification of development as a research activity. These distinctions can be described in terms of examining the focus, techniques, and tools of developmental research.

The Focus of Developmental Research. The general purposes of research have been described as knowledge production, understanding and prediction. Within this framework, developmental research has particular emphases which vary in terms of the extent to which the conclusions are generalizable or contextually-specific. Figure 1 portrays the relationships among the various types of developmental research.

The most common developmental research projects fall into the first category of Figure 1. This category typically involves situations in which the product development process is analyzed, described, and the final product is evaluated, such as Buch's (1987) documentation of the development of an industrial microcomputer training program. Driscoll (1991) called this research paradigm systems-based evaluation. Some Type 1 developmental studies reflect traditional evaluation orientations in which the development process is not addressed, and only the product or program evaluation is described. An example of this type of study is O'Quin, Kinsey, and Beery's (1987) report of the evaluation of a micro-computer training workshop for college personnel. Regardless of the nature of the Type 1 study, the results are typically context and product specific, even though the implications for similar situations may be discussed.

FIGURE 1
A Summary of the Types of Developmental Research

DEVELOPMENTAL RESEARCH		
Type 1	**Type 2**	**Type 3**
Description or Analysis of Product or Program Design, Development & Evaluation	Description or Analysis of Product or Program Utilization & Impact Evaluation	Study or Improvement of the Design, Development & Evaluation Process or Components.
(Study of Specific Products or Contexts)	(Study of Extended Impact of Product or Program on Organization Change &/or Learner Growth)	(Design, Development, & Evaluation Procedural Model Development)
Context-Specific Conclusions		**Generalized Conclusions**

The focus of Type 2 developmental research is not so much upon the development of products, but more upon the impact of that product upon the learner or the **Figure 1** organization. Using Kirkpatrick's (1983) categories of evaluation outcomes, these studies typically do not address only participant satisfaction or evidence of learning, but tend to consider behavior or skill application and organizational impact. They address product or program effectiveness on a broader scale, such as Smith's (1993) comprehensive study of five years of executive development. Type 2 studies may employ confirmative evaluation procedures. This typically involves an evaluation as a part of a summative study and is designed to determine the continuing competence of learners or the continuing effectiveness of instructional materials (Hellebrandt and Russell, 1993). Type 2 studies also attend to program implementation and maintenance issues. One example, of this latter focus is the case study of cost-effectiveness evaluation described by Klein and Doughty (1980). Their conclusions, as is typical of a Level 2 study, are context-specific, but they also suggest general principles for cost-effectiveness evaluation procedures which can be used in a variety of design and development projects. In this respect, the study approaches the purposes of a

Type 3 developmental research project.

The third type of study is oriented toward a general analysis of either design development or evaluation processes as a whole or any particular component. They are similar to those studies Driscoll (1991) calls model development and technique development research. While there are fewer studies that focus on the more global orientation, Taylor and Ellis's (1991) study did so by evaluating the use of instructional systems design in the Navy and Kress (1987) did so by comparing the impact of systematically designed training with a non-systematic approach. Other studies in this category focus upon only one phase of the design/development/evaluation process, such as Jonassen's (1988) case study of using needs assessment data in the development of a university program. Type 3 research may draw its population from either one target project such as King and Dille's (1993) study of the application of quality concepts in the systematic design of instruction at the Motorola Training and Education Center, or from a variety of design and development environments. Examples of the latter approach include Riplinger's (1985) survey of current task analysis procedures, and Cambre's (1978) historical study of formative evaluation in instructional film and television. Typically, conclusions from Type 3 developmental research are generalized, even though there are instances of context specific conclusions in the literature.

Non-developmental Research in the Field. A critical aspect of any concept definition is the identification of non-examples as well as examples. This is especially important with respect to developmental research since it often seems to overlap with other key methodologies used in the field. Even so, developmental research does *not* encompass studies such as the following:

instructional psychology studies;
media or delivery system comparison or impact studies;
message design and communication studies;
policy analysis or formation studies; and
research on the profession.

While results from research in these areas impact the development process, the study of these variables does not constitute developmental research. For example, design and development is dependent upon what we know about the learning process. We have learned from the research literature that transfer of training is impacted by motivation, organizational climate, and previous educational experiences. Therefore, one may expand a front-end analysis to address such issues, or even construct design models which reflect this information, but the foundational research would not be considered developmental. If the new models were tested, or programs evaluated which were designed using such models, this research would qualify as developmental.

A fundamental distinction should be made between reports of actual developmental research, and descriptions of design and development procedural models. While these models may represent a synthesis of the research, they do not constitute research in themselves. A good example of this latter situation is Park and Hannafin's (1993) guidelines for designing interactive multimedia. These guidelines are generalized principles which speak to the development process, and they are based upon a large body of research. Nonetheless, the identification and explanation of the guidelines is not in itself an example of developmental research. The Instructional Technology literature includes many examples of such work. They often provide the stimulus for a line of new research, even though these articles themselves are not considered to be research reports themselves. There are many examples today of such work, including explorations of topics such as cognitive task analysis (Ryder and Redding, 1993), or the nature of design and designer decision making (Rowland, 1993).

The Techniques and Tools of Developmental Research. Developmental researchers employ a variety of research methodologies, applying any tool which meets their requirements. Summative evaluation studies often employ classical experimental designs. Needs assessments may incorporate qualitative approaches. Process studies may adopt descriptive survey methods. Even historical research methods may be used in developmental projects.

Traditional research tools and traditional design tools facilitate the developmental endeavor. Expertise is often required in statistical analysis, measurement theory, and methods of establishing internal and external validity. Likewise, the developmental researcher (even those studying previously designed instruction) requires a command of design techniques and theory. Additional design proficiency is frequently required when using electronic design systems and aids, conducting environmental analyses, and defining ways to decrease design cycle time.

A developmental research project may include several distinct stages, each of which involves reporting and analyzing a data set. Merely conducting a comprehensive design and development project does not constitute conducting a developmental research project even using its most narrow Type 1 definition. One must also include the analysis and reporting stage to warrant being classified as developmental research.

Developmental research projects may include a number of component parts. Sub-studies may be conducted to analyze and define the instructional problem, to specify the content, or to determine instrument reliability and validity. Sub-studies may be conducted to provide a formative evaluation, a summative evaluation, or a follow-up of post-instruction performance. Consequently, reports of developmental research are frequently quite long, often prohibiting publication of the full study.

Reports of developmental projects can often be found in:

- professional journals;
- doctoral dissertations;
- Educational Resource Information Center (ERIC) collections of unpublished project reports; and
- conference proceedings.

The nature of the reports vary depending upon the dissemination vehicle. Sometimes, full developmental projects are split into more easily publishable units (or even summarized) to facilitate publication in the traditional research journals. Developmental research reports are also published in practitioner-oriented journals and magazines, and the methodology and theoretical base of the studies is omitted to conform to the traditions of those periodicals.

Conclusion

Developmental research, even though frequently misunderstood, has contributed much to the development of the field as a whole. It often serves as a vehicle for dissemination of model techniques and processes, especially as new technologies, new procedural changes, new programmatic trends emerge. Moreover, developmental research can provide a basis for both model construction and theorizing, one which is rooted in the experiences of practitioners as well as researchers.

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Title:

Using Interactive Software To Develop Students' Problem-Solving Skills: Evaluation of the *Intelligent Physics Tutor*

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Abstract
The present study was a formative evaluation of the *The Intelligent Physics Tutor*, an interactive software program designed to improve physics students' problem-solving skills. Multiple data sources used in the evaluation included teacher experiences and attitudes; and student attitudes, achievement, and problem-solving strategies. Findings from a semester-long tryout in a high school physics class indicated that both the teacher and the students were very positive about the *Tutor*'s instructional benefits. The most favorable reactions were by lower-ability students who had trouble solving problems on their own. While there were no differences in achievement between the *Tutor* class and two control classes, *Tutor* students demonstrated relatively greater use of systematic problem-solving strategies over time.

Introduction

As orientations in instructional theory and practice continue to evolve from their behavioral roots, cognitive and "constructivist" viewpoints have had increasing influence on the design of computer-based instruction (CBI) (Bednar, Cunningham, Duffy, & Perry, 1991; Di Vesta & Rieber, 1987). Such viewpoints emphasize the processes by which students learn higher-order skills and the attitudes and interests they develop through their experiences The marriage today of cognitive perspectives with interactive, automated delivery systems orients today's designers toward considering how learner needs and mental models can be diagnosed on task and instruction adapted accordingly. The present project, involving the design and evaluation of an intelligent tutoring system for high school physics, was grounded on this orientation.

The Intelligent Physics Tutor Project

The Intelligent Physics Tutor project (Loftin, 1990), was sponsored by NASA/Johnson Space Center and Apple Classrooms of Tomorrow. Its purpose is to create an interactive environment, using the architecture of an intelligent tutoring system, in which physics students can practice problem-solving applications while receiving individualized guidance and feedback. Consequently, as students work on the Tutor in class, the teacher is freed to give special attention to individuals who need it. The *Tutor* operates on an Apple Macintosh II computer and makes use of high resolution graphics and sound.

The basic instructional model is designed to diagnose students' misconceptions while they solve problems. The identified misconceptions then form the basis for determining the immediate feedback provided on the current problem and for selecting additional problems to be worked. The analysis takes place via a "local strategy" that records every response (as "student action codes") that the student makes in solving the problem. Using the work space, an available calculator, the keyboard, and given variables and equations that can be selected for the problem solution, the student attempts to work the problem. At each step, a comparison is made between the student's action and the correct or expected action. If a discrepancy is indicated, the most likely misconception for that problem is diagnosed on the basis of the error response and the cumulative action codes. Appropriate feedback, as outlined below, is then provided.

Students receive on-task feedback messages only when an error is detected; otherwise they are allowed to proceed without interruption. An example of an error feedback display is shown in Figure 1. The instructor pictured is Dr. Bowen Loftin, the *Tutor* developer; individual teachers can scan their own pictures into the program to personalize this feedback.

The error messages provided are geared to the specific misconception diagnosed and become increasingly specific as errors reflecting that misconception accumulate. Importantly, by correcting the error at the time it is made, the system prevents the learner from proceeding down an incorrect pathway (and thus losing time and experiencing frustration). Based on the cumulative frequencies of misconceptions recorded for the individual across completed problems, the *Tutor's* "global model" then selects a new problem that requires practicing skills directly related to the diagnosed areas of weaknesses (i.e., the specific misconceptions having the highest frequencies of occurrences).

Additional feedback systems provide summaries and analyses of performances for both classes (see Figure 2) and individuals (see Figure 3). The basic feedback display shows the misconceptions currently diagnosed while suggesting a prescription of how many related exercises (or problems) should be given for strengthening the problem-solving skills for a given misconception. Parallel feedback for the class as a whole provides useful guidance for whole-group followup instruction.

Evaluation Objectives

The purposes of the present evaluation were threefold. One was to describe how the *Tutor* was being used in the pilot high school class. This information was considered important for (a) identifying possible strategies for integrating the *Tutor* with conventional instructional methods, and (b) understanding the application context in which results occurred. A second purpose was to determine student and teacher reactions to the *Tutor* with regard to weaknesses, strengths, and suggestions for improvement. Based on this information, more confident decisions can be made about needs for "fine-tuning" the user interface and program content. A third purpose was to examine possible impacts of using the *Tutor* on problem-solving strategy and performance. This interest included both the *processes* (how a problem was solved) and *products* (accuracy of solutions) of problem-solving activities.

In interpreting the results, readers should be aware of several limitations of the present evaluation context. First, the population tested consisted of honors physics students attending a middle-class suburban high school. These students were more capable and experienced problem solvers than are typical, beginning physics students at most schools in the United States. Second, as will be described below, the inability to randomly assign students to "treatment" and control classes necessitated the use of a "quasi-experimental" design, i.e., comparison of pre-existing classes. Third, only one teacher was involved, thus confounding *Tutor* outcomes with her personality, orientation, and style. Given that these factors, the present evaluation was designed to be primarily "formative" in nature, in the sense of identifying how the Tutor operates and its "likely" effects. A summative evaluation (testing its "effectiveness") would be the next logical step in the research and development process.

Evaluation Methodology

Participants and Design

A quasi-experimental design consisting of three intact classes of students was employed. All were honors physics classes taught by Ms. Beverly Lee at Clear Creek High School. Unfortunately, due to chance factors, the three classes differed somewhat in size and in ability. It was therefore decided to provide a strong rather than weak test of the *Physics Tutor* though the selection of the lowest-ability (and second largest) class as the PT group. This class was taught sixth period and consisted of 19 students. The PT group worked problems on the Tutor following regular instruction in four course units (one-dimensional motion, two-dimensional motion, one-dimensional dynamics, and dynamics). In most instances, students worked on Tutor problems initially in pairs and later independently. The rationale for this procedure was both practical, to increase practice opportunities on the available computers; and pedagogical, to give students the opportunity to help each other during the beginning stages of problem-solving.

The "conventional problems" control group (n = 13) was established in the first period class, which was the smallest in size and the highest in ability. This group received conventional textbook and teacher-made problems on the selected units.

The second-period class consisted of 25 students. It received print versions of the same *Physics Tutor* problems administered to the PT group and, like the PT group, worked on the problems initially in pairs and later independently. However, these students were not afforded the advantages of immediate feedback, diagnosis, and adaptive problem selection available to the PT group. This group will be referred to as the "no-feedback" group. Both this group and the control group had limited computer activity through their work with a simulation program early in the year. Neither group had any exposure to the *Tutor*.

Demographic and pre-course achievement data were available for describing and comparing the three classes on (a) the mathematics subtest of the Stanford Achievement Test taken the previous spring, (b) a knowledge pretest administered in the physics class at the beginning of the year, and (c) the highest-level mathematics course completed. Inferential statistical analysis (one-way analysis of variance) was used for comparing classes on these pre-course variables. Although the PT and no-feedback class scored directionally lower than the control class on the two tests, no significant differences were indicated.

Instrumentation

Two times during the year (September and November), a reaction survey was administered to students in class. Part 1 of the survey, which was administered to all three classes, consisted of six questions dealing with feelings about physics and problem solving. Examples are "I like learning physics" and "I feel confident about my ability to solve physics problems." Responses were made on a five-point Likert scale, ranging from "strongly disagree" to "strongly agree."

Two additional sections of the survey were administered to PT students only. Part II contained six ratings items dealing specifically with experiences in using the *Tutor;* e.g., "The procedures for using the *Tutor* were easy to follow" and "I prefer the *Tutor* problems to doing textbook problems." Part III consisted of two open-ended questions asking what was liked best and least about using the *Tutor* for the current lesson.

An overall survey was administered to the PT class in February, several weeks after they had completed their last Tutor exercises. This survey consisted of 24 ratings items dealing with specific features of the Tutor (e.g., understandability, operation of the mouse and calculator, problem selection, graphics).

In addition to the survey, approximately five randomly selected students from each of the classes were interviewed in September and November. For the two control groups, the interview consisted of four questions concerning attitudes toward physics as a subject, solving physics problems, and their physics course. Students in the PT group were asked those questions along with five additional questions concerning experiences in using the *Tutor*: activities, likes and dislikes, impact on problem solving, and suggestions for improvement.

During the fall semester, the teacher kept a journal in which she recorded her impressions and activities in using the Tutor in the sixth-period class. Information about the curriculum, instructional objectives, and student characteristics was also given.

Students' semester test results, as scored by the teacher, were recorded for analysis purposes. The specific tests were 1st six-weeks test, 2nd six-weeks test, 3rd six-weeks test, semester exam, and final average. The scores analyzed were total scores (0-100%) without any breakdowns for subsections or specific problems. Also, to explore whether students in the three classes differed in their approaches to physics problem solving, a scheme was devised by the class teacher (Beverly Lee) and the Tutor developer (B. Loftin) for evaluating how individual problems were set up and worked. The system involved identifying specific steps or features of a correct, systematic problem-solving procedure for the particular problem types administered (e.g., statement of correct formula, identification of variables, etc.). Discussion and informal tryout of an initial model led to the development of the final scheme consisting of 25 features (e.g., initial position, velocity, final position, etc.). Two physics teachers from local high schools, who were trained to use the scheme, demonstrated a very high rate of agreement (Overall $M = 94\%$) in their scoring.

The same two judges evaluated 28 problems that were selected from different tests on the basis of having varied degrees of structural similarity with actual *Tutor* problems. Specifically, some were exact repetitions of Tutor problems, and some were similar to Tutor problems but contained different contexts. Analyses examined results on individual problems and on clusters of problems representing similar problem types (e.g., one-dimensional kinematics, two-dimensional dynamics, etc.).

Results

Student Surveys

Results on the student surveys showed generally positive and consistent reactions toward physics as a subject and the physics class. No significant differences between classes were found on any of the items. The strongest trend for class variations was indicated on Item 2-Round 2, "Confident in ability." Total agreement ("agree" + "strongly agree") on that item was highest for the PT group (94%) compared to the no-feedback (84%) and control (64%) group. Also noteworthy was that the PT and no-feedback classes became somewhat more negative across rounds about working with a partner (from 6% and 4% disagreement, respectively, to 20% and 11% disagreement). In general, the PT group was somewhat more negative toward physics and problem-solving during Round 1 than were the two control classes, but was comparable to the controls by Round 2.

Reactions by the PT group to the Tutor were highly positive on both rounds. In fact, the highest percentage of students expressing disagreement on any item was only 18% which occurred on Round 1 in reacting to "able to work problems" and "prefer *Tutor* to homework." In Round 2 the highest level of disagreement was 13%, on "procedures were easy to follow." In reacting to the statement, "Overall, I liked using the *Tutor*," 92% of the students agreed (only 1 disagreed). Specific features that received the highest percentage of agreement responses were "helped to accurately read problem" (92%), "helped me learn to set up problems" (85%), "liked Yabba Dabba Doo sound" (85%), "initial instructions were sufficient" (84%), and "makes physics fun" (83%).
On the other hand, only 53% percent found the calculator "easy to use," 48% agreed that "feedback helps to identify mistakes, "16% thought the "help button offers useful assistance," and 62% agreed that the "screen design tends to clutter as I work." These less positive reactions seem at least partly attributable to students' lack of familiarity with the software. In any case, they indicate relatively mild degrees of dissatisfaction and are clearly outweighed by the clearly positive reactions on nearly all items.

Student Interview

Student interview responses supported the survey findings by showing generally positive attitudes toward the physics course and considerable liking of the Tutor. When asked what they liked best about the Tutor, students most frequently mentioned the immediate feedback. Other responses given by more than one student were "easier to work with formulas," "gives step-by-step instruction, and the "picture helps to understand the problem." Least liked features identified by more than one student were "too slow," "too many windows, "and "calculator is hard to use."

The last question was whether the *Tutor* helped them to become better problem solvers. Nearly all students strongly agreed. Among the reasons given were demonstrations of the problem, review, and immediate feedback. There was a clear difference between higher- and lower-achievers in the reactions expressed. Students who felt comfortable about their problem-solving abilities felt that the Tutor was useful for initial learning and practice, but slowed them down once they gained proficiency. Specifically, they didn't feel that they needed to work through all the steps that the *Tutor* required. They understood those steps well enough to skip them. As "expert" problem solvers, they were at the stage where they relied on heuristics (general strategies) and did not need step-by-step procedures.

Contrasting views were expressed by four students who described themselves as "struggling" due to weaknesses in mathematics background. They felt that the Tutor was extremely helpful at all stages of the learning process. The main advantage was guiding them through systematic problem-solving procedures, while not allowing them to proceed down an incorrect pathway. Because of these features, they felt that their approaches to problem-solving were changing. Specifically, they were more confident, more reflective and systematic, and less concerned about mathematics than about procedures. All felt that they were able to transfer these new approaches to problem-solving to textbook and examination problems.

Teacher Journal and Interview Reactions

The main advantage of the Tutor, in the teacher's view, was helping students to become more systematic problem solvers by writing down correct formulas and input variables before attempting solutions. For example, on October 21, the teacher wrote:

> One student had not identified the initial horizontal velocity (same magnitude). The program would not allow him to begin working with a formula until he had identified that piece of information, since it would be needed later...The [error] messages he had received all referred to the concept of velocity...Once he had identified that value [V_{ox}], he could use the formula. **This is exactly what the program should be doing!!! The student received the correct messages and had to THINK** [*bold type and capitalization, hers*].

Later (November 8), the teacher discussed how PT students began to accept (though reluctantly at first) the need to complete each step, no matter how small or obvious, in the problem-solving process. Students in the control classes were seemingly less receptive to and less practiced at this orientation.

Not all aspects of the *Tutor* experience were positive, however. Sometimes (November 3) the *Tutor* problems were too few in number or did not operate correctly. Other limitations were excessive time needed for equipment set-ups, equipment failures, and minor problems that students experienced with the interface (getting lost in "too many windows"). The teacher's feeling was that these difficulties were infrequent and minor in importance. She expected their impact to increasingly diminish as students and teachers became more familiar with using the *Tutor* and the few remaining "bugs" in the software were corrected.

In the interview, the teacher expressed the overall feeling that this year's uses of the *Tutor* were much better than last year's. Her hope was that students would be able to transfer what they had learned about problem-solving to paper-and-pencil problems. Although the steps that the *Tutor* required took extra time, that sacrifice was clearly worthwhile if students became more systematic problem solvers. In her opinion, the high achiever who was successful with both procedures and answers probably did not need the *Tutor* nearly as much as the lower achiever.

Based on her early observations of test results (in November), she felt that some students did not transfer the problem-solving procedure outside the problem domain. With additional practice, however, they seemed to perform better, so there was hope that transfer would increase with experience.

The teacher felt that students looked forward to the days when the computer was used and to their turns on it. Without cooperative learning, it would probably have been more difficult for them to learn the problem-solving skills. They conversed extensively before making responses, especially on new or complex problems.

In characterizing the overall experience, the teacher indicated that "there have been no disappointments." Set-up work and equipment problems were more of an investment at the beginning of the year and with new topics. While she was very pleased with having access to the *Tutor*, she did not feel that she substantively changed her teaching style in employing it. Nor did she believe that the primary value or impact of the *Tutor* lied in engendering such changes. That is, whether or not the Tutor were available, she would have maintained her primary methods of lecture, demonstration, cooperative practice and independent practice. What the Tutor did provide, in her view, was a highly valuable tool for facilitating applications of these strategies through its functions for demonstration, practice, feedback, and record-keeping. While qualitative changes in teaching methods may not occur, the teacher believed that they did take place in student learning, namely, the adoption of more reflective and systematic problem-solving approaches.

Achievement

Class performances were compared on the following achievement tests: 1st six-weeks, 2nd six-weeks, 3rd six-weeks, semester exam, and final average. To determine whether group differences were statistically significant, a one-way ANOVA was conducted on each measure. None of the achievement comparisons was significant, thereby, suggesting that the three classes performed comparably on the five overall achievement measures. Nor were there any significant class differences when test scores were adjusted for pre-course aptitude variables.

Problem-Solving

Problem-solving approaches by students in the three classes were analyzed in several ways. The most narrow and molecular data category consisted of mean scores on individual *elements* across all problems. A second, broader category examined *problem* means by tabulating the number of elements represented in the given problem solution. The third and broadest category combined similar problems representing a certain type of application (e.g., 1D-kinematics, 2D- kinematics, etc.) to yield an overall *problem type* score.

For *problem* scores., results showed an uneven pattern, with significant class differences obtained on only 5 out of the 28 problems and on the overall score (points summed across all problems). On the five significant problems, the PT group's adjusted mean was directionally highest on one, second highest on one, and lowest on three. The no-feedback group was highest on three, second highest on one, and lowest on one. The control group was highest on one, second highest on three, and lowest on one. On total score, the order of groups was no-feedback (M = 407), PT (M = 394), and control (M = 387).

For *problem-type* scores, only one out of the five comparisons was statistically significant. On the 2-D kinematics problems, the PT group was lowest and the no-feedback group was highest. However, in an effect that approached significance, the PT group was highest on 2D-dynamics-inclined plane problems, whereas the control group was lowest. The direction of the means on the various problem types indicated a trend for the PT group to score relatively higher compared to the other groups as problem complexity (and course experience) increased. Specifically, PT scores were lowest of the three groups on 1-D kinematics problems, but highest on the more difficult 2-D dynamics problems.

For *element* scores, significant effects were obtained on 18 out of 187 elements associated with 1-D kinematics problems (the easiest level). The direction of the means showed the PT group to typically be lowest of the three groups (in 72% of the cases), and the no-feedback group to be highest (in 94%). Results for 2-D kinematics problems showed significant differences on 20 out of 56 elements. As with 1-D kinematics problems, the PT group typically scored lowest (in 95% of the cases) and the no-feedback group highest (in 65%). On 1-D kinematics with 1-D dynamics problems, 9 out of 56 elements showed significant group effects. Here, the results were less consistent, with the PT group scoring highest on 2 elements (22%), second highest on 4 (44%), and lowest on 3 (33%). Finally, significant group differences were obtained on 17 out of the 191 elements on the 2-D dynamics problems: the PT group scored the highest of the three groups on 15 elements (88%). The no-feedback group was second in nearly all cases.

Conclusions

Conclusions based on the results for student attitudes, teacher experiences, and student problem-solving outcomes are described below.

Student Attitudes

Judging from our five independent visits of PT classes during the past two years, and student survey and interview responses, there is no question that students felt very positively about using the Tutor. They greatly looked forward to "Tutor periods" as opportunities to break from the routine of working problems by hand without the benefit of error-sensitive feedback. Working with a computer appeared to be as motivating for these advanced high school students as for the elementary school children we've observed in numerous contexts. There is also no question that the cooperative learning format used by the teacher enhanced the experience for most students, especially lower-achievers who, if forced to work alone, would have struggled with identifying correct problem solving steps. The latter impression is important in considering instructional uses of the *Tutor*, given that the *Tutor* primarily "reacts" to student responses but does not directly "teach" the physics concepts needed to understand the problem. Cooperative learning allows students to discuss (and teach each other) the problem-solving strategies and principles, and then see the results of their decisions.

Negative reactions to the Tutor were infrequently expressed. In fact, not one PT student indicated that he/she preferred conventional methods over the PT problem-solving activities. The dissatisfactions that were conveyed tended to concern minor aspects of the user interface that made the Tutor less convenient to use than paper-and-pencil modes. The most noteworthy of these concerned the ease of using the calculator and the

Help function, the slowness of the system, and the cluttering of the display windows. These factors seemed to become less important as students acquired more experience in using the *Tutor*. In the November interviews, for example, several students characterized the interface procedures as difficult (or new) at first, but "second nature" now.

Our overall conclusion is that no major revisions in the user interface are indicated by the evaluation results. The program developers should review the student reactions, in relation to considerations of the time and cost requirements of associated programming changes, and decide which, if any, revisions would be desirable.

An additional conclusion supported by the student reactions is that the *Tutor* offers greater benefits to lower-achieving than to higher-achieving students. This interpretation is hardly surprising, given that high achievers are, by definition, relatively successful learners who have performed well using traditional learning methods and resources. The literature on problem solving (e.g., Chi, Feltovich, & Glaser, 1982) suggests that expert problem solvers tend to use a "top-down" approach, which emphasizes understanding of problem patterns and contexts, as opposed to a "bottom-up" approach, which emphasizes the piece-by-piece building of the problem solution. From this perspective, it is reasonable that the highest-achieving students sometimes felt constrained by the step-by-step procedures that the *Tutor* enforced. They felt that they were able to skip many of these steps and consequently, solve the problem more efficiently using paper and pencil. All students agreed, however, that beginning a unit with a few *Tutor* problems served a valuable function, by exposing them to a complete, systematic procedure.

It is important to remember that the present subjects were all physics honors students attending a middle- to upper-middle-class suburban school. Thus, the proportion of high-achievers, who experience success working independently, was likely to be substantially greater for this sample than would occur in "regular" physics classes at other schools.

Teacher Attitudes

As conveyed by the teacher journal and interview results, the teacher was very satisfied with the *Tutor* software. She shared the students' perception that the Tutor problems were especially valuable at the beginning of a new unit and for students who were experiencing difficulties. During the year, she encountered few difficulties with the operation of the software or hardware.

Because only one teacher participated in the evaluation, it is risky to make general conclusions about how other teachers would utilize or react to the *Tutor*. Some teachers, for example, might prefer individual problem solving over cooperative activities; some might use the class and individual feedback reports to a greater or lesser extent. Given the ease of using the Tutor and the few problems that were encountered in the present application, our strong impression is that most teachers would react quite positively to the *Tutor* and welcome its availability for their classes.

Unique to the present application, however, was the teacher's long-term involvement with the development of the *Tutor*, interest in the project, and access to the developers who worked locally at NASA. New users, not associated with the project, would be less knowledgeable about and adept at using the program. Support material, such as a "user's manual," is needed to provide guidance on both operating procedures and instructional methods.

Achievement Outcomes

Results on the various problem-solving tests did not indicate significant advantages for the PT group. The latter class began the year as the lowest of the three classes in physics aptitude and mathematics experience, and completed the year in the same position as measured by examination scores. This outcome should not be interpreted negatively, but as inconclusive in view of the constraints of the present program context.

First, the *Tutor* was utilized for an extremely small proportion of the instructional time during the year. It thus seems unreasonable to expect it to impact performances that are likely to be influenced by so many confounding variables (e.g., student preparation for tests, learning from conventional teaching methods and other resources, homework, practice problems, cooperative learning, learner characteristics, class size, etc.).

Second, subjects consisted exclusively of honors students, thus representing a relatively homogeneous sample of students who generally perform well academically. Chances of treatment differences occurring with this select population would be greatly reduced relative to using low- or average-achievers.

Third, chance factors resulted in an uneven distribution of class sizes and abilities in the three comparison groups. The control (first-period) class, for example, was the smallest and highest in ability of the three.

Fourth, the *Tutor* was primarily designed to influence students' *approaches* to problem-solving, by reinforcing systematic solution steps and recording of step-by-step mathematical work. Such influences may increase "general" or long-term problem-solving ability, while having little impact on immediate test scores based on a restricted, known group of problems. Seemingly, short-cut or idiosyncratic solution strategies can be used on the latter problems with much greater success than would be case for transfer problems from many different domains.

Based on the above considerations, we consider the evaluation of *Tutor* effects on course achievement to be inconclusive. Further evaluation is recommended, using matched, regular physics classes over a longer treatment period.

<u>Problem-Solving Strategy</u>

Results from the analyses of problem-solving strategies were highly suggestive regarding the potential of the *Tutor* to influence *how* students solve problems. These results were also consistent with both student and teacher perceptions of *Tutor* effects.

The pattern of behavior indicated by the problem-solving measure revealed little change by the PT group early in the semester, in solving the beginning one- and two-dimensional kinematics problems. Consistent with their low standing on the pre-course variables, the PT group had the lowest scores of the three groups in representing relevant elements in their problem solutions. As the semester progressed, and experiences with the *Tutor* increased, this pattern reversed to reflect increasing use by the PT group of the problem elements. On the last and most advanced unit, two-dimensional dynamics, the PT students had the highest problem-solving strategy scores of the three groups.

These results suggest that the Tutor is effective at developing more systematic problem-solving strategies. Such influences, however, take time to incubate and may therefore may not emerge until later units of study. It is also noteworthy that the no-feedback control group scored relatively high on the strategy measure. The implication is that the use of print versions of the *Tutor* problems, coupled with teacher feedback, was also effective (perhaps more in the beginning, since such feedback may have implicitly or explicitly conveyed the teacher's expectancy to see complete representations used on subsequent problems.) However, the disadvantage relative to the *Tutor*, in the long-run is the difficulty for teachers of adapting feedback to individuals as problem complexity and the variability of student needs increase over time.

<u>Recommendations</u>

Despite the failure to show differences in problem-solving (test) scores, the evaluation findings, overall, were positive regarding the Tutor's utility for instruction and effectiveness for student learning. The following recommendations are made for further development of and research with the *Tutor.*

1. The developers should review the student and teacher evaluations regarding the user interface, and make whatever minor improvements they consider desirable.

2. Cooperative learning should continue to be recommended as a desirable instructional strategy for using the *Tutor.*

3. A user's manual and teacher's manual (or a combination) should be developed to provide clear information about the program (instructions, set-ups, operating procedures, etc.) and guidelines for instructional uses.

4. Additional evaluation should be conducted at different schools, using regular (not honors) classes that are matched in ability and size.

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Title:

Curiosity, Motivation, and "Flow" In Computer-based Instruction

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Introduction

Computer-based learning systems, especially those which have as design goals a high degree of learner control, generally require a correspondingly high degree of motivation in the learners involved. As an important and long recognized element in learner motivation, curiosity thus becomes a significant concern for designers of highly interactive computer-based learning environments (Kinzie, 1990). However, the role that curiosity plays in the learning process seems so integral that its importance is often assumed. In recent research literature (with few exceptions) the term is either applied loosely or is subsumed into the general body of work on learner motivation, especially as it pertains to intrinsic motivation. With the exception of those investigators engaged in ongoing research with very young children, the work of Berlyne and Maw & Maw in the 50's and 60's remain the standard.

Recently Arnone and Grabowski (1992, 1993) have begun to investigate the role of curiosity in computer-based interactive video lessons. In addition, other investigators have continued to pursue more broadly empirical and theoretical work in curiosity, building upon Berlyne's seminal work in the field (Wohlwill, 1987). Of particular note to this paper is the work on "flow" experiences by Csikszentmihalyi (1975, 1990a; Whalen & Csikszentmihalyi, 1991). His work provides insight into the kinds of engagement experienced by learners whose curiosity has led them deeply into a lesson. In the light of these investigations and theorizing, this research paper seeks to investigate the phenomenon of curiosity in learners involved in a highly interactive, computer-based multimedia lesson.

This paper will examine the relationships between curiosity, intrinsic motivation, and Csikszentmihalyi's "flow" state of absorbed participation. Specifically, this study of the literature will investigate the possible roles curiosity plays in the triggering and maintenance of a flow state amongst learners engaged in an interactive lesson. Establishing a role for curiosity in flow states will, it is hoped, provide further insight into how this potent motivational tool can be better utilized by designers of instruction.

Background

In his often cited work Conflict, Arousal, and Curiosity (1960), Berlyne formalized curiosity as "exploratory behavior" and posed the existence of a number of kinds. Generally, he grouped them into two broad types. Included in the first type were those that were overt responses to external stimuli (or the lack of them) which he called "perceptual responses." The second type he termed "epistemic responses" and he typified them as being an internalized search for some of a number of kinds of knowledge by the person. He admitted these two types "may often coincide," clearly indicating the distinctions were for purposes of discussion and analysis alone (p. 80).

Berlyne (1960) saw organisms as continually seeking to maintain an optimum state of arousal and that exploratory behavior's purpose was to either boost or reduce an unacceptable level of arousal. In the case of epistemic behaviors, arousal was caused by a "conceptual conflict," a term Berlyne synonymizes with Piaget's "disequilibrium" (p. 220) and Festinger's "cognitive dissonance" theory (p. 283). He saw a search for knowledge as a search for the assuagement of a too high or too low state of arousal caused by some sort of conceptual conflict engendered by the person's mental or physical activities of the moment. "Epistemic curiosity" is the term Berlyne applies to the result of conceptual conflict occurring, and a search for knowledge is the behavior that results. The internalized nature of this stimulus-response-reward process places Berlyne's curiosity theorizing in the middle of almost any discussion of intrinsic motivation (Day, Berlyne, & Hunt, 1971; Deci, 1975; Keller, 1987).

The work of Maw and Maw (1964, 1965) centered on the detailed measurement of curiosity levels in individuals (children) and on classifying observable behaviors that evidenced epistemic curiosity at work. They defined curiosity based on the presence of the following behaviors:

When children--

1. react positively to new, strange, incongruous, or mysterious elements in their environment by moving toward them, by exploring them, or by manipulating them
2. exhibit a need or desire to know more about themselves and/or their environment
3. scan their surroundings seeking new experiences
4. persist in examining and exploring stimuli in order to know more about them

--they are being curious (1964, p. 31)

The labels "high curious-" and "low curious child" were then used to investigate possible correlations with such factors as socioeconomic status, parental attitudes, creativity, etc. In these pursuits they developed instruments that served to objectify the curiosity level of a child. Their definition has remained useful and is often cited to this day (e.g., Arnone & Grabowski, 1992; Day, 1982).

Many researchers since then have continued to explore the measurement-classification-dissection of exploratory behavior. Some researchers have tended to study curiosity (in children especially) alongside of "play," "imagination" and "creativity." Other theoreticians have grappled with the question of whether it is a "state" (i.e., a condition brought on by some stimulus or process) or a "trait" (i.e., a universal psychological need or drive). In his last work, Curiosity and Learning (left incomplete by his death in 1976), Berlyne (1978) repeatedly called for the development of a theory of motivation for explaining human behavior (as noted in Keller, 1987). That he did so in a work ostensibly about curiosity's role in learning reveals the inextricable relationship he saw between curiosity and motivational issues in learning.

Motivational psychologists mirror the divided opinions about curiosity outlined in the preceding paragraph. On the one hand, a divergence from the person's optimal level of arousal results in (motivates) behavior (called curiosity) which seeks to restore their arousal level (Berlyne, 1971). On the other hand, curiosity is seen as a result of "cognitive incongruence" for which persons "inherently" require corrective action in order to feel competent (Deci, 1975; Deci & Porac, 1978). The question, as before with the nature of curiosity itself, remains: Is intrinsic motivation a state, or a trait, of human existence? While there are areas of common ground between these two, theoretical discussion continues (Keller, 1987; Voss & Keller, 1983). In the meantime, those with a more practical bent have begun to apply some of this theorizing to everyday practice.

Csikszentmihalyi (1975, 1990a) has posed the existence of a state of human experience he calls "flow" wherein the individual feels (a) a merging of action and awareness, (b) the centering of attention on a limited stimulus field, (c) self-forgetfulness or loss of self consciousness, (d) a sense of control over one's actions and their environment, (e) the coherence and noncontradiction of demands for action and the provision of clear, unambiguous feedback from one's actions, and (f) an "autotelic" nature, i.e., the experience requires no goals or rewards to itself, (from Keller, 1987, p. 35). The internal nature of "flow" clearly places it, as a phenomena, well within the general arena of intrinsic motivation studies (Csikszentmihalyi, 1978). In addition, such an experience, fully realized, also represents a fair description of the desired state of a learner fully engaged in computer-based instruction, at least according to many interested in the development of such instruction (Keller & Suzuki, 1988; Kinzie, 1990; Lepper & Malone, 1987).

Curiosity and Instruction: Research

As has already been noted, there has not been much applied research done with human subjects concerning curiosity and learning in the ages beyond the preschool years. Opinions and attendant theorizing about it are more common, but unless the topic involves motivation, curiosity is either broadly assumed or the research effort itself is concerned simply with recognizing, defining or measuring it (Boykin & Harackiewicz, 1981). In the case of Maw and Maw, whose work pioneered the field of curiosity measurement, their prescriptive conclusions summarized and reported later (Maw, 1971) remained very general: "If a school wishes to increase curiosity, so essential to learning, it must turn its attention to seeing that each child feels... worthy... of some importance... secure... accepted... loved," etc. (p.97) [emphasis added]. Harty and Beall (1984), answering the same call as Maw and Maw for useful curiosity measuring instruments, engaged in the creation of the "Children's Science Curiosity Scale." The test they developed went through six versions before settling on a 30 question instrument using a Likert type agree/disagree five point scale. They concluded that the instrument appears to be reliable and valid but cautioned that further testing with larger populations was needed before it could become a standardized tool for educators to use (they used less than 200 students overall).

With the notable exception of Berlyne himself, other research applying his theories of curiosity to actual learning situations (in humans) remains sparse or flawed (Koran, Koran, Foster, & Fire, 1989). An exception is the work of Boykin and Harackiewicz (1981). They were particularly interested in discovering how subjects, uncertain of their abilities to answer a question, would evidence curiosity as a response and, additionally, how their uncertainty would translate into later recall of the knowledge. The results confirmed the linear relationship between uncertainty and curiosity as those most uncertain expressed the highest curiosity. Also, the problems with the highest likely uncertainty (i.e., the most difficult) elicited the highest levels of curiosity. Subjects also tended to remember the most difficult words in the recognition test. The authors concluded that the supposed relationship of uncertainty to curiosity and of uncertainty/curiosity to retention was confirmed. The authors felt their methodology was sound and that their instrument could be used successfully for further investigations into curiosity.

Another example is the work of Inagaki where the author tested a number of hypotheses regarding curiosity, learner effort, and performance in science classes. In the first study (Inagaki & Hatano, 1977) (using fourth-graders) the treatment group (curiosity aroused) showed stronger desire for confirmation of a science experiment by observation, better generalization of the knowledge to other situations, and a higher correlation between performance and curiosity.

In another study (using kindergartners), citing the theory that highly curious children will interact more with their environments and thus gain increased mastery over it, Inagaki (1978) posed two hypotheses: (1) The higher the curiosity, the more actively the subjects will explore an experimental environment containing uncertain or dissonant elements; and (2) the higher the curiosity, the more measurable information the subjects will acquire, regardless of verbal ability. The results indicated a degree of correlation (but not a significant one) between curiosity and amount of exploration. High curiosity did correlate significantly with performance, even with verbal ability held constant, confirming hypothesis No. 2. The author concluded that curiosity (as a trait) played a significant role in learning. He goes on to predict that highly curious students will be more apt to have success in "student-centered learning," i.e. learner controlled environments.

The research reviewed here (obviously) represents only a sample of the empirical work done in the area. However, studies tend to confirm (a) the presence of "curiosity" through observable, quantifiable behaviors, (b) that its presence or activation results in improved learning/performance, (c) that it can be aroused by various instructional techniques, and (d) that aroused learners will persist and be self-sufficient in their pursuit of learning goals (Day, 1982). Its psychological basis and attendant cognitive issues remain open to debate, however. As noted before, the work of neonatal and infant researchers is the cutting edge for this aspect of the field. For the rest, including those involved in creating computer-based interactive instruction, "curiosity" in all its theoretical and practical manifestations) remains an elusive target to hit, albeit an important one.

Curiosity and Interactive Instruction

Curiosity's role as a motivator in computer-based learning has been an object of interest for some time (e.g. Miller & Hess, 1972). Currently, curiosity figures prominently in the work of several important theorists within the field of instructional technology. J. M. Keller's "ARCS Model of Motivation" (Keller & Suzuki, 1988) and Malone's "Taxonomy of Intrinsic Motivations for Learning" (1981; Malone & Lepper, 1987) each find a place for "curiosity" in their respective schemes meant to explicate the role of motivation in instructional design.

In the case of the ARCS model, Keller places curiosity in the "A" for "attention" part of his scheme. In this placement he emphasizes the ability of novelty, uncertainty, surprise, etc. to get attention (i.e., arouse curiosity). He hopes that the gaining of attention will be followed by engagement of the learner "in an inquiring frame of mind." This deeper engagement is epistemic curiosity, Berlyne's search for knowledge (Keller & Suzuki, 1988, p. 410). However, a close examination of the remainder of the model, Relevance-Confidence-Satisfaction, reveals those elements to also be elements in the curiosity theories posed by Berlyne and others. Novelty, et al., are insufficient arousal agents in and of themselves to insure the kinds of epistemic exploration we think of as learning. If the situation does not show promise of being useful, moderately non-threatening, and of being rewarding, we will not be led to explore it in any extended way. The entire ARCS model requires "curiosity" as a motivator for learning, at least as Berlyne (1971) would have it.

Malone's taxonomy poses a more comprehensive set of motivators than Keller. He, too, places curiosity in a separate category from the other catch words that make up his theory. In his discussion of it, however, he states, "In a sense, curiosity is the most direct intrinsic motivation for learning," and draws many parallels between it and the "challenge" element of the taxonomy (Malone & Lepper, 1987, p. 235ff.). In his first discussion of his theory he states, "In fact, challenge could be explained as curiosity about one's own ability, or curiosity could be explained as a challenge to one's understanding," (Malone, 1981, pp. 362-363). Clearly this relationship has much in common with the idea that curiosity's purpose is to assuage a perceptual or cognitive conflict, again from Berlyne (1960).

The point of this analyzing is to highlight the centrality of curiosity (at least as a full expression of Berlyne's curiosity theories would have it) to these two attempts at delineating the motivational underpinnings of computer-based instruction. Keller, especially, is limited in his appreciation of the comprehensive nature of curiosity in relation to the field of motivation. Perhaps Berlyne, the father of curiosity theorizing, was right in insisting, "A theory of motivation is indispensable if questions of performance are to be answered," (1978, p. 119).

In the work of Arnone and Grabowski (1992) mentioned earlier, empirical researchers have begun to address curiosity and its role in computer-based interactive instruction directly. In their study they focussed on how variations in learner control affected their subjects' curiosity and achievement. The researchers' concern was with the relative "amount" of curiosity demonstrated, similar to the Maw and Maw studies in the 60's.

The authors created a lesson on art museums using a computer controlled videodisc with a touchscreen monitor. The lesson was presented in three versions: (1) program controlled; (2) learner controlled; and, (3) learner controlled with advisement. 101 first and second graders from a public school were randomly divided into four groups, one for each treatment, plus a base (control) group that received no instruction. After the treatments all groups took a posttest that measured achievement and three different curiosity measures: content exploration, questioning, and persistence, again using an interactive videodisc setup.

The results indicated that advisement resulted in achievement that was significantly better than without advisement, though no difference was found between these two groups and the program control group. All three treatment groups significantly outperformed the base (no treatment) group. In the curiosity measures, there were no differences in the "questioning" measure. Significant differences were found between the base group and the others in "persistence" with the base group persisting longer. A significant difference was also found in the "content exploration" measure between the base group and the advisement group with the the latter showing greater curiosity.

In their discussion the authors took interest in the fact that the learner control group's achievement was on a par with that of the other control options, possibly due to the content's inherent interest. They also found the non-instructed base group's high curiosity (as measured by persistence) indicative of their lack of prior exposure to the content-- it was all new to them and they took their time (the actual measure used) examining the stimuli during the posttest. On the other hand, the advisement group's greater curiosity (as measured by content exploration) than the non-treated base group represented the fruits of being instructed to "think" about the content during the instruction, thus making them more "intrigued" about museums in general.

While Arnone and Grabowski's work provides insight into how curious (or non-curious) subjects perform in interactive instruction, practitioners are more interested in how curiosity can be invoked in all subjects experiencing computer-based interactive instruction. Arnone and Grabowski (1993) have continued their work in this area specifically. On a broader front, Westrom and Shaban (1992) have applied Malone's work in a study comparing the motivational levels of players in "instructional" vs. "noninstructional" games. The authors found all of Malone's four factors (Challenge, Curiosity, Control, Fantasy) played roles in the initial and continuing engagement of the players / students. They concluded that a better understanding of motivational effects would lead to more effective instructional tools wherein students "might find that learning is, once again, fun," (p. 444).

While many factors have been posed as contributors to learner motivation in the field and several theories proposed (i.e., the Keller and Malone theories above), curiosity remains a difficult concept for most authors and researchers to deal with concretely in isolation. Like many of humankind's affects, it is easier to describe what it does than what it is. Perhaps we need to forego reductionist approaches and take up those that are integrative and holistic in their place. An example of such an approach follows next.

"Flow" and Interactive Instruction

Connecting the work of Csikszentmihalyi in the field of motivation theorizing to computer-based interactive instruction represents the final expository section of this paper. As can be seen from the summary earlier, his work lies with those researcher/theorists we classify as phenomenological or holistic in their approaches. As such, his work is probably suspect by those who require empirically reductionist approaches to establish truth. On the other hand, his methodology, while subjective, involves and reports on people and events in the real world: rock climbers, chess players, dancers, surgeons, and the like. Csikszentmihalyi (1975) is interested in why they do (and keep on doing) the things they enjoy. What is there about the experience that keeps them engaged? His answer, "flow," is one of those words whose meaning, in this psychological context, is almost immediately understandable. We know what it is because we have experienced it ourselves and it represents truth to us as much as any empirical result from the lab.

But how can his theorizing provide guidance to designers of computer-based interactive instruction? Malone (1981) lumps Csikszentmihalyi with others who see meeting challenge as the vital element in intrinsic motivation theory and faults him for ignoring the role of curiosity. Others (Keller, 1987) fault his work for being over broad and merely descriptive. This writer searched in vain for "curiosity" or "exploratory behavior" in the various indices of Csikszentmihalyi's work read for this paper. The answer, I think, lies not with his work or theories, but with our own approaches to learning and instruction.

At its most basic, Csikszentmihalyi's "flow" state is simply a description of people enjoying themselves. They are in a state of enjoyment because they have situated themselves in an environment that challenges them optimally. This should strike a responsive chord within the educator that should resonate, "That's how I want my students (and me!) to be in the classroom." It represents a desired state to strive for (i.e., an instructional goal!) for us as creators of educational environments. He has thoroughly documented his extensive work with many different populations, even across cultures (Csikszentmihalyi, 1990a). That flow states exist and are achieved regularly by people in all walks of life, at all times of day, at every age he has chosen to investigate, is well documented. If educators find it difficult to see possibilities for enjoyment in learning, flow states will seem foreign through no fault of Csikszentmihalyi's.

Besides being a particularly well described goal for educators (including CBI designers), flow also has the desired property of being "autotelic," i.e., it seems to reward itself. Much has been written about the desirability of intrinsic motivation vs. extrinsic motivation in learning that indicates its significance to educators (Day, et al., 1971; Lepper & Greene, 1978). Csikszentmihalyi's work is so representative of the field of intrinsic motivation his contributions have nearly become lost in it. Certainly Malone (and later Lepper and Malone) seemed to ignore the larger ramifications of flow states even as they proposed motivational strategies that could likely bring them about. Perhaps, again, there is some problem with seeing (and designing) learning as openly enjoyable.

Csikszentmihalyi does have much to say about the teaching/learning process and does so in several of the sources surveyed for this paper. In Play and Learning Csikszentmihalyi (1979) presented his flow theory to a group of early childhood scholars sharing views on the role of "play" in child development. While his work up to that time had involved only adolescents and adults, his flow theories found a ready and enthusiastic audience. The participants quickly adopted "flow" as synonymous with adult "play" and applied it to their own work with children and play. Csikszentmihalyi cautioned them "about the separation of play and 'real life,'" (p.269) making clear his position that play (children's flow) was life, just as adult flow was a real and genuine experience.

The "Flow Activities Room," a project applying Csikszentmihalyi's theories at Indianapolis' Key School (a magnet elementary school), provides a place for students to engage in and experience flow states through "structured play" and other coordinated activities (Cohen, 1991). In this room students are expected to engage in some purposeful activity that they enjoy. After a year long period of observation, a study (Whalen & Csikszentmihalyi, 1991) showed that students were able to describe fully their flow experiences and did so positively. They also demonstrated a marked preference for the flow room and its methods over their classroom subjects (also designed to be intrinsically motivating but, of necessity, more directed). The room and its activities were seen by the students as challenging but enjoyable. The learning that occurred there can only be related on an individual basis, but the authors conclude that the experience was clearly rich in individual and interpersonal growth.

Recently some investigators have begun to relate Csikszentmihalyi's work to human-computer interactions (Webster, Trevino, & Ryan, 1993). Studying the "playfulness" of students and (later) employees using various application software, the authors developed a measure of flow. They found flow, in this context, had three dimensions: control, attention focus, and "enjoyment." The latter was a combination of curiosity and intrinsic interest.

In an essay meant to provide philosophical direction to educational reform, Csikszentmihalyi (1990b) states that "It is not that [U. S.] students cannot learn; it is that they do not wish to," (p. 115). His thesis is that technology and methodology will not educate students if they are not motivated to learn. After explaining flow, Csikszentmihalyi maintains that students can and do experience this state on occasion, and that educators need to actively promote its presence during instruction.

Since it is a naturally occurring state in someone engrossed in what they are doing, teachers must be wary imposing conditions that tend to discourage its occurrence. Citing Amabile (1983), Csikszentmihalyi (1991) says these conditions include: (1) excessive control, rules, procedures, time constraints; (2) emphasis on evaluation, rewards and punishments, norm referenced competition; (3) too much emphasis on "winning;" (4) making the individual self-conscious. These are all counter motivational, generally, and serve to reduce the exercise of the individual's intrinsic motivators and the likelihood of "flow" states occurring in the classroom. He concludes, "It is hoped that with time the realization that children are not miniature computing machines will take root in educational circles, and more attention will be paid to motivational issues" (p. 138).

Conclusion

The goal of this paper was two fold: Place the fuller version of curiosity theorizing into current thought regarding motivation for learning, particularly as is applies to the creation of computer-based interactive instruction; and relate these theories to the "flow" state theorizing of Csikszentmihalyi. With respect to "curiosity" the result has been to raise more questions than were answered. The death of Berlyne left the field without anyone to be the grand visionary. The result has been the near total subsumption of curiosity by the motivational psychologists, particularly those concerned with intrinsic motivation. Where intrinsic motivation and learning are discussed, curiosity and motivation become nearly one and the same.

Perhaps this is the best stance for those interested less in the (presently unknowable) biological mechanisms underlying cognition and impatient to get on with creating interactive learning environments. While cognitive science and neurobiology forge links and much is promised (Sejnowski & Churchland, 1989), we are left facing our students today. As reflective practitioners concerned with the whole person before us, we are prepared to incorporate as many useful "tricks of the trade" as are needed to foster learning. It is precisely at this viewpoint that Csikszentmihalyi's flow state theorizing becomes both a metaphor and a practical design goal for the types of instruction that will encourage learning, empowering us and our students to better understand each other and our world.

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Title:

Trends in Instructional Technology: Educational Reform and Electronic Performance Support Systems

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Abstract: As a result of [the society] moving into the information age, changes in the educational process as well in the workplace are inevitable. Parents, students, school officials and business leaders are currently experiencing the effects of the information explosion era on a daily basis. Upgrades and new releases of computer hardware and software are occurring almost before we can fully understand our old systems. Are decision makers ready to make the changes necessary to prepare students with the competency and foundation skills (as identified by the Secretary's Commission on Achieving Necessary Skills) that they will need for the changing workplace? This paper will address two trends in the instructional technology field: reforming the educational process and implementing electronic performance support systems into the workplace. These trends are important because they have influence on moving the teaching and learning process to a new evolutionary stage.

As society approaches the 21st century, technology will play an important role in the lives of adults as well as in the lives of children. Business leaders, school officials, parents, and students need to be aware of the impact technological change will have on the educational system as well as on business and industry (Secretary's Commission on Achieving Necessary Skills [SCANS], 1991). Furthermore, with markets becoming more global and companies desperately striving to stay ahead, jobs of the future will demand more highly skilled employees (Naisbitt, & Aburdene, 1985; SCANS, 1991; Work Force 2000, 1988). During the coming years, jobs that require skills with information-processing technology will be of the norm rather than a rarity (Naisbitt & Aburdene, 1991). To prepare students for a work force that is different from their parents Reigeluth (1992) argues that the educational system requires moving from an industrial age model towards an information-age model that views the educational process as the integration of learning tasks, with the teacher as a coach or facilitator using electronic technologies as tools within the classroom.

The mastery of reading, writing and arithmetic will no longer be enough to propel students to success in the work place. According to the SCANS (1991) report, researchers identified five competency skill areas and three foundation skill areas that are necessary for success in the workplace. The five competency skills, as defined by SCANS (1991) are:

1. Resources: Identifies, organizes, plans, and allocates resources,
2. Interpersonal: Works with others,
3. Information: Acquires and uses information,
4. Systems: Understands complex interrelationships and,
5. Technology: Works with a variety of technologies.

In addition, included in the SCANS (1991) report is a description of the three-part foundation skill requirement. They are:

1. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks,
2. Thinking Skills: Thinks creatively, makes decisions, solves problems, knows how to learn and
3. Personal Quality Skills: Displays responsibility, self-esteem, sociability, self-management, integrity and honesty.

Will high school or college graduates be able to master the competency and foundation skills upon graduation? This question focuses on how society is changing and as a result the needs of students who are preparing to enter the workforce have changed.

> Education is our passport to the future, for tomorrow belongs to the people who prepare for it today.
>
> Malcolm X

Educators are seeking new ways to ensure that students have the appropriate skills on a local and national level. On the local level, school officials are re-thinking the design of schools for the information age (Molenda, 1992; Reigeluth, 1987) and on the national level the Bush administration announced America 2000, a new education strategy, designed to provide national educational goals for the nation's schools (Eley, Foley, Freedman & Scheel, 1992). The fundamental purpose for these initiatives is to empower students to tackle the challenges facing them in "the real-world".

Employees can no longer believe in job security (Naisbitt & Aburdene, 1985) or that a college degree alone (without constantly upgrading ones' skills) will propel him or her in the workplace. Employment for many people, currently and in the future, requires a commitment (whether embraced by the employee or imposed by the employer) to change and life-long learning. Naisbitt and Aburdene (1985) argue that "in the new information society where the only constant is change, we can no longer expect to get an education and be done with it. There is not one education, no one skill, that lasts a lifetime now" (p. 141). Furthermore, Packer (1988) argues that if the U.S. economy is to stay competitive, "twenty-five million American workers will need to upgrade their basic skills during the 1990's" (p. 8). This is a low estimate when taking into account the bases for projections are only on the changing mix of jobs and do not include workers who need to upgrade their skills as a result of new technology (Packer, 1988).

Nevertheless, will graduates be ready to face a world that is constantly changing at a rapid pace? There was a time when a clerical employee learned how to type and file and would not have to learn a new procedure for years- if ever. However, today the replacement of a word processor occurs almost as often as the assignment of a new manager. Many times, in response to receiving this new software application, the employee must become proficient without a decrease in productivity. This situation places the employee in the position of seeking the quickest and "least painful" method of training.

By keeping abreast of the changes in society as well as in education and training, instructional technology professionals can play a key role in restructuring the educational system from its current industrial model to a system that reflects the information age. In addition, restructuring that includes integrating electronic technology into the educational system can be one solution for bridging the skill gap from high school or college to the workplace. This restructuring movement can also be the catalyst for using electronic technology as a tool to assist the teacher in developing the competency and basic skills as defined by the SCANS (1991) report. Furthermore, to bridge the skill gap for employees accessing new information, employers are investigating electronic performance support systems (EPSS) which is a computer-based tool designed to assist the employed with on-demand training and support.

The implementation of EPSS in the work place and the restructuring of the educational system are two important trends in the instructional technology field (Eley et al., 1992; Seels, 1993). These trends are important because they represent moving the teaching and learning process in our schools and on-the-job to a new evolutionary stage.

A Proactive Mindset to Change

Systematic Change Process

Change, whether planned or chaotic, brings on stress and anxiety. Moreover, unplanned change combined with minimum involvement from the people affected by the change, produces resistance (Burke, 1982). Furthermore, Burke (1982) argues that "what people resist is not change but loss, or the possibility of loss" (p. 52). This loss is generally one of two kinds: loss of the known and tried or loss of personal choice (Burke, 1982). Rickleman and Henk (1989) argue that change does not have to be unsettling if everyone involved take a proactive stand.

> By taking a proactive stand, we shift from asking "What is going to happen to us in the future?" to "What can we do to create the kind of future we want?" (Rickleman & Henk, 1989, p. 175).

Kurt Lewin, a psychologist and educator, was one of the earlier researchers to take a proactive stance for change. Lewin argued that a key principle to organizational change is a three-phase change process "unfreezing, moving, and refreezing." In trying to imagine the phases required for change Lewin used the metaphor of melting ice. Unfreezing means reducing the negative forces through new or disconfirming information, which is the function of diagnosis. Changes in attitude, values, structure, feelings, and behavior incorporate the moving stage and refreezing means reaching a new status quo with support mechanisms to maintain the desired behavior (Weisbord, 1987).

Many systematic change models have evolved from Lewin's model of change (Burke, 82). A key issue with Lewin's model is the involvement of everyone associated with the process. In addition, Lewin states "people are likely to modify their own behavior when they participate in problem analysis and solution and more important they are likely to carry out decisions they have helped to make" (Weisbord, 1987, p. 89).

Educational reform is a hot topic in the school system as well as in all levels of government. Recently, the reform movement has been shifting from a disjointed incremental effort towards more of a Gestalt perspective, where the focus of change is on the whole educational system (Bagley & Hunter 1992; Campoy, 1992; David, 1991; Pearlman, 1989; Raywid 1990; Sheingold, 1991).

David (1991) argues that "restructuring presumes the goal for educational system is not simply to catch up to the world, it needs the capacity to continue to evolve as the world continues its rapid pace of change" (p. 77). To reach this goal Reigeluth (1992) identifies "Ernest Boyer (1983), John Goodlad (1984), Theodore Sizer (1984), Lewis Pearlman (1987), Ann Lieberrman and Lynne Miller (1990), Albert Shanker (1990) and Banathy (1991, 1992)" (p. 1) as advocates for systemic change in education. Reigeluth (1992) further argues that true educational reform has occurred only once in our nation's history- when the industrial assembly-line model, which is currently in place today, replaced the one-room schoolhouse. This paper will not address all the issues associated with restructuring the school. However, the author will focus on a small portion of the educational reform movement that considers integrating electronic technology into the classroom and the uses of EPSS as a tool for promoting training and support in education or business and industry work settings.

Integrating Technology into the Educational Process

Restructuring the educational system is not an easy task. It can be a very complicated and long term project yet, the results of reform can be fruitful and enriching especially if decision makers do not view electronic hardware and software as the sole answer for entrenched ills. A decision maker who believes integrating computer-based technology (into the school system) requires simply supplying teachers and students with additional new hardware and software is focusing on a "device-driven" learning environment versus a "student-centered" environment. Bagley and Hunter (1992) cited Rockman who cautions "policy makers against 'technohype', which he describes as the efforts by advocates and vendors to sell technology as the one and only answer to restructuring the school system" (p. 22). Sheingold (1991) further argues that "computer-based technology has been brought into schools during the past decade largely because the technology was seen as important in and of itself-because it was an increasingly centra. component of the world of adult work" (p. 77). Technology is more than just electronic devices. Eley et al. (1992) define technology as applying scientific principles to solve practical problems- a process that deals with problem solving. This definition decreases the emphasis from specific devices and places it on solving the problem (Wager, 1993). For example instructional design and teaching and learning methodologies fit the definition of technologies, however they are forgotten examples. The author suggests that the lessening of "technohype" can occur by informing decision makers that electronic technology is "a systematic blend of peopie, materials, methods and machines" (Eley et al., 1992, p. 27).

More important, the integration of computer-based technology into the educational process requires decision-makers to re-think their opinions on several topics- for example their views on:

1. The role of the teacher in the classroom as well as their views on teaching and learning,
2. The organization of student desks and computers in the classroom,
3. The life-cycle and maintenance of computer hardware and software.

In addition Collins (1991) identified, from the literature and observations in schools where teachers are using computers, several major trends on how computer technologies have an affect on the classroom. First, Collins (1991) argues that the role of the teacher will move from a lecturer to a facilitator and coach who actively engages students in long-term computer projects. These projects may simulate relevant "real-world" problems, where students are actively participating in arriving at solutions.

The classroom will shift from desks placed in rows where the whole class participates to desk arranged in small groups. This new classroom arrangement, along with the teacher's encouragement, can provide an environment where students can focus on cooperation and collaboration. Lastly, the author suggests that by exposing students to electronic technology used as a tool or resource for the teacher students will have an opportunity to practice the foundation and competency skills as describe by SCANS (1991).

Sheingold (1991) provides several recommendations that may assist in the change process that includes integrating computer technology. They are as follows:

1. Bring technology and learning to the same 'table' when restructuring is being planned,
2. Reconsider how technology is organized in the district and finally,
3. Work towards teacher expertise in using a critical mass of technology.

Instructional technologists are also facing issues on how to support employees, such as teachers, administrators and business managers, when many school systems, universities and businesses are facing huge budget cuts and downsizing efforts. As a result of these changes, employees are being called upon to "do more with less" and decision makers are looking towards instructional technologists to investigate ways electronic technologies can increase productivity with a leaner workplace and fewer people available for employee support.

Currently, employees may receive their formal training off-the-job in instructor-led courses or by computer-mediated training (interactive video, computer-based training, or a combination of both), however, when the employee returns to the actual job, training and support may consist of human interaction, non-centralized reference manuals or company documentation. Problems arise when employees need specialized training but none is available until several weeks or months later. Uncertainties in the employee's ability also arise when he or she is trying to complete an assignment and need specific support but receive either too much information, conflicting information or no information at all (Brechlin & Rossett, 1991).

Employers can no longer ignore employee training. Decision makers are slowly realizing that training is a factor in ensuring that the workforce is productive. It is only after the elimination of training programs that decision makers sometimes realize its importance.

> "Training is like rowing against the current. Once you stop you are dragged downstream."
>
> Jozef M.M. Ritzen

As a result of these problems, decision makers are entertaining the idea of providing employees with software applications that provide immediate support and on-the-job training (OJT) from the employee's desktop computer at the specific moment of need.

The development of electronic performance support systems (an integrated electronic system that provides training and support at the moment of need for the employee) is a trend in instructional technology that can bring training and employee support to the desktop computer. In addition, with the introduction and advancements of tools such as: relational and multimedia databases, computer-based training, expert systems and on-line references, the foundation for developing electronic performance support systems (EPSS) is in place.

What is an EPSS?

Since the recent introduction of EPSS into business and industry, leaders in the field are still trying to develop a working definition associated with this tool. Raybould (1990) describes an EPSS as a "computer-based system that improves worker productivity by providing on-the-job access to integrated information advice and learning experiences" (p. 4). Whereas Gery (1991), a leader in the field of EPSS, defines an EPSS as "an umbrella concept that includes any of a variety of performance support interventions delivered on computer to the worker on the job at the time of need" (Clark, 1992, p. 36).

In describing an EPSS there are two major areas to consider, the content and the components of the system. To identify the contents of an EPSS, Gery (1991) uses the term "Infobase" which is the collection of information the employee will inquire into, access, or have presented to him or her when accessing the system. For example, the information located in a text relational database, multimedia database, expert system or on-line reference system are the type of data the employee could select from within an infobase. When manipulating the infobase, the user interacts with the components of the EPSS that can include the following:

> A range of support mechanisms and software tools including an advisory system to help in instructing or executing tasks and decision making, commercially available software programs, organizational specific application software, special purpose software utilities built especially for use within the EPSS and other interactive capabilities (Gery, 1991, p. 42).

Components of a complex EPSS can, ideally, include a combination of hypermedia databases, expert systems, modular interactive training, a dynamic maintenance system, as well as other interactive software support applications, whereas, a basic EPSS may include only a database and an on-line help system (Geber, 1991). The common feature found in both a basic and complex EPSS is the ability of the application to provide information to the user at the moment of need (Scales & Yang, 1993).

EPSS in Educational Process

Researchers are investigating and developing EPSS and other support tools in academia as a way to increase productivity in the workplace. Merrill (1993), Gustafson (1993), and Dick, (1993) are advocates for increasing productivity as a result of decreasing the instructional development time by using an EPSS. Educators from Florida state looks towards an EPSS to increase productivity by providing an integrated information and learning system for staff involved in special education. This project is part of Florida State School year 2000 initiative (Huestia, 1993). In the mist of companies as well as academia downsizing employees are being called upon to "do more with less". To assist employees with this change EPSS are being designed to bridge the training and support gap.

Decision makers who are not ready to invest in an EPSS, may consider embedded interactive training, as a solution for some OJT needs. Embedded training, as defined by Andrews (1991), is the integration of multimedia training applications into a workplace tool. EPSS and embedded training applications are moving the training from out of a classroom onto the employee's desktop computer. In to prepare for the coming changes in workplace training, managers, software developers and instructional designers, will be faced with seeking a clearer understanding of the EPSS development process. More specifically, decision makers must addressing the issue of moving the development of training from the end to an earlier software development stage. Therefore, EPSS or an embedded training application will change the way they receive training on-the-job. In addition, individuals involved in developing software must work together in re-thinking how to incorporate the development of training applications as part of the initial software development process.

Changes in Software Development Process

In order to take full advantage of trends such as the computer-base training component of an EPSS, or embedded training, changes in the software development process are necessary. Traditionally the development of training and support documentation have not been an integrated part of the software development process. Howell (1992) provides a summary of six methods used for general software development projects. Of these six techniques, none address training and support as part of the development process. However, advances in computer hardware and software technology have made it possible to integrate embedded training and support within the software development process before the completion of the project.

The author suggests that to effectively develop the training component of an EPSS, embedded training or even non electronic support materials, the traditional software engineering model should be modified. Figure 1. displays a software engineering model that accommodates the parallel development of the application software process, user interface process, and has been modified to incorporate the parallel development of training and user support materials. This abbreviated software development model is one way to displays a general diagram of each of the three development processes. It is important to note that

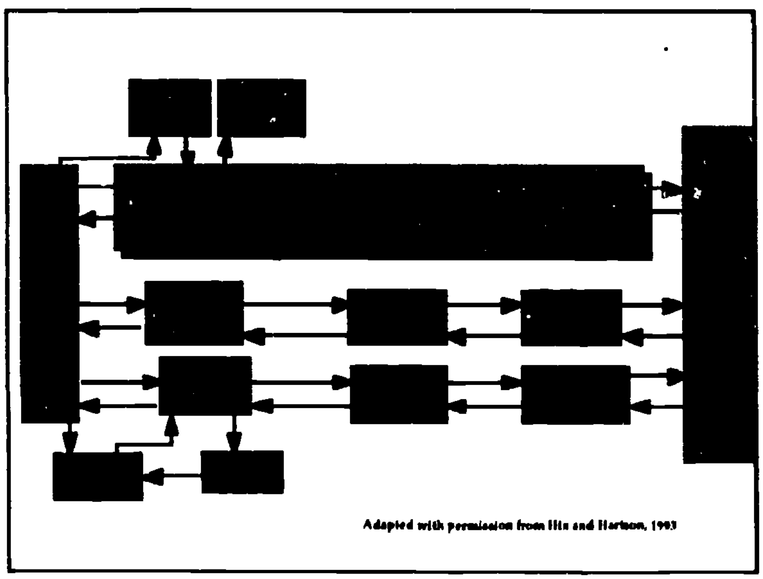

Figure 1. Software development model with training & support

throughout each process efficient and effective communication must occur between each development group. By moving the training and support process from the end of the software development process the user will be able to test a final system complete with training and support materials. In addition, this is one suggestion of a software development model for an EPSS. Furthermore, this change would incorporate the price of training in the overall cost of the system whereby eliminating the purchase of training as an afterthought or as part of the software bundle that is "nice to have".

Summary

Educational reform and the development of EPSS are occurring as the result of the changes in the skills and knowledge needed for the workplace today. Moreover, the implementation of educational reform and EPSS in instructional technology will require following a systematic change process that looks at the entire organization for change and not just single components. Restructuring the educational system is not an easy task therefore it requires advocates for change committed to an on-going and sometimes difficult process. Any advocate for systematic change in education must first question him or herself on their views of teaching and learning and the role of electronic technology in the classroom. Having an advocate for change who is uniformed could potentially promote technology as a cure all versus as a tool for supporting teachers in their teaching and learning process. More important, to successfully integrate computer hardware and software into the teaching and learning practice, advocates for change must prepare teachers and administrators not in just "how" the computer works but also in how the teacher and student can learn "with" the compute using it as a tool or a resource. This concept calls for a change in the role of the teacher, classroom structure and social structure.

Instructional technologists are also being called upon to develop EPSS. The idea of supporting an employee with information, advice and training at their specific moment of need is attractive to employers who are seeking to increase productivity in the mist of downsizing and budget cuts. However EPSS is not a cure all solution for every training situation and does not necessarily mean eliminating additional training before or after using the system.

Lastly, our society has moved from the industrial era to the information and service age. Decision makers, whether in the work place or academia, will require involvement from their entire organization to prepare our future graduates with the appropriate skills for a changing society. Are business leaders, school officials, parents, and students, ready for this challenge?

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Title:

A Major Children's Educational Art Exhibit: An Evaluative Case Study

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Introduction

This paper examines the results of a case study of an exhibit of art and artifacts designed for children. The exhibit was well funded by several sponsors and housed in a major national art institute. While museums tend to market their exhibits as "educational," they tend not to acknowledge them as "instructional." The focus of the case study was to attempt to apply the principles of instructional message design (Fleming & Levie, 1978, 1993) to the evaluation of the exhibit. What follows is a description of the exhibit viewed critically from the perspective of these instructional design principles.

The exhibit is at the Art Institute of Chicago in the Kraft General Foods Education Center. The Art Institute of Chicago is a large, well-known art museum. It is famous for its excellent collections, particularly its collection of French impressionist paintings, its fine physical facilities, and its prime location in "The Loop" in downtown Chicago. For many years, the museum had a facility for children known as the Junior Museum which was housed in the basement of the museum. The Junior Museum closed in 1990 for an extensive remodeling, and reopened in October of 1992 as the Kraft General Foods Education Center. The new "Education Center" is an excellent facility with a large area for orientations and mural projects, an auditorium, two large studios for student and family workshops, offices for docent and education staff, a teacher resource center, a family storytelling room, a "hallway" gallery, and exhibit preparation area, and a large area for exhibits that change periodically. This exhibition area is titled the Sol and Celia Hammerman Gallery. This exhibition space measures approximately forty by sixty-five feet. The overall Education Center is large, attractive, spacious, nicely designed; the ambiance of the Education Center belies the fact that it is in the basement of the Art Institute.

The inaugural exhibit in the Hammerman Gallery is titled ***Art Inside Out: Exploring Art and Culture Through Time***. This exhibit is the subject of the case study reported here. The exhibit opened in October of 1992 and runs through October of 1994. The exhibit was in preparation for approximately two years. The cost of the exhibit was nearly $250,000. The funding was provided by the Chicago Community Trust, the National Endowment for the Arts and the Dr. School Foundation. It should be noted that as a condition for providing funding for the *Art Inside Out* exhibit, contributors specified that "major" works of art be included in the exhibit.

While the case study examined all aspects of the exhibit, the current paper will present a sampling of the various components. Included will be textual elements, identification games, videos, art-related computer games and contextual environments that had been created to elaborate the major artifacts included in the exhibit. Selected components of one of these contextual environments was examined in depth to provide a more holistic look at how some of the principles work in tandem to shed light on the quality of an exhibit.

Methods Used in the Study

The research methods used in this case study include observations of visitors to the exhibit, interviews with the curator, other museum staff, and visitors to the exhibit, and analysis of all text and components that make up the exhibit. One of the interviews of museum visitors was with a curator from an Israeli children's museum. The observations and analysis of exhibit components comprise the major data base of this case study.

The interviews with the curator and other museum staff provide useful and interesting insight into the hopes and intentions they had for the exhibit, but the actual exhibit has to be judged upon what comprises the displays the visitor encounters. Interviews with visitors also yielded interesting comments, but in general this avenue of investigation reflected the cursory and superficial involvement of many visitors with this exhibit. Observations of visitors yielded a number of valuable insights into the workings of the exhibit. Observations conducted at different times of day or different times of year yielded vastly different results. Likewise careful analysis of the exhibit components and textual elements provided many valuable insights; this analysis would appear to explain much of the lack of visitor involvement with the exhibit. Touring the exhibit with a curator from another children's museum confirmed many of the observations and analysis.

What the Exhibit Designers Were Trying To Accomplish

A brochure prepared for the opening of the Kraft General Foods Education Center describes *Art Inside Out* as presenting "12 works of art from the African, ancient American, European, and 20th-century art collections within a museum environment, surrounded by alcoves exploring the origin of six of these objects through learning games, interactive computers / videos, and music." The curator of the exhibit and other staff who worked on the exhibit described the "objectives" of the exhibit as an attempt to present a cross-section of the museum's collections as an introduction for children and other visitors not familiar with the museum. The exhibit was also to address the question of cultural diversity in an "experimental and interactive environment." "Experimental" was defined as using presentation techniques not typical of the Art Institute of Chicago.

The experimental nature of the exhibit is derived from the exhibit's division into the "Inside" section which displays the artifacts and the "Outside" section which elaborates on the artifacts to place them in a richer context than is usually done in art museum exhibits. This elaboration is accomplished with contextual environments for six of the artifacts and an interactive, art-related, computer game that deals with six of the other artifacts. (There were originally 12 artifacts in the exhibit, but one was stolen.) A "calendar" brochure for the Art Institute states, "This installation will be enriched by an interactive environment – involving a mix of computers, video, games, and music – that will help visitors to more fully understand and appreciate art from around the world." The brochure says that the exhibit is designed to explore the point that "the meaning of an object in its original context often may vary from that evoked in a museum gallery."

Brief Overview of the Exhibit

When a visitor enters the exhibit, they are in an area with explanatory text panels and several illustrations to their immediate left, three computer stations are to their immediate right, and straight ahead are several slit-like windows through the partition which sets off this area from the rest of the exhibit. These window slits allow a view into the central gallery hall of this exhibition space – the "Inside" section – where the 11 remaining artifacts displayed in the exhibit are mounted. At this point the visitor is faced with the decision to turn left or right in order to go around this partition. The presence of the text provides a minimal cue that a visitor should turn to his or her left, read the text panels and then proceed around the partition to enter the "Inside" gallery hall. However, there is no explicit direction that a visitor should do so. Visitors were observed proceeding around the right side of the partition, thereby missing the explanatory text, the only advance organizer for the exhibit . Thus the designers fail to establish a perceptual set for some of the visitors to the exhibit. They miss an opportunity to assist visitors with selective perception and to help them interpret what they are about to see.

If the visitor proceeds to his/her left and reads the text panels, they would be walking around the partition and into the main gallery-like section of the exhibition. This gallery runs away from and perpendicular to the partition with the slit-like windows mentioned above. In this gallery the 11 artifacts are displayed much like they would have been displayed in the other public galleries in the Art Institute. The paintings are mounted on walls, while a vase, sculptures, and a large oval dish are in plastic vitrines (Plexiglas display cases) on pedestals; one large sculpture is free-standing on a platform in the center of the room. The lighting is low key and each artifact is accompanied by a label giving the title of the piece, the artist (or creators), medium, place of origin and date, as well as the acquisition information for that art work.

However, the setup of this gallery is somewhat different from what visitors might expect to experience in the other galleries of the museum because the artwork is mounted at a lower than normal height. In addition, each artwork has a second label which asks several questions related to the artifact. These differences might be seen as concessions to children, in particular the mounting of the artwork at a more child-friendly height. The artworks housed in this gallery include a Greek bell krater vase; a Chinese grave guardian beast; a Mayan royal emblem stone; an Italian Renaissance painting; a large, Italian, ceramic, oval dish; a Japanese, wood block print; a French Impressionist painting; an African, carved wooden mask; an American, abstract sculpture; a modern abstract painting; and an American, constructed, wood sculpture. (A small, gold, Coclé armadillo pendant had been the twelfth artifact, but, as previously noted, it was stolen.)

Adjacent to this gallery hall are six alcoves, or contextual environments. Three environments are located off of each side of the gallery. Each environment provides additional information or a context for one of the artifacts in the exhibit. In many cases there is no overt connection drawn between the artifact which inspired a contextual environment and the information or constructions displayed in the environment. In other words, the principles that facilitate the perception of unity – such as proximity and inclusion – have not been applied. As a result, the visitor fails to perceive the relationship between the artifact and the contextual material and the goal of providing greater understanding and, therefore, appreciation of the artifact is thwarted.

After the visitor has toured this gallery hall and visited the contextual environments which might have interested them, they would logically proceed out of the gallery by walking around the other side of the slotted partition which they had come around to enter the gallery. In so doing, they would pass two visitor comment books, which solicit opinions about the exhibit, a series of questions about art and museums displayed on the wall, and three touch-screen, computer terminals, each of which has the same compliment of art-related, computer games. These art-related, computer games provide more context for the five artifacts in the exhibit (and the missing armadillo pendant) which were not accompanied by contextual environments.

Representative Sample Exhibit Components

Perhaps the best way to provide an overall impression of the exhibit is to discuss representative samples of each of the exhibit components. Many of the same problems appear over and over again in the exhibit. When this overall impression has been conveyed, an in depth examination of one of the contextual environments will integrate these separate pieces into one salient picture of this exhibit and its difficulties.

The Use of Textual Elements

The textual elements used in this exhibit play a more central role than the text used in many art exhibits. There is both more text than is usually found in an art museum exhibit, and the text takes very prominent positions in the design of the exhibit. The choices of typeface, font size, ink color and background colors are consonant with principles of figure/ground, legibility, and typeface selection. Instead of the diminutive light gray print on a dark gray background found in some exhibits, much of the text used in the exhibit is a large typeface in solid black on plain white backgrounds. Both the size and the readability of this type are positive aspects of the overall exhibit. Unfortunately, the exhibit also makes an attempt to use smaller sizes of type to differentiate levels of meaning in many of the textual elements of the exhibit. This strategy is not successful as there is no discernible reason or logic for it. Perception principles indicate that the reader's attention will be drawn to the change in stimulation, yet he/she cannot make meaning of it. It is an apparent cue with no significance.

Other problems with textual elements are poor writing and the use of a number of icons dispersed throughout the text in the exhibit. With regard to the first problem, the writing is frequently not well organized, not always accurate, does not convey the information necessary to understand the exhibit, assumes too much requisite knowledge, is not designed to lead the visitor through the text in a logical order, and is studded with mistakes of grammar, spelling, capitalization, and punctuation. The second problem presents an illustration of a non-research based use of icons interspersed in text. It also presents an example of how the collaborative nature of exhibit development allows persons, such as graphic designers, to insert elements into exhibits for decorative purposes or, as in this case, because they were thought to be "fun."

The use of these icons follows no apparent set of rules. The small, black images are about the same size as capital letters in the text and are interjected literally between words in running text. The icons appear frequently in some sections of text and not at all in other sections of text. Icons also appear in the several timelines which are used throughout the exhibit. The icons sometimes appear to mean something and at other times they are totally incongruent with the text. The reader is frequently left wondering why a given word has an icon and another word does not have an icon. The icons in many places appear to disrupt the reader's thought process as he/she tries to figure out the meaning of the icons.

There are a number of strange juxtapositions of icons and text in the exhibit. One representative example follows some text in the contextual environment devoted to the Chinese Grave Guardian Beast. The text reads as follows:

> To make the earthly spirit comfortable, elaborate underground tombs were created with all the furnishings that one would have in this world. In this way, a spirit would never want to leave the tomb and cause trouble for the family of the person who had died.

This icon appears to be a coffee pot. (!) There is no discernible relationship between a coffee pot and early Chines tomb furnishings made explicit in this contextual environment. If there is a meaningful relationship here based upon historical traditions, it appears safe to say that most *children* would not be able to determine the meaning of the icon.

Other inserted icons are disruptive not only because they lack a discernible relationship with the text, but also because they are signs in our culture, i.e., they have conventional meanings incongruent with the passage where they appear. For example:

> It is only in recent years that scholars have learned how to read the complex Mayan hieroglyphs. Even when the stone was carved, most Mayans could not read it. . . .

The arrow implies directionality; it means "look in this direction." Inserting this sign to look away must surely be disruptive to someone reading a line of text, especially if the reader were a novice.

There is also the repeated use of one icon where it appears that the icon has several different meanings, some apparent and some not. Several examples of text and how this icon is used are presented below:

> New ideas and inventions came one after the other. People changed the way they thought about the world after Nicolas Copernicus wrote a book that proved that the earth revolved around the sun. . . .

> . . . This public record of a king's family history told everyone that the ruler had a right to serve as a link with the gods.

> African carvers generally choose soft young wood for masks because it is lighter for the wearer and easier to carve. They carefully choose the tree to be used and make offerings to the nature spirits that the Bwa believe inhabit trees, rocks, and water. . . .

This icon (a dot with concentric circles) appears to be a solar system which at least bears some relationship to the first passage where it appears. However, its meaning in the other two passages is not clear at all. Cognitive psychology tells us that readers cannot help but try to make meaning out of this confusing image in this context. It is difficult to imagine that such confusion could be considered "fun." One is reminded here of the principles that suggest that the effect of humor in an instructional message is unpredictable.

Identification Game in *Grave Guardian Beast* Environment

In the contextual environment which accompanies the exhibit's Chinese Grave Guardian Beast, there are two glass-covered cases set into the wall. In each case there are several cardboard, cut-out figures which represent camels, horses, court members, and hunters. These are "interactive" identification games. Each case has two questions and two buttons to push to reveal the answers to the questions. These figures, which look like poor Xerox copies which have been enlarged and mounted on foam board, include excessive detail, making it difficult to see their criterial attributes. Principles regarding cueing, visual contrast, and light levels are violated in their rendering and presentation. Only one of the figures was described in the text of the exhibit; for the other three figures, the visitor must rely on the text of the question and his/her ability to decipher what the figures depict to be able to answer the questions. An example question would be:

> **Clue:** Hunting is my favorite pastime. I always hunt with my specially trained bird, a falcon. Who am I?

After guessing or figuring out which is the figure which is holding a bird (the only clue), the visitor should press the button under the question to reveal the answer. The rendition of the figures is so poor that it is difficult to see which figure is holding a bird. The answer is revealed by a light which comes on under the correct figure. This is the level of interactivity in much of the exhibit, with the exception of the art-related computer games which will be discussed later. Answers to the questions asked either rely on superficial characteristics of the objects, requiring no problem solving and no inference, or they rely on prerequisite information that most visitors do not have in their existing schemata. In other words, the questions are either too easy or too hard. This circumstance violates principles suggesting that attention and motivation are best maintained when complexity is at a moderate level – challenging, but doable. This game also represents the significance level of much of the content in the exhibit's text overall. No exposition of the meaning, importance, or frequency of falconry in China is given in this environment. This activity is meant to provide context to the Grave Guardian Beast which is displayed at the entrance of this contextual environment; however, the only apparent connection is things Chinese.

Video Presentation in *Butterfly Mask* Environment

The contextual environment for the Butterfly Mask contains text about the use of masks among the Bwa people of Africa where this mask originated. There is also a display of masks from countries around the world and text about the use of masks in some of the cultures represented. There is a stylized reproduction of a butterfly mask and the type of costume that might have been worn with this type of mask. In addition, there is a brief video shown continuously in the environment, which depicts the type of festival where the mask might have been worn and the dancing which might have been performed when the mask was worn in such a festival. (The original Bwa mask is nearly 100 years old; the video was taken in recent times by Christopher Roy of the University of Iowa.)

This display of the mask, the text describing the mask's role in Bwa culture, the stylized reproduction, and the video are all intended to honor cultural diversity which was one of the goals for the exhibit and the artifacts chosen for inclusion. The issue here is what message is conveyed to the exhibit's visitors -- those who tour the exhibit superficially and those who read all the text and watch the video tape. The text and Christopher Roy, the videographer, explain that the Bwa people wear these masks and dance in a frenzy in something of a fertility rite to increase the chance of having a good harvest. Dr. Roy and the curator are both interested in conveying a sensitive picture of the Bwa people.

However, it is questionable that this is accomplished in this exhibit. The problem here is what communication theorists call "framing," i.e., the tendency for humans to interpret stimulation in terms of their previous experiences. This process is closely related to the principles governing perceptual organization and response set. Most visitors to the exhibit do not believe that masks and dancing will help to bring about an improved harvest. There is a chance that they will perceive the Bwa as "silly." More superficially, they may associate the frenzied movements of the dancers with child-like behavior at best and with mental disturbance at worst. It is questionable that enough context could be provided in this exhibit to allow naive visitors to reframe their perceptions of this video. The tragedy here is that the exhibit designers may have unintentionally confirmed prejudices that some visitors have about the value of African cultures.

Art-Related Computer Games

Near the front of the exhibition space, there are three computer stations. These computers each offer the same games and other activities. The games and activities are meant to provide additional context for the six artifacts in the original exhibit that were not contextualized with environments. These computer stations are fairly sophisticated. They are equipped with touch screens which allow players to access all parts of the games – there is not a keyboard or mouse in sight. The games which operate on these computers utilize brilliant color, animation, fading, and sound, and the player has the ability to move or drag various images around the screen during some of the games. For the most part, the programming is competent, but the content is quite limited. These machines could do much more if the games' design had been more sophisticated or perhaps was overtly instructional.

There are eight different games on each computer, as well as, "visits" to several artists' studios, and a look at three additional paintings. The computer games make more use of the technology, while the two activities are basically slide shows. The computer games allow players to create a mock-up of a ceramic dish, play a decorative arts matching game, go on a treasure hunt, remember the colors in a painting, change the color scheme of a painting, construct a sculpture from a collection of scrap metal, deconstruct a sculpture and reconstruct it, and play "brushstroke detective," a game that allows matching of paintings by identification of brushstroke technique. An explanation of two of these games will serve to illustrate the sophistication of the games and their utilization of the technology.

In the Brushstroke Detective game, the players are given sections of four paintings and four smaller circular portions of these same paintings. The instructions tell the players to match the circular portions to the larger sections of the paintings by noting the type of brushstrokes used in each painting and the circular sections. The player then drags the circular section to the larger portion of the painting by placing his/her finger on the screen and dragging the circle to where it fits into the larger part of the painting. If the circle is "released" in the correct position, the computer reveals the entire painting to the game player.

The major flaw in the conceptualization of this game is that the brushstrokes are not the most apparent characteristic of the illustrations given. Frequently, the more salient characteristics are color and pattern. The learner cues on these characteristics rather than the type of brushstrokes that were used, thus circumventing the objective of the game. The designers of the game have done a poor job of identifying the cognitive processes actually required by the game. Therefore, the objective of the game and the process of playing it are misaligned.

Another of the games is described as a "decorative arts matching game." In this game, the player is given a picture of a small portion of some decorative arts object and the choice of "matching" this picture with the names of four decorative arts objects: bowl, clock, vase, or piano. The player makes the match by touching the name of the object which he/she thinks matches the small portion of the object depicted. There are always the same four names from which to choose.

The objective of this game is not to match, but to guess. The player has not previously been given any information by the computer or in the overall exhibit about any of the decorative arts objects depicted in the game . Indeed there is even very little information contained in the small pictures from which one might make an educated guess. This experience is very likely not to be a rewarding one for the visitor. They are set up to fail at this matching task. Here again the game designers seem to have done a poor job of analyzing both the cognitive processes required by the game and the prerequisite knowledge required to play it. Therefore, the game does little to add understanding or appreciation of the larger exhibit.

Representative Contextual Environment: *The Adoration of the Magi*

In order to describe how several of these components are integrated in a single contextual environment, selected elements in the environment for the painting *The Adoration of the Magi* is examined and criticized in some detail below.

Original Painting and Labels

The painting *The Adoration of the Magi* is hung in the "Inside" gallery section of the exhibit *Art Inside Out*. The painting is accompanied by two labels. The first is a typical art museum label which gives the title of the painting, the artist, the medium (tempera on panel), geographic origin (Italy), approximate date of its creation, and the persons donating the work and the accession date. This first label reads as follows:

**THE ADORATION
OF THE MAGI**

Attributed to Raffaelo Botticini
Tempera on panel
Italy, c. 1490

Mr. and Mrs. Martin A. Ryerson Collection, 1937.997

The second label, which asks four questions, is directed at a cognitive level for very young visitors / learners. This second label asks the reader:

Find the three crowns of the three Magi.

How many different animals can you find/
How many people?

Do you hear any music at this event?
What kind?

This type of label is not typically found in art museums. This label is an attempt to make this exhibit communicate more with its visitors, particularly to stimulate conversation between children and parents, docents, or teachers. However, finding crowns, counting people or animals, or identifying that someone in a painting is playing a musical instrument would pose a challenge for only the youngest visitors, perhaps first, second or third graders. However, the labels also pose a problem for such visitors in that it asks the visitor to "find the three crowns of the three Magi." For young visitors, "Magi" would be a problematic word, particularly if the child was not of the Christian faith. It should be noted that diversity is not being addressed well when those of a non-Christian background – those not familiar with the term Magi - are excluded. This insensitivity to those not of the Christian faith is demonstrated in several places in this environment. Here again we see questions that are at once too easy and too hard, both superficial and demanding prerequisite information not available to many if not most young visitors. Failures of both learner analysis and task analysis are evidenced in these questions.

In the contextual environment which accompanies this painting there are several individual components, including a "viewer" and a model, two exhibit cases set into a wall, a timeline and two maps and a "big book" discussing the iconography of the painting.

The "Viewer" and the Three-Dimensional Model

As one enters the contextual environment adjacent to *The Adoration of the Magi*, there is a "viewer" consisting of a partition which holds a line drawing on acetate and an eyepiece on metal supports centered in front of the drawing. When the visitor enters this contextual environment and stands in front of this viewer, they are in one corner of what is basically a rectangular room approximately 12 by 18 feet. The viewer is designed to look from the entrance corner of the environment to the opposite corner of the room at a three-dimensional (3D) model of what might be street scene in a Renaissance city – with palatial buildings lining both sides of a street and a triumphal arch astride the center of the street to the rear of the scene. The model is quite large, and it is set into a frame which measures approximately five by eight feet. The 2D line drawing mentioned above is of this street scene and is approximately 8 inches by twelve inches. The metal supports hold the eyepiece approximately nine inches from this drawing. The eyepiece of the viewer is located at the assumed eye-level of the "generic child" in this child-friendly exhibit. For many children, the eyepiece is too high and for others it is too low.

The object of this arrangement is to look through the eyepiece and align the 2D line drawing with the 3D model located approximately 7 feet in front of the viewer. It must be assumed that the model was intended to demonstrate the artist's technique of one-point perspective. A lack of specified objectives or explanatory text does not help clarify the purpose of the model for the visitor; however, the text on the front of the viewer directs the viewer to find the vanishing point – a term used in one-point perspective drawing.

The purpose of the viewer is not very well realized; the nature of the human eye prevents the perfect meshing of these two "images." The eye cannot focus on the plane of the drawing (nine inches away) and the "plane" (volume / depth) of the model (seven feet away) at the same time. Further, there is no connection made between the viewer and the use of perspective in *The Adoration*. The scene in the model and drawing is similar to those depicted in a number of Renaissance paintings, but it is not at all similar to the architectural scene depicted in *The Adoration*. And, while the use of perspective does play a major role in the painting, it certainly is not the best choice of paintings if one wishes to show an example to teach about perspective.

There is text on the side of the viewer you face as you enter the environment and additional text on the reverse side. This viewer, and the model in particular, attract a great deal of visitor attention. As the curator has noted, the model is very attractive to visitors to the exhibit. The model also represents a major commitment in time and resources for its design, construction and installation. The viewer and model section of this contextual environment succeeds on the level of attractiveness, size, and its ability to generate visitor interest. However, it is a failure and overall negative aspect of the exhibit due to problems with the theoretical basis for using this 3D model.

The use of one-point perspective allows the illusion of three dimensions while depicting them in two dimensions. A typical example of this type of illusion is that railroad tracks appear to meet in the distance, when in reality they are parallel. In this exhibit, the model depicts, *in three dimensions*, how a street scene appears to come together in the distance. This is accomplished by using what might be termed "3D perspective" or "sculptural" perspective. The effect is achieved by distorting the shapes of the buildings and the plane of the ground in the model, i.e., by having the plane of the ground in the model rise as it recedes and the buildings get smaller and closer together as they "move" toward the rear and center of the model. Thus the visitor is asked to compare a 2D drawing - using one-point perspective - with a 3D perspective model (a model using "sculptural" perspective). *These two forms of perspective are not analogous.* What this actually "says" is that the railroad tracks (or the curbs of a city street) really do come together in the distance – that railroad tracks are *not* parallel. This is, of course, highly confusing. This confusion is, however, "modified" by the fact that the purpose and explanation of the model are so poorly presented that the discrepancy is not perceived by most visitors – they do not understand, but only see the attractiveness of the model. The seriousness of this error on the part of the exhibit cannot be underestimated.

The fundamental error of the viewer/model is difficult to explain in a few words. However, once the mistake in the theoretical grounding of this configuration of 2D and 3D images is conceptualized, the seriousness of the error becomes apparent. The implications for what is communicated to the visitor, the waste of resources, and the loss of opportunity that results from this error are made clear. This viewer/model configuration gives the visitor an attractive, but highly confusing, i.e., wrong, explanation of perspective. Even if this confusion only operates at a subconscious level, the visitor is less likely to want to return to the museum. Confusing messages violate recently articulated principles of maintaining motivation; humans are motivated to attend to information that is challenging, but not incoherent or internally irreconcilable.

Wall-Mounted Display Case About Egg Tempera Paint

If a visitor continued to proceed around the contextual environment in a clockwise fashion, they would next encounter a wall-mounted display case (set into the wall) which addresses the egg tempera paint used by Botticini to paint *The Adoration*. This display case contains both text and artifacts, i.e., objects and materials which illustrate the text. There are a number of problems with the text and the information it presents. As with other portions of the exhibit, there is no connection (delineation of objectives) drawn between *The Adoration* and this exhibit case. The visitor is left *to assume* that this case seeks to "explain" the tempera paint utilized in the painting. The visitor would have had to draw this inference from the phrase "tempera on panel" from the gallery-like label which accompanies the painting in the "inside" gallery portion of the exhibit. This, of course, assumes the visitor read the label. (Many gallery visitors do not read labels due to their small size and the dearth of information they give -- and possibly because the labels are confusing.) Observations of visitors to the exhibit reveal that many visitors do not read the labels which accompany *The Adoration*.

A major problem with this display case is the text is poorly written and not particularly accurate. For example, the statement, "A layer of rabbit skin glue and chalk gesso, a plaster of paris [*sic*] mixture [*sic*] are applied to prevent the wood from deteriorating," is fraught with problems. Of course, the word "paris" should be capitalized. It also appears that this sentence is jumbled. Perhaps the curator intended to say, "Renaissance painters painted on wood. A layer of chalk gesso (a mixture of rabbit skin glue and plaster of Paris) was applied to prevent the wood surface from deteriorating." As the text was originally written, a novice visitor might find themselves asking "What wood?" Even if the visitor read the label on the original painting and recalled the wording on the label, the label says "panel," not "wood." Furthermore, even if the sentence is clarified and "unjumbled" for the visitor, the novice is misinformed. The purpose of gesso is not to protect the wood, but to provide a smooth white surface on which the tempera paint might be applied.

Overall, this wall display case is confusing. It had the potential to explain an important element (tempera paint) in the creation of *The Adoration*. The important potential of the display case is particularly undermined by the lack of a clear connection between the tempera paint medium and the painting, *The Adoration of the Magi*, which is the "excuse" for the introduction of the topic of tempera paint into this contextual environment. The text in the display case violates principles regarding the use of standard, correct English as well as principles of structured text suggesting continuity in terminology.

Time Line

Proceeding around the room, the visitor would encounter a time line. A similar but somewhat more extensive time line was also part of the introductory section for the entire exhibit. However, the time line in this contextual environment has a section of the "line" colored in brown, 900 to 1900 AD. There appears to be no logical, discernible reason why this block of time is highlighted in color. Perhaps it would have made sense to highlight the period of time which is generally considered to encompass the Renaissance. The time line uses color as a cueing device – a good perceptual strategy – but focuses the visitor's attention on a time period that does not represent the Renaissance.

This time line (and the six other time lines in the rest of the exhibit) lists a number of historical "happenings" and their associated dates. Some of these historical happenings are accompanied by an icon which might be associated with the historical happening it accompanies; however, some of these icons are indecipherable. The text used in the time line is crowded and suffers from a lack of good text design; the information included for the entries on the time line is inconsistent and its placement varies from entry to entry. . Very few visitors have been observed to spend a significant or even a small amount of time viewing the time line in this environment (or those elsewhere in the exhibit). This may be due in part because these significant historical happenings are not explained or related, except by chronology, to *The Adoration* and because the time line overloads perceptual capacity.

Recommendations for Improving Museum Exhibit Development Practices

While the principles discussed in this case study are generally accepted by instructional designers, they run counter to the thinking of and are not a part of the knowledge base of many museum professionals. For example, providing guidance for the visitor through the exhibit would be counter to the expressed beliefs of the exhibit's curator. In an interview she stated, "An exhibition in a museum is different from say a course in a classroom. If you are teaching a class and you've got their 100% attention for an hour or whatever you get, and you have specific goals and objectives and a lesson plan. An exhibition is a larger kind of entity and people approach it differently. And you might say you would number things, but I really wouldn't want to restrict a visitor. I would not want to do an exhibit where I numbered and gave people a specific path. I think that it's [an exhibit] a more complex process and that learning can take place. I guess I don't feel that I really want to have that kind of set goals; it's too narrow."

The authors of this case study obviously disagree. We are inclined to believe that museum professionals have ignored fundamental human information processing principles having to do with perception, framing, prerequisite knowledge, short term memory, drawing inferences, and in general, making meaning. They would be well advised to master instructional design principles as well as to adopt instructional development processes to increase the likelihood that critical steps such as envisioning outcomes, learner analysis, task analysis, message design, and formative evaluation are well carried out.

The following recommendations will provide excellent guidelines for the improvement of the exhibit development process at the Art Institute and museums in general. These recommendations address systemic problems in the exhibit development process at the Art Institute. The implementation of these recommendations will improve the overall educational value of exhibits developed in the future.

Each time a new exhibit is created, it should have broad, general goals to guide its development. From these goals, specific, detailed, precise, behavioral objectives should be written. These objectives should be re-written, added to, modified, expanded, deleted, as necessary, throughout the exhibit development process. Formative evaluation (as well as, the other concepts and principles of instructional development) should be utilized to create exhibits. Exhibits should be evaluated in a mock-up stage before exhibit elements and total overall design is finalized. Problems discovered should be corrected, and the exhibit should be evaluated again. When an exhibit is completed and on display, it should be evaluated and information learned should provide feedback to improve the exhibit evaluated and to "inform" the exhibit development process in the future. It should be noted that the objectives are what permit and drive a meaningful evaluation process – an evaluation process that yields evidence about the educational success of an exhibit and information which would improve future exhibits and the skills of the exhibit development team. For the optimum utilization of the feedback provided from the evaluation of an exhibit, the information gathered must be considered/utilized/reflected upon through the lens of a research-based, instructional design schema or construct.

Artifacts and works of art utilized in an exhibit should be chosen for their ability to convey the objectives of the exhibit. Use of the "best" or "most famous" object or work of art does not always best facilitate the exhibit's attainment of its objectives. For example, Botticini's *The Adoration of the Magi* might not be the best choice if a curator wanted to illustrate perspective.

Instructional message design should be utilized to facilitate communication. The decorative or "fun" impulses of graphic artists should be resisted. Only decoration that does not interfere with communication should be allowed. Graphic artists working in educational settings should master the principles of instructional message design. When instructional message design is utilized to create effective communication, there is still much creative work to be done to make an exhibit, and the included text, attractive.

Spelling, punctuation, and grammar, should be correctly used. This is especially true when designing exhibits for children; the exhibit should model correct English. It would seem wise to hire professional proofreaders for precision in this matter. *This is not a call for an editor* who might be tempted to change the text – thereby altering the meaning intended by the instructional designer/exhibit developer/curator.

Unless a very specific audience is the reason for an exhibit or program, accommodations to one specific audience that limits the access of a number of other audiences should not be made. In the case of Art Inside Out, the "child-friendly" elements made the exhibit less accessible for small or large children and adults. Instead, strategies that would make an exhibit accessible to everyone, or the greatest number of visitors possible, should be utilized. During the summer months when school groups do not visit the museum regularly, observations of visitors to the *Art Inside Out* exhibit indicate that the majority of visitors to the exhibit are adults. This is unfortunate since a number of aspects of the exhibit are geared to the height of a small child.

Instructional message design should be mastered by museum exhibit designers. Without these principles, the exhibit developer only knows something is wrong and does not necessarily know why *unless* this knowledge is related to a theoretical framework or schema. If this theoretical framework is not present as an "exhibit development" schema, the curator is likely to repeat the same types of mistakes over and over again in different exhibits. They may never realize that they are making similar mistakes which violate the same instructional principles because the mistakes are in a completely different context.

Incorporate instructional design principles into all facets of museum education, including exhibits, programs, teacher workshops, and materials for teachers. For educationally effective exhibits and programs, it must be recognized that some members of the exhibit development staff must possess knowledge and skills in instructional design – skills which are more important than subject mater expertise skills in art history or fine arts.

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Title:

What Works: The Results of Evaluations on Two Interactive Multimedia Programs

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Introduction

American schools and the way they teach have failed to keep pace with information technology changes in society at large. Schools have clung to the printed word. As a result, students are increasingly distracted and disengaged from the formal learning process. Schooling fails to provide the rich, visual images and interaction so readily available in the Information Age. But not all schools ignore the call of technology. At the American Institute for Learning (AIL), a model self-help program for youth, information is presented to young people in a stimulating way by using interactive multimedia. Multimedia is typically defined as the dynamic combination of technologies such as computer text, video, audio, graphics, and animation.

AIL has developed two drug awareness programs for secondary students who have used substances experimentally or are being challenged by peers to experiment. The first program is on addiction while the second program explores the process of recovery. Two separate production companies collaborated with AIL in developing these programs and the result is two related programs with different design and interface approaches.

Program Overviews

The fist program, *Addiction and Its Processes* is designed to help young people become aware of the primary symptoms and phases of chemical addiction and the effects of chemicals on the mind, body and spirit. The program objectives are as follows:

1. Identify phases of chemical abuse and addiction.
2. Recognize some of the possible symptoms of each phase.
3. Identify some of the physiological and psychological effects of each phase.
4. Determine if he or she is in one of the phases.

The power of video illustrates the experiences of three young people as they deal with the effects of their use of alcohol, marijuana and cocaine. Each character's story is presented separately through a series of video scenes. Learners may follow each character through the phases of addiction linearly or select between scenes. Using the capabilities of the computer, learners can explore issues and answer questions about the video vignettes. A rich, informational database provides facts on the characteristics of the phases of addiction, effects of substances on the body, thoughts and feelings of the characters and their friends and family, and insight on the character's perceptions of their addiction.

The second program, *Life Moves: The Process of Recovery* shows that there is hope for recovery from chemical dependency, what recovery involves and the advantages of sobriety and a healthy lifestyle. The following are the overall program objectives:

1. Identify the process of recovery from chemical addiction.
2. Identify the basic tools of recovery.
3. Identify the critical role of support groups in recovery.
4. Identify actions necessary to maintain sobriety.
5. Describe the impact of relationships with family and friends on recovery.

Three different young people's stories are explored along with a portrayal of attitudes and behaviors of friends and family that enable chemical dependency. The three characters introduced in *Addiction and Its Processes* are also involved in the recovery process. This program, using support meetings as focal points intertwined with scenes from the character's lives, follows a basically linear path through the first year of recovery. The interactive multimedia allows people not only to learn about the process and stages of recovery, but to also witness and fell the struggles associated with recovery. The program also provides graphical and database information on strategies to integrate recovery into daily lives, the 12 basic steps common to many recovery methods, and material on the nature of chemical dependency.

The interface of these two programs is different. *Addiction and Its Processes* is separated by the three stages (early, middle and late) of addiction in each of the three character's lives. Learners aren't provided a recommended path and can progress through the program in any manner. In *Life Moves* the lives of the characters converge at a series of support group meetings, then diverge as they go out into their lives. All program components are accessible through a navigational system called the "Roadmap", but several features of the interface encourage linear progressions through the story. At interactive choice points, which are interspersed throughout the program, the interface discourages learners from skipping segments by requiring completion of all branches before continuing on with the story.

Evaluations

AIL conducted evaluations of *Addiction and Its Processes* in the Spring of 1992 and *Life Moves* in the Spring of 1993 to ascertain if revisions were needed and to evaluate the program's effectiveness. Prior to the actual field testing, evaluations were conducted as part of an on-going process throughout the developmental stages of each program. When developing costly and labor intensive interactive technology-based instruction, on-going evaluation is necessity (Savenye, 1992). Subject matter experts reviewed all scripts and storyboards. Teenagers representative of the target audience provided ideas and reviews. A common feature of systematically designed materials is formative evaluation which involves testing draft versions of materials with representative learners (Andrews & Goodson, 1979).

Formative evaluation is one of the stages of the systematic design of instructional materials (Dick & Carey, 1985). The three major areas addressed by formative evaluation are :

1. student achievement.
2. student and teacher attitude toward the content and curriculum,.
3. Use of the program in the actual instructional setting.

The evaluations conducted addressed all three of these important areas. Bear in mind, however, that this evaluations looks at interactive programs with complex sets of interrelated factors. Due to the complexity of this technology, researchers are challenged to isolate factors crucial to the success of interactive technologies (Reeves, 1986; Savenye, 1990).

Method

During the Spring of 1992, AIL evaluated *Addiction and Its Processes* in seven different facilities. These locations represent the range of people who will actually use the program. Six of the locations were in Texas and the seventh was in Arizona. A total of 44 students participated and used either an IBM platform or a Macintosh platform. *Life Moves* evaluations were conducted a year later in five facilities with a total of 35 students. Again, students involved were representative of the target audience. The following research questions were separately investigated for each program:

1. How do students use the program?
2. What are the factors affecting students' acceptability of the program?
3. How effective is the program in teaching content? What did the students learn?
4. What are the facilitator's perceptions of the program?

Instruments

To gather information about student achievement and attitudes, interface issues. screen design, authoring, and instructional design concerns, data were collected on several different forms. Student data collected included a general subject knowledge pre- and posttest, program posttests and attitudinal questionnaires. The students were given the pretest prior to any exposure to the programs and then given the same test as a posttest after they had concluded the programs. They viewed the program and completed separate posttests for each section. They also responded to an evaluation survey (for biographical data and for their perceptions on instructional presentation and content) as well as an orally administered student interview.

Student achievement was measured by the pre- and posttest and by the posttest after each section. The evaluation survey and student interviews assessed students' attitudes and perceptions. These instruments were brief and matched to the program's objectives. Prior to the actual administration of these instruments, they were tested with a small group of students to verify if the tests were at a seventh-grade reading level. Site facilitators also reviewed the tests prior to their implementation.

Data regarding the facilitators' perceptions were gathered on an evaluation questionnaire. On this form, there were 4-point scale from "strongly agree" to "strongly disagree" questions, yes/no response and open-ended questions to assess opinions on program interface issues, content and factors influencing program acceptability.

Data Analysis

Program Use

Prior to using *Addiction and Its Processes*, students possess some information about drugs and their adverse affects. Yet only eleven of the forty-four students were aware that there are three stages of addiction. When asked if they thought it would be helpful to have an instructional program about addiction, all the students agreed. In general, students came to the program open-minded to an instructional program on addiction and willing to learn.

With regards to the question on how students use the program, the students were in agreement that the instructions and menus were easy to use. When asked if they felt comfortable using the program without teacher assistance, only four students disagreed. However, it was apparent that some students wanted to select only the video vignettes. While the students liked the learner control and freedom, they may not be well suited to know how to best select instructional paths. As it is now, they can skip relevant instructional content. Though the user is encouraged to follow the story of one addict, the interactive capabilities of random access to other stories did allow for a user to get lost. There is nothing within the program that offers a recommended path or that provides information about what to review if remediation is needed.

The interface of *Life Moves* provides a basically linear approach by using an interface that links important content to guide students to program essentials. One student stated, "They got to the point and that makes us think instead of just watching the story." Another student liked all the different options, while another felt that all the choices made the program too long. Six of the students found there was too much information presented. However, a few students requested more information on specific topics, such as how to get healthier. While the program presents a comprehensive, layered approach, it also requires more learning time.

Interestingly, some students watching *Life Moves* did not feel comfortable about using the program alone. However, all of the students found the instructions and menus easy to follow. The program provided a command and control center, but the students seldom went to it. When they were led through the program, the students didn't feel a need to reference a program map.

On the Student Interview form, they were asked if they liked using this type of program for this topic. All but a few of the students said they did with one student noting, "It is better than listening to someone talk." Five of the students said that it is neat watching TV on a computer.

Acceptability Factors

When students were asked if they were influenced by *Addiction and Its Processes*, all but four of the students believed they had been. One student said that it was helpful because, "...it made me think." The single most engaging feature of this program is the video vignettes. They are powerful, realistic and dramatically outline three young people's chemical dependency struggles. The stories were told in short (2 minutes or less) scenes that clearly documented the stages of addiction. The students overwhelming agreed that the video stories brought to life people's experiences. One student left the room wrought with emotion after viewing a scene.

The program dealt with numerous tough issues in a frank manner. For example, had emotional or spiritual issues been avoided, some of the program's impact would have been lost. The students need honest information in dealing with addiction and *Addiction and Its Processes* does not skirt sensitive issues. While you can present information in a realistic way in a book, it helps when you can bring it to life with video.

The video vignettes in *Life Moves* did not so strongly affect the students. The stories were presented and then linked to additional content. The video was in some respects "lost" in all the material. In fact one student remarked, "So much going on that I couldn't concentrate sometimes."

While a majority of the student s found it engaging, they did offer changes they would like to see made. Some wanted more on the characters. It was hard to get to know the video characters due to the way the program is presented. Several students wanted to shorten the program and to make it more realistic. One student noted, "Some people may find the God parts disturbing because of the different views." Often the students had to click on a button to go on in the program. Some felt they were asked to click to keep the program going, but they were not allowed any instructional choices. If students are asked for input, they should be able to make a real choice.

Effectiveness Results

In general students possess street knowledge of drugs, but lack understanding about medical and emotional drug issues. Often what they need is a way to sort out their feelings and experiences concerning drugs and knowledge to help them differentiate between healthy and unhealthy drug choices.

Students using *Addiction and Its Processes* scored highest on test questions that were taught through the video rather than through the informational sections. The emotional power of the video helped the students to comprehend the information. Also, the students often omitted related instructional content, such as information presented in The Body section. It appears that the students gained new knowledge and were affected emotionally.

Most of the students using *Life Moves* could correctly answer questions on the video segments on the posttests. Half of the students experienced some difficulty, however, with Ben's story. Did this stem from the complex issue of spirituality or from the way the story is presented? This issue needs further exploration.

Students were able to correctly respond to questions covering content they were automatically connected to in the program, but they did not do as well on topics they were given an option to explore. For example, students had problems answers questions on slogans presented in the Quick Help section. It is probable that the students never accessed that section.

Facilitator Perceptions

Facilitators for *Addiction and Its Processes* found it meaningful for people who are trying to understand addictions. While they endorsed the program, they still have some reservations about it. One felt that the reading level was way too high and others felt students would not read the screens no matter what the level. A suggestion was made to have all printed screens read aloud. Due to the technical jargon presented, a read aloud feature would be useful.

They gave a variety of comments. One stated, "This program personalizes addiction and stimulates an emotional response which in turn leads them to want to know more." Another facilitator, tentative in accepting this type of instructional mode , noted, "I think they want to watch, but I don't think they automatically learn. They have to try to learn, passively it won't happen."

The facilitators found *Life Moves* easy to use and informative. They all found the content accurate and without bias. Interestingly, three of the seven thought the program should be used after the topic of recovery has been introduced. A broad introduction or a chance to go over prerequisite knowledge should be included.

All the facilitators found that the variety of resources were applicable and useful and that the information presented related clearly to real life applications. However, there appears to not be enough opportunities for students to practice. Seldom were they given any activities that helped them practice or review the content.

Conclusion

These evaluations were used to validate and revise *Addiction and Its Process* and *Life Moves*. Both multimedia programs present stories enhanced by realistic video and layers of textual and animated content. The data indicate that these programs are a viable way to teach young people about addiction and recovery. The power of video pulls the students into the programs, but it can be weakened by too many other instructional options. In *Addiction and Its Processes*, the video was more compelling because it was allowed to carry the programs.

The results of this study were used to revise the programs. While these specifics are not presented in this paper, other findings are of general interest. Designers should look at how to effectively integrate the video segments, ways to link content that still give learners some control, how to decide when student input is truly needed, ways to teach technical jargon at different reading levels, and how to provide adequate prerequisite instruction in a multimedia format.

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Title:

Educational Technology Adoption: An Information Systems Perspective

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Introduction

Educational reform is a leading topic in socio-political debate, and was one of the key issues in the latest U.S. presidential election. Many educators envisioned educational technology (ET) becoming a large part of that reform. Heinich (1970), for example, foresaw a major role for educational technology as a tool to support teachers, as a replacement for teachers and a conduit for directly educating students, and/or as a means to forming a partnership with teachers whereby technology delivers routine instruction and teachers focus on planning and educational management. Indeed, interest in educational technology and some practical successes during the last 50 years led educational technology to become a unique academic and professional field. The field has academic departments and courses, professional organizations, journals and conferences, academic professionals who identify themselves as educational technologists, and of particular significance, a considerable amount of scientific research. One could easily assume that with so much interest in educational improvements, with so much potential for educational technology as part of the expanding information age of technology, and with all of the research within the field of educational technology, deep and broad improvements in established education would have resulted.

Many educational technologists, however, lament what they perceive to be few implementation successes and a decidedly low impact of educational technology on established education (Reigeluth, 1989; Winn, 1989; Gentry and Csete, 1991; Heinich, 1991a). Educational technology is said to be an applied field, yet its knowledge, based on empirical research, is not applied by practitioners to the degree expected.

Many authors, publishing within the field of educational technology, have analyzed the problem and blamed a wide range of factors. Some view teachers themselves as the culprits; citing the idea that teachers are threatened by perceived professional irrelevance that would cause them to naturally resist educational technology (e.g. Heinich, 1991a). Other authors blame simple bureaucratic inertia and lack of educational funding (Gentry and Csete, 1991). While there have been many accusations concerning weak adoption of educational technology in general education, some educational technologists criticize research as a malefactor, it is either too descriptive and not prescriptive enough (Clark, 1989), it is based on too many confusing or conflicting theories (Ross and Morrison, 1989), the research simply lacks external validity to everyday situations (Reigeluth, 1989), or that it fails to take advantage of related research in other fields (Clark, 1989).

The problem of innovation and adoption (and ruminating self-examination) is not, however, unlike what occurred in the information systems (IS) field during the early 1980s before the widespread proliferation of personal computers and readily available commercial software packages. A considerable amount of information systems research and writing has been done on who, what, when, where and why (or why not) information systems are adopted, including research on why some information systems are adopted but then not used. It is unlikely that the problems with the adoption of educational technology innovations are entirely unique to education and educational technology. Instead they include problems commonly faced by proponents of any new technology.

This paper concentrates on the how problems of educational technology adoption. It presumes the validity of educational technology research on effective and efficient innovations and focuses instead on the adoption and implementation process and its factors. This paper outlines and compares the conceptual definitions of educational technology and information systems and relates the histories of ET and IS adoption. It outlines and explains information systems adoption paradigms, models, and frameworks and suggests similarities and differences between IS adoption/implementation and educational change. Finally, this paper discusses educational change and what can be learned from information systems adoption models.

Definitions

One of the immediate issues in discussing the educational technology adoption problem are the varying definitions of educational technology. The Association for Educational Communications and Technology (AECT) defines educational technology as

a complex, integrated process involving people, procedures, ideas, devices and organization, for analyzing problems, and devising, implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning. (AECT, 1977, p.59)

Others define educational technology as a methodology or set of techniques (Cleary et al., as cited by Gentry, 1991), a "body of knowledge" (Dieuzeide, 1971, p.1) and as procedures and devices (Silverman, as cited by Gentry, 1991).

Instructional technology (IT), a phrase frequently used interchangeably with educational technology, often carries two connotations. The definition stated by the Presidential Commission on Instructional Technology (1970) includes both the view of instructional technology as

the media born of the communications revolution which can be used for instructional purposes along side the teacher, textbook, and blackboard. (p.19)

and as

a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communications, and employing a combination of human and non human resources, to bring about more effective instruction. (p.19)

Engler (1972) similarly defines instructional technology within two categories, the first as "hardware-television, motion pictures, audio tapes and discs, textbooks, blackboards, and so on" and secondly as

a process by means of which we apply the research findings of the behavioral sciences to the problems of instruction. (p. 59)

One should not view these definitions of educational technology (and instructional technology) as nebulous, contradictory or exclusive definitions, but rather as inclusive definitions to bound the area of interest. By combining the essence of the definitions above (and others cited by Gentry, 1991), this paper defines educational technology as

the application of people, devices, knowledge, and procedures for efficient and effective education.

The significance of combining the varying ET and IT definitions is a clear correlation with a textbook common definition of computer-based information systems (e.g., Davis and Olson, 1985; Laudon and Laudon, 1993):

devices (computer hardware, software and communications), people, and procedures for organizing, storing, accessing, and maintaining information.

The definitions of educational technology and information systems identically focused on devices, people, knowledge, and process suggest a theoretical linkage between ET and IS application and adoption. The problems and issues associated with adopting information systems appear to have direct bearing on the problems and issues with adopting educational technology. Information systems research on adoption, therefore, would seem to offer rich insight and direction for fruitful educational technology adoption research. If the theoretical and practical parallels between ET and IS adoption hold, what information systems has learned about IS adoption may be what educational technology can benefit from in the future.

Educational Change: A Summarized History

Fullan (1991) identifies four distinct historical phases in educational change: adoption (1960s), implementation failure (1970-77), implementation success (1978-82), and intensification versus restructuring (1983-90).

Fullan's first phase (adoption) came largely as a result of Soviet success in launching a satellite in 1957 (years before the U.S.). The subsequent "Sputnik crisis" led to large-scale curriculum innovations, technologically-oriented instructional systems, and the advocacy of inquiry-oriented and student-centered instruction. In the rush to meet the crisis, according to Fullan, the emphasis was on how many innovations could be adopted. the more the better as a mark of progress. During this period instructional systems were researched and developed. Significant federal funding for R & D laboratories, mandated evaluation of federally funded educational projects, and the redefinition of audiovisual instruction to include instructional development and technology gave the field of educational technology increased visibility and credibility with educators.

During the 1970s, however, innovation got a "bad name." According to Fullan, the 1960s' innovations had been adopted haphazardly with little follow-through, leading to pronounced implementation failures. By the end of the 1970s, nevertheless, there were some significant, well-documented successes that provided important frameworks and theories for comprehensive educational reforms. The comprehensive reform movements that began in 1983 (as a result of the watershed document A Nation at Risk by the National Commission on Excellence in Education) took many approaches, including the use of educational technology.

The advent of microcomputers in the 1980s appeared to offer the dawn of a new era with computer-based instructional systems. The wide availability of relatively inexpensive desktop computers, the capabilities of computer-driven media, and the inherent ease of developing, using, and improving software, provided a ready vehicle for applying educational technology. By 1989, 76,395 of the 79,693 U.S. public schools had two or more microcomputers, averaging about 20 per school (Quality Education Data, 1989). Their use, however, was primarily for administrative and clerical applications and not for the process of teaching and learning. The most common educational use of microcomputers was limited to teaching computer "literacy" (Ely, 1991). Higher education wasn't reported as any better; the average U.S. university, in terms of its use of information technology in teaching, was substantially behind the typical elementary and secondary school (Newman, 1989 as cited by Ely 1991).

The Information Systems Adoption Problem: A Brief History and Comparison to the Adoption of Educational Technology within Education

Although electronic computers were used for military purposes in the 1940s, the public application of computers for information processing began in 1954 when one of the first computers was installed to process payroll at a large U.S. corporation (Davis and Olson, 1985). There have been three generally recognized eras in information systems adoption.

The first era was from 1954 to about 1964 when computers were used for accounting and clerical applications in major organizations. Information systems were very difficult to use and expensive. Very few people understood how they worked, even fewer knew what to do with them. There was a wealth of research and theory that predicted enormous benefits from computers in everyday business and personal life, far beyond accounting and clerical use, but potential users and those in management positions could only wonder at the futuristic predictions while continuing traditional work habits. With considerable simplification, this era could roughly equate to the adoption of educational technology innovations in education prior to 1983.

During the second era, from around 1965-1980, the breadth of applications expanded due to improved general purpose programming languages. Major businesses saw computers as a strategic weapon, or at least an image maker, and management began to see the potential efficiency benefits from computers. There were large investments in computers and one-of-a-kind application software. Computers were ensconced within glass "throne rooms" tended to by computer specialists who were intermediaries to users of computed data. Users still didn't understand computers or their potential, but they began to be exposed to the effects of computing. People were mostly forced to adapt to computers and, increasingly, to depend on them for record keeping as well as finance and accounting. These systems were designed by computer specialists who tended to oversell capabilities, had little understanding of user needs, and increasingly built systems that either didn't work, went way over budget, or users wouldn't use. Management perceived the importance of computers, but not how to apply them. As the chief strategist for a major U.S. bank said: [Computer] technology is our top strategic concern, not because it outweighs everything else, but because we are unsure what to do with it. Although we have a strategy for the marketplace, the technology issues seem to be eluding us. We can't seem to grasp the bigger picture (Parsons, 1983).
Information systems academics and professionals bemoaned the dirth of effective IS applications taking advantage of empirical research, while management complained that IS research wasn't practical enough or relevant.

This second IS era seems to correlate with the present state of educational technology research, development, and adoption. During the 1980's, educational technologists also foresaw the importance of the use of technology in education. Educational software increased in availability and to become more "user-friendly." Innovators, however, made mistakes similar to IS designers. Educational programs and products have often been designed by specialists who did not understand the user (teacher) or the classroom learning environment. These innovations, therefore, were not implemented as the designers intended.

The third IS era began with the advent of microcomputers around 1980. The entire mindset of users adapting to computers was reversed as powerful applications that adapted to users were mass-produced and made commercially available. Moreover, non-procedural programming languages allowed non-programmers to write software specifically tailored to their needs, conditions, and location. Simultaneous communication innovations that digitally tied computers together allowed the full potential (widely predicted by researchers in the 1940s) of computers and IS to overcome time and distance. For most industries, information systems were no longer a service or simply a medium for information, it had become the core impetus for an entire re-engineering of organizational processes. The second era issues about what can be done with information systems became third era how issues as new, practical applications spread. Information systems researchers began to struggle just to keep up with IS practice, let alone perform research that isn't obsolete before it's published.

This third IS era parallels current trends in educational technology in the 90's. Given the theoretical and practical parallels between educational technology and information systems, educational technology should explore information systems research on adoption and implementation for insights and guidance.

Information Systems Adoption Theory and Research

Information systems research on IS adoption and implementation has been ongoing since the 1950s with the earliest computer system applications. By the 1980s, implementation was one of the four most heavily researched areas within the discipline of information systems [Culnan and Swanson, 1986]. Two basic adoption paradigms were used for research: factors and process.

Factor Paradigm. The factor paradigm, the dominant paradigm in information systems implementation research, sought to identify and relate the many factors involved in IS implementation success, the what behind successful adoption. Six key variables have been identified from scores of empirical research and analysis efforts:

1. organizational need and support
2. user personal stake in success
3. user assessment of system and organizational support for it
4. user acceptance of system
5. use of system
6. satisfaction [Lucas, Ginzberg and Schultz, 1990].

These factors are linked into a generic model for IS implementation as shown in Figure 1 found in Appendix F.

In this model, management support for a system, organizational changes required as a result of the system, and the urgency of the problem the system is supposed to address combine to affect the user's perceived stake in the system's adoption. User stake, in turn, influences user perception about the system (how efficiently and effectively it works toward the user's goals) as well as the organizational support behind the system (e.g., corrective maintenance, improvement, supplies, etc.). The user's perception of the system and its organizational support in turn directly affects the user's acceptance of the system, in addition to the technical characteristics of the system and the characteristics of the user. User acceptance, overt organizational support, and the user's personal stake in the system then determine how (or whether or not) the system is used. Experience using the system then directly determines satisfaction with the system from a user and organizational standpoint. Also generally believed to be important factors (but not empirically confirmed with strong data or consistently among researchers) are: user knowledge of the system purpose, user decision making style, user job characteristics, user/designer joint system development, and user knowledge of the system (Lucas, Ginzberg and Schultz, 1990). Underlying the entire model is the assumption that user acceptance and use are voluntary; the model changes considerably when system use is mandatory.

Under the IS factor implementation model, adoption and successful implementation largely depend on:

1) gaining support and commitment from the user's management (e.g., funding, job re-design, organizational changes, rewards and incentives, operational support and training)

2) seeking out potential users as early adopters who have a significant personal stake in the problem the system is designed to address, directly involving them in the design process, designing the system to target their technical needs as well as personal characteristics, and focusing attention on their adoption and early use

3) ensuring that the system addresses user personal stakes in system use.

Process Paradigm. This paradigm for information systems adoption and implementation research addresses the process of organizational change and management support behind system adoption. This paradigm takes the standpoint that systems simply address organizational and user change needs and provide a vehicle to implement those change needs. Therefore, how one implements a technological change is the key in this paradigm to successful adoption and use. Three models are prevalent in the IS adoption and implementation research under the process paradigm: technological imperative, organizational imperative, and emergent perspective (Keil, 1991).

The technological imperative model is based on the sociological assumption that external forces (the environment) cause internal changes, namely technological changes, to user behavior. In consonance with innovation theories, this model revolves around two change process factors: the technological advantage the system provides a user in performing his or her functions, and the system's ease of use. Together, these process factors determine system use. To promote adoption, management ensures that the system provides technological advantages (or at least that the benefits outweigh the detriments) and that the system is technologically easy to use. Management's agents to this end are IS specialists who are trained in systems, the organization, how to elicit requirements, and how to appropriately design systems for the users. This model is consistent under voluntary or mandatory use situations.

The organizational imperative model assumes that people are causative decision makers in anticipation or in response to environmental changes. Successful adoption and implementation therefore depend on successfully managing the decision making and implementation processes. This model, primarily based on the change and innovation work of Lewin (1947), consists of three phases. According to this model, successful change depends on unfreezing a situation by creating a climate or motivation for change. The second phase consists of the actual change based on analysis, design, development, implementation and training for a system and the organizational changes that must accompany the system. The final phase requires refreezing by institutionalizing the new system (with resulting organizational stability). This model (as shown in Figure 2) emphasizes that an organization with stable political, personal, and social coalitions must first be disturbed before change can be accepted. Although there are many roles (e.g., the user, management, IS developers), management plays the key organizational role in directing the change process.

(Figure 2 found in Appendix F)

The key to adoption according this model, therefore, is management awareness of the need for change, awareness and support for a change vehicle (the system with attendant personnel, data, process and organizational structure changes), determination and follow-through on changes, and institutionalization of the changes. While this model is associated more with mandatory than voluntary IS adoption, it can apply equally to both situations. Based on the managerial approach to implementing the change, management can serve as a catalyst to user change as well as an orchestrator.

The final model under the process paradigm is the emergent perspective model that assumes people and technologies interact in unpredictable ways. What's important is perpetually adjusting that interaction in response to uncovered barriers to success (as shown in Figure 3) (Leonard-Barton, 1988). The key point of this model is that there must be mutual adaptation between technological systems and the organization (including the organizational structure, its management, support, and the users). Change is assumed to be the norm, whether from internal or external environmental forces. No technological system, the model presumes, can ever satisfy all organizational needs forever and will therefore require continual, incremental changes. Likewise, no organization can remain static in light of technological changes or opportunities provided by systems.

(Figure 3 found in Appendix F)

The key to adoption in this model is the initial deployment of a system, followed by orchestrated monitoring and adaption. Management and users must be willing to innovate and to take risks on the initial adoption and implementation with the understanding that problems will occur. Management and users must also be willing to invest resources (e.g., time, personnel, budgets) to identify and analyze implementation problems. Most importantly, they must be willing to continually implement system and organizational changes in a perpetual cycle of change, analysis, and correction. In organizational terms, this is conflict management, an essential feature of organizational management that entails managerial processes, structure, and content.

These information systems adoption and implementation paradigms, models, factors and processes provide ample suggestions for how to increase and improve successful educational technology implementation in education, as well as provide plentiful opportunities for research.

Educational Change Theory and Recommendations to Educational Technology Adoption and Implementation

Research on educational change has also produced knowledge of factors associated with adoption and affecting implementation. Fullan (1982) synthesized existing information and reported the factors contained in Tables 1 and 2 below.

FACTORS ASSOCIATED WITH ADOPTION

1. Existence and quality of innovations
2. Access to information
3. Advocacy from central administrators
4. Teacher pressure/support
5. Consultants and change agents
6. Community pressure/support/apathy/opposition
7. Availability of federal or other funds
8. New central legislation or policy (federal/state/provincial)
9. Problem-solving incentives for adoption
10. Bureaucratic incentives for adoption.

Table1. Factors Associated with Adoption (Fullan, 1982, p.42).

FACTORS AFFECTING IMPLEMENTATION

A. Characteristics of the Change

1. Need and relevance of the change
2. Clarity
3. Complexity
4. Quality and practicality of program (materials, etc.).

B. Characteristics at the School District Level

5. The history of innovative attempts
6. The adoption process
7. Central administrative support and involvement
8. Staff development (in-service) and participation
9. Time-line and information system (evaluation)
10. Board and community characteristics.

C. Characteristics at the School Level

11. The principal
12. Teacher-teacher relations
13. Teacher characteristics and orientations.

D. Characteristics External to the Local System
14. Role of government
15. External assistance.

Table 2. Factors Affecting Implementation (Fullan, 1982, p.56)

When comparing the factors considered in educational change (above) to the IS Implementation Factor Model, a number of apparent consistencies can be noted. An important difference is that the characteristics described as affecting the adoption / implementation process in education are stated and treated in a static manner. What is omitted is any consideration of organizational change. Even the mutual-adaptation perspective which considers implementation as a process in which both the user and the innovation adapts or changes, defines the user narrowly, and does not consider changes which may be necessary at the organization or the larger systems level.

Educational technology adoption research and practice should also bear in mind that educational systems have a characteristic rarely seen in general organizations used in information systems research. Educational systems are professional bureaucracies with a unique organizational structure, unique coordinating and controlling apparati, user roles and culture, communication channels, flow of decision making and authority, and situational factors. For example, information systems factor research consistently reveals management support as the most important, overriding factor in IS adoption and implementation success, but the role of management in a professional bureaucracy is small, existing mainly to provide resources to the professionals (i.e., educators), resolve conflicts among the professionals, and liaise with the external environment. In a professional bureaucracy, a successful decision to adopt an innovation won't likely be made by the administration alone, it will be made and carried out by individual professional educators. This characteristic does not negate ET application of IS adoption models, however, it only suggests that the factors and processes for successful educational technology adoption will likely have different relative weights than the factors and processes in previously-researched successful information systems adoptions.

There also exists an important difference between the use of new information systems and the implementation of new programs, products, or technologies in education, at the level of the teacher. The way that a teacher adopts and adapts an instructional innovation is affected by his or her personal constructs concerning learning and instruction (Jost, 1992). In addition, classroom instruction includes social interactions and constructions which influence both teacher's thought processes and actions.

User acceptance and use has consistently been identified as essential to information systems adoption. Given the professional bureaucracy structure of the educational system, professional educators rightly have the authority and discretion to adopt or not adopt innovations for teaching, they're hired because of their expertise in education. An important factor to improve success should be adopted from the IS factor model: directly involving users in the design process and designing systems that target their needs and characteristics. Without consideration of the user, support and incentives, widespread user acceptance by existing educational professionals is unlikely to occur. In professional bureaucracies, attrition or replacement is the most common means of organizational sea changes, in addition to changing the standards of who can newly enter the profession, changing what individuals learn in training for the profession, and re-educating those professionals who are willing to be re-educated (Mintzberg, 1993). Re-educating must take into consideration the issues of conceptual change and role changes as well as technical and curricular competencies.

Education systems and educational change involve complex and dynamic interrelationships. We must expand our understanding of mutual adaptation to include changes in the innovation, the teacher, the organization and the system. Successful change, particularly change involving sophisticated and pervasive uses of technology, requires both bottom-up and top-down involvement and support.

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Title:

Navigating through Hypertext: Navigational Technique, Individual Differences, and Learning

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Background

Information presented in instruction consists of declarative and procedural knowledge as well as structural knowledge -- the way declarative knowledge concepts are interrelated (Jonassen, 1990). Individuals selectively incorporate this new information into their existing cognitive structures and then utilize the information in these frameworks when applying the knowledge to new situations. Knowledge of content structure portrayed in instructional materials can help the learner in two ways: 1) by organizing information in short-term memory to build internal connections among the new information and 2) by integrating this information with existing knowledge structures in long-term memory to develop internal connections (Mayer, 1984).

Strategies. In designing instruction, generally an expert's conception of the structure of the knowledge is mapped onto the instructional materials, either implicitly in the text structure and text elaboration techniques or explicitly through graphic portrayals of the text structure. Beissner and her colleagues (1993) list types of implicit strategies: signalling (Meyer, 1975), frames and slots (Armbruster & Anderson, 1985), and elaboration theory (Reigeluth & Stein, 1983). Explicit strategies that graphically portray the structure of knowledge for the learner or ask the learner to construct such a representation include semantic mapping, semantic features analysis, structured overviews, graphic organizers, spider maps, pattern notes, concept maps, networking, text mapping, schematizing, advance organizers, and insertions such as pictures, questions, and verbal elaboration (Beissner, Jonassen, & Grabowski, 1993; Gagne, 1986).

Mapping structural knowledge onto instructional materials is thought to help learners assimilate the new information into their cognitive structures -- adding to existing schema, modifying them, or creating new ones as necessary. Studies have shown that a student's cognitive structure grows more similar to that of the instructor or the instructional materials studied (Shavelson, 1974; Thro, 1978; Naveh-Benjamin, McKeachie & Lin, 1989).

Hypermedia. Many of these techniques assume the learner is using a linear form of instruction, similar to a textbook. The learner is led through a prescribed path and exposed to the information in a structured fashion reflecting the expert's model. Some of the newer technologies, such as hypertext or hypermedia, offer the ability to give the learner control over his/her path through the instructional materials, hopefully discovering the structure of the knowledge in the process. Each individual can take a different path, encountering different amounts and types of information in different sequences. Hypermedia offers both potentials and problems in conveying structural knowledge and assisting learners in incorporating this structural knowledge into their own personal frameworks. Such non-linear systems offer the ability to present various complex structural representations in a domain, to show different points of view, to show diversity among similar examples, and to show similarities across different categories (Spiro and Jehng, 1990). They can allow the learner to explore alternatives and discover relationships (Heller, 1990). As the learner maps out a path through the material, he/she must make choices and become a more active learner (Bourne, 1990).

At the same time, such systems can cause disorientation in the learner, overtax cognitive processing capabilities, encourage over-simplification, over-generalizations, and over-compartmentalization (Conklin, 1987; Hammond; 1989; Jones, 1987; Spiro and Jehng, 1990). The learner is required to absorb layers of information, make it personally meaningful, and gain a comprehensive picture of the subject (Bourne, 1990).

Hypermedia's organization of nodes and links perpetuates the designer's assumptions about the nature of knowledge (Doland, 1989), but this structure is not as explicit as in traditional print materials (Charney, 1987). Some question whether this semantic network reflected in hypertext can be transferred to learners or whether hypertext's network is analogous to the mind's semantic network (Duffy & Knuth, 1990; Romiszowski, 1990; Whally, 1990; Landow, 1990).

One of the challenges for instructional designers and learners is how to represent the information and connections for learning and information retrieval. Research on text structure and comprehension, schema development, metacognition and self-regulation, learner control, and text enhancement techniques provide a basis for designing instruction to improve acquisition of structural knowledge. Most of this research has dealt with linear, text-based instruction. The current study examined some of these findings in light of a non-linear computerized database that allows the individual learner control over his/her own learning. Horn (1989) describes human memory as associative, sometimes connecting information in unpredictable, idiosyncratic ways and other times in hierarchical, structured ways. Jonassen (1991) proposes that the node-link structure of hypertext reflects the semantic structure of the expert's knowledge. Semantic maps of an expert's or experts' structure of a subject could be used to create a node and link structure in hypertext.

Individual Differences. Research has shown that degree of prior knowledge, i.e., existing schemata, influences learning, reading, and inferencing (Clark, 1990; Anderson & Pearson, 1984; Roller, 1990; Gay, 1986; Fincher-Kiefer, 1992; Spilich, Vesonder, Chiesi & Voss, 1979; Chiesi, Spilich & Voss, 1979). Users may have difficulty tracking the overall structure of information in a hypertext system and relating it to their prior knowledge. This problem may be exacerbated for students with low prior knowledge by causing disorientation and cognitive overload.

Verbal ability differences may also influence a student's ability to process new information in a hypertext system, particularly since students with low verbal ability may be inefficient in semantic, syntactical, and pragmatic processing of linguistic information (Hunt, 1983). Landow (1989) claims that some of the new technologies change the way readers read because determining relationships among the linked concepts, which may not be obvious to the user, becomes central to understanding. This requires a new type of understanding, especially difficult for poorer readers who tend to strictly follow a text's linear presentation and seldom use traditional connective aids such as glossaries and introductions in print materials. They are not used to having to create associations among concepts on their own.

Graphical Browsers. New skills and instructional aids may be required to use these technologies. Explicit techniques different from those in traditional text can help the learners perceive the structure of the knowledge. Spatial learning strategies provide a way of graphically portraying structural knowledge for the learner or asking the learner to construct such a representation. Breuker (1984) sees them as providing external memory storage and explicitly depicting concept interrelationships. They focus attention on relevant information and help the learner create internal and external connections among the concepts.

Maps or graphical browsers of the structural knowledge allow the user of a hypertext system to navigate from node to node through the structure while spatially portraying the links between concepts (Halasz, 1988). They generally allow the user to directly access any node on the map, speed up information access, and prevent disorientation (Tsai, 1989). "The learner can use a semantic network as a map of the content knowledge in a curriculum and use this map to explore topics that are of interest to him or her at the time the interest is present" (Denenberg, 1988, p. 309). Denenberg recommends showing only the structure around one node to avoid overwhelming the learner. This avoids some of the problems of global maps (Conklin, 1987).

These graphical browsers are thought to influence information processing by facilitating both the organization and integration of new information, similar to the way signalling techniques such as typographic cues and the placement of certain words highlight the text structure (Spyriakis, 1989). Graphical browsers draw the learner's attention to the important concepts and how they are related to each other. They can help the learner tie the new information to prior knowledge in long term memory, especially when some terms in the graphical browser are already familiar to the learner. This tie to already known schema may be most useful for learners with high prior knowledge who recognize some concepts and can use the browser to help decide where to go next. They benefit most from this learner control.

Graphical browsers can also help the learner organize the new information in short term memory by setting up a framework to facilitate encoding. This may be more useful for those with low prior knowledge who have little existing framework for the new information but could potentially interfere with encoding by those with high prior knowledge who already have a well established framework. A system without such graphical browsers would force the learner to generate his/her own framework, creating a more active learner. The effectiveness of this navigation technique may be tied to the degree of prior knowledge, both of facts and of the relationships between them, i.e., the learner's existing cognitive framework.

Jonassen and Wang (1990, 1992, 1993) and Jonassen (1991) have conducted several studies on the use of several types of graphical browsers in hypertext systems to acquire structural knowledge. They found no significant increase in structural knowledge and, in some cases, an actual decrease in recall. Only those specifically told they would be required to create a semantic network after the task showed significantly increased structural knowledge. They concluded that merely showing the structural relationships was not sufficient to result in encoding. In their studies they used measurement techniques that attempted to assess higher level skills and transfer, often achieving a basement effect in the scores. Learners were unfamiliar with these testing techniques and were unable to complete them. Also, these studies used a very large database, raising the question of how much information each learner actually covered.

Phillips and his colleagues (1992) examined different types of navigational devices in a hypertext database and found that those provided with the most minimal navigational tools (i.e., hotwords in the text itself) achieved the highest recall. This study investigated only recall of facts and concepts, but combined with the Jonassen and Wang studies, it raises the question of how much explicit structure is optimal for facilitating information processing by learners. The current study examined both higher level structural knowledge and declarative knowledge, measured retention over time, measured structural knowledge using an assessment technique more understandable to the learners, and compared learners with different degrees of prior knowledge in the content area and different degrees of verbal ability to determine the optimal degree of explicit structure for different learners.

The study examined the results of using two different graphical browsers providing different amounts of information about the structure of the knowledge to learners who have been given a specific, externally imposed objective and a structural knowledge task at the beginning of instruction. This was compared to the use of hotwords embedded in the instructional text itself showing no explicit structure. These pre-lesson strategies of providing objectives and a structural knowledge task were intended to alert the learners to the importance of acquiring structural knowledge and to provide a purpose for their browsing. Given that Jonassen and Wang (1990) found many participants were unfamiliar with structural knowledge acquisition and integration, hypertext techniques, and methods of assessing structural knowledge, the study also provided practice in basic hypertext navigation to reduce anxiety and to develop appropriate strategies for navigation and integration and familiarity with a graphical browser before the instruction.

Several authors (Whalley, 1990; Duchastel, 1990; Spiro and Jehng, 1990) have suggested that hypertext may not be appropriate for many instructional uses. Whalley suggests that browsing is the most appropriate use of hypertext. Browsing may not be most appropriate for instructional purposes, but it may be appropriate for facilitating discovery learning (Bruner, 1960). Duchastel (1990) and Spiro and Jehng (1990) suggest that hypertext is inappropriate for highly structured learning tasks. There is little empirical research to support these claims. This study examined some of these criticisms of hypertext by using it for just such a highly structured content domain that includes facts, concepts, and principles.

Research Questions

These questions about the educational use of hypertext led to the following research questions.

1. Will students given no explicit graphical representation of relationships among concepts (Hotwords group), those given a graphic method for showing the relationships (Links group), and those given a graphic method for showing relationships with the relationships labeled (Detailed Links groups) have different levels of structural knowledge and perform differently on tests of comprehension and recall of facts and concepts?

2. Is there an interaction between degree of *prior knowledge* and type of graphical method for showing structural knowledge on the learner's immediate and delayed structural knowledge, comprehension, and recall of facts and concepts?

3. Will the graphical method for representing structural knowledge during instruction bring the learners' *structural knowledge representations closer to that portrayed in the instructional materials*?

4. Will the type of graphical method for representing structural knowledge affect the retention of facts, concepts, and structural knowledge *over time*?

5. Is there an interaction between degree of *verbal ability* and type of graphical method for demonstrating structural knowledge on the learner's immediate and delayed structural knowledge, comprehension, and recall of facts and concepts?

This study examined the use of three types of navigational techniques representing structural knowledge in a hypertext system for their influence on the acquisition of declarative and structural knowledge. The effects of prior knowledge, verbal ability, amount of the content seen, and time spent using the system on achievement were examined. In addition, the change in a student's structural knowledge and its similarity to an expert model were assessed. Finally, retention over time was assessed using the same measures.

Methods

Subjects

One hundred-thirteen undergraduate volunteers from a large state university received extra credit for participating in both sessions of the study. One-hundred forty-started the study, but five did not have SAT scores, ten did not return for the second session, and twelve did not complete the first session. These subjects were dropped.

Treatments

Subjects were randomly assigned to a system using hotwords, one using a graphical browser representing the links between concepts, or one using a graphical browser labeling the relationships between concepts.

A sixty-screen hypertext database on the parts of the heart, circulation, and blood pressure based on the materials of Dwyer and Lamberski (1977) was developed for this study. This content was selected because it covers a variety of facts, concepts, and processes and represents a limited subject domain on which there is general consensus on the organization of the content. An overarching structure for the system with each screen represented as a node was created. Graphical browsers and hotwords representing all nodes linked to each screen were created for the different treatments. Links were hierarchical, heterarchical, and following the flow of blood through the heart.

Each treatment had the same screens with only the structural knowledge representation methods differing. The treatments were:
1. A group which highlighted the terms to be linked that, when clicked, took the learner to a related screen without describing how the two screens are related (HOTWORDS).
2. A graphical browser with links visible but not described but otherwise the same as the third treatment (LINKS), and
3. A graphical browser with links described along the lines (DETAILED LINKS).

The learner could go to each link in succession from hotspots on the screen. By clicking on all the hot buttons, the learner could access the same screens in all three treatments. The students were allowed to work through the program at their own pace, accessing whatever screens they saw fit. They could exit the program at any time.

Instruments

The students were randomly assigned to the three treatment groups, based on the assumption that prior knowledge and verbal ability scores would be equally distributed among the groups.

The following measurements were taken for each subject:
1) a pretest of prior physiological knowledge,
2) a pretreatment assessment of structural knowledge,
3) verbal Scholastic Aptitude Test score,
4) a posttreatment survey of previous computer use and attitudes toward computers, hypertext, and this program,
5) the number of different screens each subject chose to view, and
6) the amount of time spent on the treatment.
7) a 40-question immediate criterion posttest measuring recall of facts and concepts and comprehension consisting of three multiple-choice tests and one drawing test used to assess recall and comprehension developed by Dwyer (1978) (Test),
8) an alternate form of the 40-question criterion posttest administered approximately two weeks after the immediate posttest (Retest), and
9) a post-treatment assessment of structural knowledge (Tree2)

From the Test and Retest scores, a change score was calculated for the posttests. From the third, the ordered-tree technique, a similarity measure to an "expert" structural knowledge representation and a change in structural knowledge were calculated.

The ordered-tree technique has been used in numerous studies to assess a learner's cognitive structure (NavehBenjamin and others, 1986; McKeithen and others, 1981; Naveh-Benjamin, McKeachie, and Lin, 1987; NavehBenjamin, McKeachie, and Lin, 1989) and is based on a theory of hierarchical cognitive structure that assumes concepts are organized hierarchically with single concepts at the lowest level and more abstract categories at the higher levels. The technique uses recall theory which describes individuals' tendency to list all of one branch of the hierarchy before moving on to the next branch. From a number of cued and uncued trials, where subjects put sets of low-level concepts in order, an algorithm finds the set of all chunks for each subject and creates representations of the subjects' cognitive structures (Naveh-Benjamin & Lin, 1991). It measures amount of organization, depth of the hierarchy, similarity to an "expert" organization, and direction of relationships between concepts.

The method was validated by two content experts and checked for reliability through a field test. This technique was used to assess structual knowledge both before and again two weeks after the treatment in this study to examine a subject's prior structural knowledge and then the change after the treatment. The pretreatment and posttreatment structural knowledge tasks in this study were scored using the scoring system for the structural knowledge assessment technique developed by Dr. Henry Rueter of the Cognitive Science and Machine Intelligence Laboratory at the University of Michigan.

The difference between the mean pretreatment structural knowledge scores and the mean retention posttreatment structural knowledge scores of each group was also used as a dependent variable. The pretreatment and posttreatment structural knowledge scores for each individual were compared to the score of an expert model of structural knowledge (as represented in the structure of the materials). A tree can be very high in structure and have very little similarity with the "expert" tree. Such a tree indicates a highly developed, individualistic cognitive framework for this content. Another tree can be highly similar to the "expert" tree but only exhibit a moderate degree of structure. Two trees with similar degrees of structure can look very different. A change in the degree of organization does not necessarily indicate the resulting organization is closer to the "expert" one. Nor does a consistent score from pretreatment to posttreatment necessarily mean there is no change. It is possible there is a change in the type of organization, but the same degree of organization is evident.

SAT verbal scores were requested to examine the effect of verbal ability on performance in the different groups. Prior knowledge was assessed using a general physiology test developed by Dwyer for this purpose. Although it does not directly test information on the heart, performance on it has been found to correlate with the performance on the criterion-referenced tests (Dwyer, personal correspondence).

A brief survey to assess attitudes, prior computer experience, prior hypertext experience, and use of the hypertext lesson was used immediately after the treatment. Followup interviews with a sample of learners were conducted by trained interviewers to provide additional qualitative data.

The audit trails for each student were kept by the computer program. This included paths taken and time spent at each point in the program. A count of the number of different screens seen was displayed on each screen and recorded by the computer. The total time spent on the lesson was also recorded.

Procedure

Verbal SAT scores were obtained as a measurement of verbal ability. Before the treatment subjects took a basic physiology prior knowledge test developed by Dwyer, used the ordered-tree technique of Reitman and Rueter (1980) to measure their existing structural knowledge of the concepts in the lesson, and practiced using the navigational technique in the treatment.

For up to an hour, the subjects were provided with four objectives for the lesson and then navigated through as many of the sixty screens in the system as they chose to using one of the three randomly assigned navigational techniques, and then completed an experience and attitude survey and a posttest measuring the ability to construct and label a diagram of the heart, knowledge of facts, identification of concepts, and comprehension. A sampling of the students were interviewed after the treatment. Path data was recorded by the computer for each participant. Approximately two weeks later the students took a delayed retention posttest and completed a second ordered-tree to assess structural knowledge.

Data Analysis

Regression was used to test for the effect of the treatments, the influence of verbal ability and prior knowledge on recall and retention of facts and concepts, comprehension, and structural knowledge, and the interaction between variables and to find the most valid predictor variables; those which account for the most variance in the dependent variables. This was chosen over a multivariate analysis of variance to preserve the maximum amount of data on each independent variable. Multiple regression was used to determine the function that best predicts performance on the each of the dependent variables: immediate posttest, difference between delayed and immediate posttests, posttreatment structural knowledge task, similarity of a subject's structural knowledge to an "expert" representation, difference between pre and posttreatment structural knowledge tasks and to test the effect of the treatments on each of these variables.

The variables representing coverage of the hypertext database (Count) and persistence (Etime) were also included as predictors. In examining the raw data, these variables differed widely among the subjects, so their influence on the dependent variables were also sought to reduce their potential confounding effects.

For each dependent variable, the hypothesized predictors, the potential confounding variables, and the interaction of all these variables and the treatment were regressed. First, parameter estimates were obtained for all the predictor variables and the interactions of these variables with the treatment. Those that were not significant at the .05 level were dropped and the equation refit. The resulting function was the fit for that dependent variable from the predictor variables given, indicating which variables were significant predictors for each dependent variable and what percentage of the total variance of the dependent variable they accounted for as a group (i.e., the multiple correlation coefficient). When interactions between any of the predictors and the treatment were found, equations were fit for each treatment.

A method developed by the researcher was used to compare the paths the students used. This technique was carried out for a sampling of twelve subjects from each treatment. It reported information on how often they went forward or backward, where they clicked, and whether they moved hierarchically, heterarchically, or following the blood flow.

The survey and interview data were summarized quantitatively and qualitatively. Data on prior computer and hypertext use and perceptions were correlated with the test and structural knowledge results.

Results

The three treatment groups showed no significant differences on verbal Scholastic Aptitutde Test scores or prior knowledge of physiology. Groups means showed a difference between the immediate posttest, change from immediate to delayed posttest, posttreatment ordered-tree task, and posttreatment tree similarity to an "expert" tree among the groups.

Subjects in the Hotwords treatment group consistently scored the lowest except in the difference between the pre- and posttreatment trees with those in the Links and Detailed Links groups being more similar to each other. The Detailed Links group generally had the smallest within group variance except on the difference between the immediate and delayed posttests and the difference between the pre- and posttreatment trees (see Tables1,2, and 3). On this latter variable there is a marked difference in the Detailed Links group. They had a very small difference between the pre- and posttreatment scores (i.e., the post scores were only slightly higher).

Table 1
Means and Standard Deviations on Immediate Posttest, Delayed Posttest, and Change in Posttest Scores by Treatment Group

Treatment Group	Immediate Posttest		Delayed Posttest		Change from Immediate to Delayed Posttest	
	M	SD	M	SD	M	SD
Hotwords (n=37)	20.919	(8.207)	17.838	(7.984)	3.081	(4.159)
Links (n=38)	23.237	(8.221)	19.895	(7.266)	3.342	(5.800)
Detailed Links (n=38)	23.658	(7.549)	19.132	(5.757)	4.526	(5.331)
All Groups (n=113)	22.619	(8.016)	18.965	(7.043)	3.655	(5.144)

Note: The change in posttest scores was computed by subtracting the immediate posttest score from the delayed posttest score. A positive number indicates a drop in the score over time.

Table 2
Means and Standard Deviations on Posttreatment Ordered-Tree Task, Change in Structural Knowledge, and Similarity to an "Expert" Ordered-Tree by Treatment Group

Treatment Group	Ordered-Tree Task		Change from Pre to Post Ordered-Tree		Similarity to "Expert" Ordered-Tree	
	M	SD	M	SD	M	SD
Hotwords (n=37)	16.243	(13.621)	2.243	(14.504)	22.162	(20.581)
Links (n=38)	20.158	(14.045)	3.368	(15.958)	33.289	(22.445)
Detailed Links (n=38)	19.579	(11.758)	.058	(11.832)	27.447	(20.201)
All Groups (n=113)	18.947	(13.315)	1.885	(14.139)	27.681	(21.404)

Note: The change in ordered-tree scores was computed by subtracting the pretreatment ordered-tree score from the posttreatment score. A positive number indicates an increase in the amount of structure.

Table 3
Means and Standard Deviations on Number of Screens Seen and Time in Treatment by Treatment Group

Treatment Group	Screen Count	Elapsed Time (in seconds)
	M SD	M SD
Hotwords (n=37)	43.9 (12.7)	1113 (609)
Links (n=38)	45.1 (10.5)	1293 (636)
Detailed Links (n=38)	44.9 (12.7)	1360 (564)
All Groups (n=113)	44.7 (11.0)	1257 (607)

While not included in the hypotheses, both time on treatment (Etime) and number of different screens seen (Count) were included in the analysis since Elapsed Time represents the degree of persistence or use of the navigational tools, depending on how many total screens were seen, and Screen Count represents the actual coverage of the content. The latter indicates the number of different screens seen out of the sixty possible. Although they are highly correlated ($r=.61378$), both were included.

Immediate Posttest

Multiple regression analysis revealed predictors of performance on the immediate posttest were treatment group, prior knowledge, an interaction of number of screens seen and treatment group, and an interaction of time spent on the treatment and treatment. Approximately sixty percent of the total variance in the criterion variable Test can be accounted for by these predictors (R-square=.604873, $F=17.52$, $p=.0001$). The predictors of this variable were then tested for their significance as main effects and in interaction with treatment adjusted for all other variables in the regression (see Table 4).

A significant main effect was found for Prior Knowledge, Number of Screens Seen, Elapsed Time, and Treatment. Because there was a significant interaction between two of the predictor variables and the treatment, equations were determined by treatment. The equation for each treatment is listed in Table 5.

Table 4
Test of Significance of Predictor Variables for the Immediate Posttest Criterion Variable

Source	df	Sums of Squares	Mean Square	F	p
Prior	1	1567.6573	1567.6573	56.78	.0001*
Count	1	159.0293	159.0293	5.76	.0182*
Etime	1	276.0847	276.0847	10.00	.0021*
Treatment	2	190.4967	95.2484	3.45	.0355*
Count*Treat	2	376.6657	188.3328	6.82	.0017*
Etime*Treat	2	248.8115	124.4058	4.51	.0133*

*$p<.05$

The same predictor variables were not significant in the equations for each of the treatments. Prior Knowledge remained significant in a positive direction in all three treatment equations. Larger beta weights for the same variable, regardless of sign, contribute more to the prediction (Huck, C rmier, & Bounds, 1974, pp. 158), although these numbers should not be used for comparison when the predictors are correlated and not orthogonal as they are in this study (Darlington, 1968). Beta weights cannot be compared across variables due to different measurement scales. For variables such as Elapsed Time. the beta weights were relatively small due to the scale being used (i.e., seconds).

Table 5
<u>Functions for Immediate Posttest for Each Treatment</u>

Equation	R-square	Variable	Parameter	p
Treatment 1	.6656	Intercept	-11.790777	.0326*
(Hotwords)		Prior	1.385386	
	.0001*			
		Count	- .178874	.0636
		Etime	.008288	.0001*
Treatment 2	.6340	Intercept	-13.466263	.0198*
(Links)		Prior	.768232	.0018*
		Count	.340977	.0009*
		Etime	.002544	.1210
Treatment 3	.5164	Intercept	- 9.501131	.1094
(Detailed		Prior	.962467	.0005*
Links)		Count	.236039	.0275*
		Etime	.000085	.9689 *

$p<.05$

A plot of the predictor variable Prior Knowledge against the predicted immediate posttest score showed the positive direction of its influence. It was a significant predictor in all three groups (*$p<.05$), but there was no significant interaction between prior knowledge and the treatment. The steepest slope, and hence, the strongest influence was evident in the Hotwords group, but this difference was not statistically significant. The Links group had the lowest parameter estimate and the least influence from prior knowledge.

The second significant main effect was the predictor Count which indicated the number out of the total sixty screens each subject looked at in the lesson. There was a significant interaction between treatment and the number of screens seen. The Links and Detailed Links group showed a positive relationship but the Hotwords group showed a small, slightly negative relationship. There was very little difference in the parameter estimates for the Links and Detailed Links groups. The more screens subjects in both of these groups tended to view, the higher their immediate posttest score, whereas, for the Hotwords group, the number of screens viewed did not make a difference.

The Elapsed Time predictor indicated how long each subject spent on the treatment, which may be interpreted as a measure of persistence. Only in the Hotwords group was the predictor variable Elapsed Time significant at the .05 level. Some of this may have been due to collinearity of the predictor variable, in particular the correlation between Screen Count and Elapsed Time. An outlier who viewed the lesson for almost 3500 seconds may have produced the significant effect from Elapsed Time in this treatment where it is not significant in the others.

This analysis for the immediate posttest indicated a significant main effect for treatment at the .0355 level with the Links and Detailed Links scores higher than the Hotwords group. Treatment interacted significantly with the number of screens viewed and the time spent on the treatment. Prior knowledge was a significant predictor of immediate posttest scores in all three treatments, but there was no significant interaction between treatment group and prior knowledge. Students with differing degrees of prior knowledge did not perform significantly different in the three treatments. The predictor Verbal SAT scored used to represent verbal ability did not contribute to prediction of the criterion Immediate Posttest.

Change from Pretest to Posttest

This variable was formed by subtracting the delayed posttest score from the immediate posttest score. A positive number indicates the loss in score. A negative number indicates a higher score on the delayed posttest. Predictors of change in score from immediate to delayed posttest were prior knowledge, immediate posttest score, treatment, and an interaction between verbal ability and treatment (R-square=.386828, F=9.46, $\underline{p}$=.0001).

The variables Prior Knowledge, Immediate Posttest, and Treatment were significant (see Table 6). On this criterion variable, the subjects in the Hotwords group (M=3.081) had signficantly less loss in achievement between the immediate and delayed posttest followed by the Links group (M=3.342) and then the Detailed Links group (M=4.526). The work of Phillips and others (1992) showed that the subjects given the least amount of structure performed better on recall. In the current study, those given the least structure performed the worst, but they lost less over time. The pattern of loss supports the statistical concept of regression to the mean over time.

Table 6
Test of Significance of Predictor Variables for the Difference between Immediate and Delayed Posttests Criterion Variable

Source	df	Sum of Squares	Mean Square	F	p
Prior	1	239.49088	239.49088	13.84	.0001*
Treat	2	131.11542	65.55771	3.79	.0258*
Test	1	749.61628	749.61628	43.31	.0001*
Verbal	1	57.14237	57.14237	3.30	.0721
Verbal*Treat	2	136.95793	68.47896	3.96	.0220*

*$\underline{p}$<.05

Because there was a significant interaction between one of the predictor variables, Verbal SAT score, and the treatment, equations were determined for each treatment (see Table 7).

Table 7
Functions for the Difference between Immediate and Delayed Posttests for Each Treatment

Equation	R-square	Variable	Parameter	p
Treatment 1	.2594	Intercept	11.291464	.0230*
(Hotwords)		Prior	-.0547680	.0207*
		Test	.342397	.0022*
		Verbal	-.006322	.4070
Treatment 2	.3895	Intercept	-4.437707	.4290
(Links)		Prior	-.480898	.0501
		Test	.412299	.0023*
		Verbal	.020062	.0539
Treatment 3	.4899	Intercept	-3.736668	.4115
(Detailed		Prior	-.443104	.0600
Links)		Test	.550589	.0001*
		Verbal	.012112	.1572

*
p<.05

Thirteen students actually improved between the immediate and delayed posttests (i.e., two in the Hotwords group, eight in the Links group, and three in the Detailed Links group). The predictor Prior Knowledge contributed to prediction of the change between Immediate and Delayed Posttests. A plot of the predicted difference between immediate and delayed posttest scores for each of the groups showed a slight negative influence of prior knowledge, although the predictor was significant at the .05 level only for the Hotwords group (p=.0207). It approached significance in the Links group (p=.0501) and in the Detailed Links group (p=.0600). There was no significant interaction between treatment group and degree of prior knowledge. This variable represents retention of knowledge from immediately after the treatment to two weeks. A negative parameter estimate here indicates that those with low prior knowledge had a higher difference between immediate and delayed posttest scores. The different treatments did not help or hinder those with low prior knowledge.

Score on the immediate posttest was a significant predictor of the difference between the immediate and delayed posttest scores in all groups. Those who had higher immediate posttest scores tended to decrease more between immediate and delayed posttest than those who had lower immediate posttest scores. The different treatments did not interact with immediate posttest score to influence retention. The influence was strongest in the Detailed Links group followed by the Links group and then the Hotwords group.

Since verbal ability was not significant as a main effect but interacted with treatment, plots of this variable and the predicted value of the criterion variable were drawn for each treatment. Only in the Links group did verbal ability approach significance as a predictor (p=.0539). It was not a significant predictor in the other groups. This may have been due in part to its correlation with prior knowledge which was a significant predictor overall, but did not interact with treatment.

Posttreatment Structural Knowledge

Predictors of posttreatment structural knowledge were pretreatment structural knowledge, an interaction of prior knowledge and treatment, and an interaction of immediate posttest score and treatment. The multiple correlation coefficient predicted about thrity-four percent of the total variance (R-square=.335604, F=5.78, p=.0001).

There was a significant main effect from the pretreatment ordered-tree task. The pretreatment score may reflect both a degree of prior knowledge about the organization of the concepts and a comfort-level with the task itself. These task scores represent the degree of structure, not the structure's similarity to any standard. A student may have a high degree of structure on both the pre- and posttreatment tasks, but the results may represent two entirely different structures. Because there was a significant interaction between two of the predictor variables, Prior Knowledge and Immediate Posttest, and the treatment, equations were determined for each treatment (see Table 9).

Table 8

<u>Test of Significance of Predictor Variables for the Posttreatment Ordered-Tree Task Criterion Variable</u>

Source	df	Sum of Squares	Mean Square	F	p
Treat	2	659.9262	329.9631	2.63	.0767
Tree1	1	1793.5448	1793.5448	14.31	.0003*
Prior	1	298.4925	298.4925	2.38	.1258
Prior*Treat	2	812.3316	406.1658	3.24	.0431*
Test	1	157.3070	157.3070	1.26	.2651
Test*Treat	2	1388.3069	694.1535	5.54	.0052*

*p<.05

Table 9

<u>Functions for the Posttreatment Ordered-Tree Task for Each Treatment</u>

Equation	R-square	Variable	Parameter	p
Treatment 1	.3005	Intercept	-23.910117	.0688
(Hotwords)		Tree1	.300901	.0939
		Prior	1.893467	.0125*
		Test	- .329488	.3249
Treatment 2	.3897	Intercept	3.590528	.7643
(Links)		Tree1	.113976	.4983
		Prior	- .501087	.4137
		Test	1.136821	.0009*
Treatment 3	.3477	Intercept	13.722323	.1838
(Detailed		Tree1	.510772	.0002*
Links)		Prior	- .088868	.8707
		Test	- .086433	.7554

*p<.05

There was a definite linear relationship between pre- and posttreatment scores with those performing higher before the treatment also performing higher after the treatment, but the plot of pretreatment ordered-tree task by predicted posttreatment ordered tree task did not seem to indicate that a demonstrated understanding and ability to do the task before the treatment resulted in much better posttreatment structure. The plot seemed to indicate that the overall trend was to perform slightly worse on the posttreatment task, especially at the higher range of the pretreatment scores. Although there was not a significant interaction between pretreatment and posttreatment orderedtree scores, only in the function for the Detailed Links group was pretreatment score a significant predictor of posttreatment score.

The immediate posttest interacted with the treatment but was not a predictor of posttreatment ordered-tree score by itself. It was a significant predictor only in the Links group. In the Links group there was a definite linear pattern showing a positive relationship between immediate posttest score and predicted score on the posttreatment ordered-tree task. There was no obvious explanation for this one group performing so differently, especially since the Detailed Links group often behaved like the Links group and tended to demonstrate similar patterns. It was expected that the immediate posttest would have some predictive value for the structural knowledge task as structural knowledge is thought to be necessary to answer comprehension questions. Previous studies have not shown it to be necessary for factual recall and, in some cases, have found it to be a hindrance (Jonassen & Wang, 1992).

Prior knowledge interacted with treatment but was not a predictor of posttreatment ordered-tree score by itself. It was a significant predictor only in the Hotwords group. The plot showed a definite positive relationship with higher prior knowledge students doing better on the posttreatment ordered-tree task.

Change in Structural Knowledge

This variable represents the change in structural knowledge from before the treatment to two weeks after the treatment. A positive number indicates an increase in the amount of structure while a negative number indicates a decrease in the amount of structure. Predictors of change in structural knowledge were prior knowledge and pretreatment structural knowledge (R-square=.321461, F=26.06, p=.0001). There was no significant interaction between prior knowledge and the treatment, but there was a positive relationship between prior knowledge and change in structural knowledge (p=.0131). Those with higher prior knowledge had a significantly greater increase in structural knowledge than those with lower prior knowledge. It is important to remember the previously detailed difficulties with the posttreatment structural knowledge task when interpreting these results.

Table 10

Test of Significance of Predictor Variables for the Difference between the Pretreatment and Posttreatment Ordered-Tree Tasks

Source	df	Sum of Squares	Mean Square	F	p
Prior	1	943.3673	943.3673	6.83	.0
Tree1	1	6820.5012	6820.5012	49.38	.0(

*p<.05

A plot of the predicted difference between pretreatment and posttreatment ordered-tree task by pretreatment ordered-tree task showed a negative relationship between these variables. This can be interpreted to mean that the better one did on the initial structural knowledge task, the less difference there was between the pre and post scores on the task to a point. In all the groups, there was a point where the subjects did better on the pretreatment task than on the posttreatment task. About forty-three subjects fall in this area. This loss of structure was most evident in those with higher scores on the pretreatment task.

Structural Knowledge Compared to an "Expert"

The pretreatment and posttreatment ordered-trees of each subject were compared to each other and to the ordered-tree representing the structure of the information in the lesson as created by the instructional developer (i.e., the "expert" ordered-tree) using the program OTSim 1.0 developed by Dr. Henry Rueter at the Cognitive Science and Machine Intelligence Laboratory at the Graduate School of Business at the University of Michigan. This technique computes the Hirtle similarity measure between ordered trees. This is the ratio of the chunks in common and the total chunks of two ordered trees. A similarity measure of 1.0 indicates two identical trees and 0 indicates two trees that are maximally dissimilar. The original similarity scores were multiplied by ten and, therefore, ranged from 100 for identical trees to zero indicating total lack of similarity between two trees. Differences in directionality between two trees do not enter into the measure, so this measures loses some of the information in each tree, but it is the best available at this time. Average similarity measures are shown in Table 11.

Table 11
<u>Mean Similarity Measures for Pretreatment and Posttreatment Ordered Trees Compared to an "Expert" Tree</u>

Links	Overall		Hotwords		Links		Detailed	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Pretreatment /Expert	29.46	(20.09)	27.24	(20.28)	31.76	(19.55)	29.32	(20.56)
Posttreatment /Expert	27.68	(21.40)	22.16	(20.58)	33.29	(22.45)	27.45	(20.20)
Difference between Pre & Posttreatment Similarity Scores	-1.78	(20.86)	-5.08	(19.68)	1.53	(26.30)	-1.87	(15.06)
Pre/Posttreatment Similarity (within subject)	35.74	(28.57)	31.43	(28.30)	37.61	(27.72)	38.08	(29.92)

<u>Note</u>: Pretreatment/Expert is the similarity between a subject's pretreatment ordered-tree score and that of the "expert." Posttreatment/Expert is the similarity between a subject's posttreatment ordered-tree score and that of the "expert." Pretreatment/Posttreatment Similarity is the similarity measure between a subject's pre and posttreatment trees.

Difference between Pre & Posttreatment Similarity Scores is found by subtracting the pretreatment ordered-tree score from the posttreatment score.

The results of this analysis must be interpreted cautiously as the ordered-tree technique proved difficult and/or frustrating for many students. Eight students showed no organization at all in the pretreatment task which may have been due to a lack of knowledge or difficulty with the task. The overall mean structure score was only 17 before the treatment and 19 after the treatment. This could indicate that the task did not discriminate well between students with and without structural knowledge.

Although the statistical analysis indicated no significant difference among the treatment groups on the posttreatment-"expert" similarity scores (F=2.61, p=.0781), there was a marked difference between the Hotwords group and the Links group with the Hotwords group much lower in similarity to the structure represented in the lesson (see Table11). The Hotwords group also demonstrated lower similarity in their pretreatment trees and posttreatment trees (M=31.43). On the average, their posttreatment trees were over five points lower than their pretreatment trees.

The only significant predictor of degree of similarity to the "expert" structure of knowledge presented through the links in the hypertext system was an interaction of immediate posttest and treatment. There was no significant main effect. The multiple correlation coefficient between these predictors and the criterion was .219811 (F=3.47, p=.0014, see Table 12).

Table 12
<u>Test of Significance of Predictor Variables for the Comparison of Posttreatment Ordered-Tree Task and the "Expert" Ordered-Tree</u>

Source	df	Sum of Squares	Mean Square	F	p
Treatment	2	1315.6904	657.8452	1.69	.1896
Prior*Treatment	3	2670.9577	890.3192	2.29	.0830
Test*Treatment	3	5377.1967	1792.3989	4.60	.0046*

*p<.05

A positive relationship between the predictor, Test, and criterion variable was indicated in both the Links and Detailed Links groups, although it was only significant in the Links group (p=.0014).

The interaction of prior knowledge and treatment approached significance, so further analysis was performed. In the Hotwords group, prior knowledge approached significance (p=.0562) which would seem to follow the trend for many of the dependent variables of prior knowledge being most influential in the Hotwords group. It exerted a strong positive influence on the posttreatment similarity score in this group. This also seemed to be indicated by the plot of the Detailed Links treatment, even though it was not significant in that treatment. In the Links group, prior knowledge was not a significant predictor.

Path Data

<u>Coding Schemes</u>

The computer recorded each screen viewed, what order they were viewed, and how long was spent on each screen. To track student usage, a method for classifying each move from screen to screen was developed. The method tracked the screen the user was on currently, the previous screen, and the next screen chosen to determine:

1) if the user returned to the previous screen or went on to a new one;
2) if the user went
   a) up the hierarchy of concepts,
   b) down the hierarchy of concepts,
   c) to a concept across the hierarchy at the same level in the same section,
   d) to a related concept in another section,
   e) to a concept before or after the current one in terms of the flow of blood through the heart,
   f) back to the objectives screen;
3) what position in the map was clicked or, in treatment one, where in the text the clicked word was located;
4) how long a user moved from screen to screen before returning to the objectives screen;
5) how many screens following the blood flow were linked together;
6) how many of the sixty screens were viewed;
7) how many screens were seen more than once;
8) how many screens were viewed in total;
9) how long was spent on the treatment;
10) how many of the instruction screens were viewed;
11) how long the user spent on the instructions; and
12) in what order the user chose to start a new section and how often was each started.

This information was gathered for a random sampling of twelve subjects from each of the treatment groups and collated for each individual. The data were examined in terms of where on the map or in the text the user clicked, what typical moves were made by the user, and how much time was spent on the program.

Number of Screens Viewed

The program contained sixty screens, other than those in the instructions. In the entire sample of one hundred-thirteen subjects, the average number of screens seen by a subject was 45 (*SD*=12), and they perceived that they saw about 75% of the screens (*SD*=20) or 42 screens. They spent an average of 1257 seconds or about 21 minutes on the treatments (*SD*=607 seconds). The groups were largely the same in the average number of screens seen.

Moving Onwards or Returning to the Previous Screen

Subjects had the choice of going on to a new screen from any point, returning to the screen they had just seen, or returning to the Objectives Screen. The groups were largely similar in their movements. In general, the movement was onward to a new screen rather than returning to the screen just seen. To return to a previous screen, the subject had to remember which screen he/she just left and then click on the hotword or button for that screen. There was no "return" or "previous" button. Student ratings of feeling lost correlated with higher rates of returning to the previous screen (r=.46963, p=.0039) and with a sense of confusion instead of clarity (r=.30763, p=.0682).

Hierarchical vs. Heterarchical vs. Process Movement

In true hypertext fashion, the user of the program had the ability to link to a wide variety of related concepts from each screen. When the program was constructed, it was divided into four sections, Characteristics, Parts, Circulation, and Blood Pressure, that were all linked to the Objectives Screen. From that screen, the user could go down a hierarchy of concepts in each section. The user also had the ability to move back up the hierarchy and back to the Objectives Screen. In addition, the user could move to related concepts in the same section that were across the hierarchy rather than up or down it. They could also move to a related concept in another section. Users of the program were free to follow their interests, go to familiar concepts, or tackle new ideas. In the Hotwords group, these ideas were all embedded in the text and had to merely be clicked to move to a new screen. The user had to infer the relationships from the other words in the text. In the Links group and in the Detailed Links group the users clicked buttons in the map at the top of the screen to move on to new screens. The Links group merely had the concepts linked together by lines. The Detailed Links group had the nature of each relationship between concepts labeled on the lines.

Although the Links group moved in a slightly more hierarchical fashion and chose slightly fewer heterarchical links, the groups were fairly similar in their movements. Overall, hierarchical movement was the strategy of choice with moving down the hierarchy the most chosen strategy followed by moving across the hierarchy within the section, moving up the hierarchy, and moving across sections. The Hotwords group chose to move across the hierarchy within sections more than the other groups. This could be a function of a lesser awareness of the existence of a hierarchy in the program. With the high percentage of movement down the hierarchy, one might expect a similar amount back up, but this was not the case. The percentage of upward movement was slightly more than half of the percentage of downward movement.

Users tended to start with the first concept on the Objectives screen and work their way through the sections in order. They followed strings of screens ranging from one to over seventy screens in a row, but most followed fewer than thirty screens before returning to the Objectives screen.

Another possible screen selection strategy was to follow the flow of the blood through the heart as one went from screen to screen. Both the previous location and the ensuing location were connected to each screen. Subjects chose this strategy less than 12% of the time and most of these choices were following it only for a screen or two. A button or hotword on each screen led to the part of the heart immediately before and after the current point in the blood flow. Only in the Detailed Links group was this relationship explicitly shown, although those in the other two groups could determine this through reading the text itself. The patterns of screen selection following the blood flow do not differ greatly among the groups.

Click Locations

Another explanation for movements though the screens was that students selected the screen to go to next, not by the content, but by the placement of the hotword in the text or the button on the map. Subjects in the Hotwords group did tend to choose words near the beginning of the text. The low numbers at the bottom of the list are partially a function of the few screens that had that many words. There is not an indication that they chose only the first word, so placement alone does not appear to explain choice of screens.

Subjects in the Links and Detailed Links groups used the map at the top of the screen to navigate. The word at the top of the map was always the concept one step up in the hierarchy. Only concepts directly connected to the current screen were shown. The other terms around the current concept button were not necessarily arranged in a hierarchical fashion, although related terms were placed symmetrically (e.g., Right Auricle was opposite Left Auricle under Auricles). The two groups generally chose locations in the same proportions. The first counterclockwise position (upper left corner) was chosen most often, followed by the top position which was one step up in the hierarchy. This follows the research that people in Western cultures tend to work from the upper left corner of a screen to the lower right. The first clockwise position (upper right) was chosen third most often followed by the second clockwise position and then the second counterclockwise position. Most screens had at least these positions, so these generalizations probably can be made. Anything beyond this is largely a function of how often that position appeared in the map. It does appear that position was a factor in selection of the next concept.

Attitudes and Experiences

Before logging off the computer in session one, each participant completed a survey on the computer concerning his/her previous computer experience, perceptions of moving through the program, and preferred learning strategies. Most items were 5-point Likert-type scales (1=low, 5=high).

The majority of the students did not feel computers were very important in their daily lives and few used computers daily. Students rated the use of hypertext for learning as moderately confusing. Students indicated that they found the program somewhat overwhelming. This feeling appeared similar across all groups. Related to this overwhelming feeling, many students indicated that it was relatively easy to get lost (M=3.37). No one group appeared to have this feeling more than any other. On the other hand, the Links group appeared to find the program slightly more effective than the other groups. Students felt the program was harder than text (M=3.21) with the Hotwords and Detailed Links groups especially leaning in that direction.

Students were asked to comment on the program as an educational strategy. Of the 59 who chose to respond, fourteen commented favorably, noting the ability to go back for review and self pacing as positive aspects. Several students commented that this new form of presenting information takes some getting used to. Many described the experience as confusing, frustrating, overwhelming, and long. Some felt it provided too many options and no logical order. One student stated, "...it bothered me that it was not easy to see the hierarchical structure behind the material. Obviously some material would be more important than others in any given lesson. I found that this program seemed to make the basic structure unclear." A number of others found the heart content boring or too technical. Many felt they missed some screens and easily got lost. In contrast to earlier statements, some found it impossible to use for review because the navigation was very difficult. A few expressed a general dislike of working with computers and/or a preference for textbooks.

Searching Strategies

Students were asked to estimate how much of the program they had covered. A counter indicating how many of the 60 different screens a student had seen was located in the upper right corner of each screen. A Pearson's Product Moment Correlation was performed on the number of different screens and the percentage estimated seen. There was only a correlation of .35494 (p=.0337) between these two measures, indicating the students did not take full advantage of this counter and had no intuitive idea of the size of the program.

All students indicated they sometimes did not go to screens they already felt they knew. Few indicated a willingness to skip such screens often. This may indicate the students either had little knowledge of the topic, could not judge what was on the next screen, or were unwilling to miss anything. Students indicated they sometimes went to concepts familiar to them which may also indicate a hesitancy to miss anything. Interesting, there was a positive correlation between amount of prior knowledge and number of screen seen (r=.28031, p=.0977). Students with higher prior knowledge had a slight tendency to view more screens. Students felt sometimes they viewed screens they had seen before, often unwittingly, but also felt they sometimes missed screens that they skipped and then never could find again.

Almost half (10 out of 22) admitted to having some problems with the lesson such as confusion due to flipping through so many screens, problems with so many options, and trouble finding missed screens to an inability getting back to where one wanted to go. Students expressed their difficulties:

> It was kind of confusing. There were several choices each time you went, and every time you picked a choice, then it would take you off in a totally different direction then you were looking at to begin with. (Hotwords group)

> Sometimes I couldn't get back or had a hard time getting back to where I wanted to get back to. The checks were a good idea. Otherwise I would have gone back to things two or three times by mistake. (Links group)

The navigational techniques used and the degree of learner control were new to most students, and many had difficulty adapting. The majority of the students (i.e., eighteen out of twenty-two) did not find the navigational technique distracting. Some felt it gave the main points to be learned. As one student put it:

> It gave me an idea of what the main points were, some of the more important information, so I'd look at those. I'd read through the text and then go back to the one I'd have the most trouble with or that would interest me the most. Then I'd go back and fill in the gaps and read the stuff I wasn't too sure of. (Hotwords group)

A few found it confusing. Two stated they read the text and then looked at the map, but one felt it made her want to move on without reading the text.

When asked about the strategy they developed to move from screen to screen, the majority said they had a strategy, although their definitions of a strategy varied. Students based their selections on prior knowledge, on an attempt to cover all screens, by relationship, or by locational cues rather than content oriented cues.

When describing the development of these navigational strategies, most tended to start with one technique and stick with it. They tended to use the asterisks or checks indicating screens already seen to determine what they had covered and went back to the Objectives screen to restart when they hit a dead end or got lost. Many never really figured out how to move back through screens.

When asked if they skipped screens on concepts they already knew, nine admitted doing that with three more saying they skipped just a few. Ten never skipped any screens. Many said they wanted to look at all the screens. Some said they went over those they knew more quickly, and a few began to skip or quickly skim screens when they realized they knew some of the information. Many said they went to the familiar screens first and then tried to relate the new screens to the familiar. Some of this hesitancy to skip screens may have been due to the fact that the subject was new to most subjects.

Twenty of the subjects interviewed said they reread screens by choice, especially if they did not understand the topic originally. Twelve of the subjects said they reread screens by accident.

Learner control was a concept fairly new to most of the subjects. They were evenly divided on a preference for learner control or lesson control. Those that liked learner control said they liked the choice so they could skip what was known, review as necessary, and focus on interests. They felt is involved them more in learning. Those that favored lesson control said it provides necessary organization so the learner knows what is important, doesn't waste energy in organizing the content, and provides a logical order for the information. Several felt lost navigating on their own. Others felt they might miss important information, especially on a subject new to them.

Those in the Detailed Links group were asked about their use of the labels in the graphical browser. Five of the seven said they read the labels, although most said they did not do it all of the time. If this is the case, subjects in this group and subjects in the Links group were often performing in the same fashion, thereby minimizing the effects of the two treatments.

At the beginning subjects had been asked to think of the lesson as a new way of learning. They were asked to list the good and bad points of this way of learning. Good points included 1) it was different and interesting; 2) it provided many choices and the chance to skip or review as desired; 3) it provided learner control to choose when and in what order screens were read; 4) it interactively involved the learner and was less boring; 5) it gave the structure of the information in the map; 6) it included useful diagrams; 7) there was a small amount of information on each screen; and 8) it was less time consuming than reading. Some of these strengths were weaknesses to other subjects. Negative aspects of this way of learning mentioned included: 1) it allowed a lot of skipping around; 2) navigation was hard, often confusing, and difficult to move back and forth; 3) it did not provide a concrete order for the information or emphasize the most important information; 4) it is difficult for those with little background knowledge; 5) use of the computer itself was distracting; 6) it was possible to go through it quickly and not learn the information; 7) it was hard to keep track of what was covered; 8) it was not an interesting topic; 9) the amount of information was overwhelming; and 10) not everyone has access to a computer. Overall, students felt there were possibilities for this type of learning but it was confusing and did not provide enough structure for the information.

Limitations of the Study

Testing was a threat in this study. The immediate and delayed posttests were alternate versions of the same test possibly causing some improvement in the delayed test due to the subjects' experience with the immediate posttest. Another threat to internal validity was the method for assessing structural knowledge. Most students are not familiar with such assessment methods and have trouble carrying them out. Mean scores for the task were only 17 out of 44 (SD=13) before the treatment and 19 (SD=13) two weeks after the treatment. Some students produced trees with no or very low structure either before or after the treatment.

A low correlation was found between the posttreatment ordered-tree measuring the structure of a learner's content information and the immediate and delayed criterion-referenced tests (r=.33156 for the immediate posttest, r=.36401 for the delayed posttest). This is another possible indication that the orderedtree task did not differentiate well between the subjects. The question of whether focusing on the concepts and their relationships helps or hinders recall of facts has emerged in the research. Jonassen and Wang (1990) showed that stressing this type of learning may actually hinder factual recall. In the present study, the students did not do worse on the posttests than in similar studies with print materials, but the structural knowledge tasks did not show a large acquisition of this type of knowledge.

The comparisons to an "expert" structure were conducted using the structure of the content in the lesson. This "expert" tree was constructed by the instructional developer and should not be considered that of an expert in the field, but rather that represented in the lesson. It was verified by a high school biology teacher and a nurse for accuracy. The similarity ratings must be interpreted with caution as there are numerous valid ways to structure this information. Each individual may go through the lesson and construct different personal structures.

The ordered-tree technique also may have influenced the study by alerting subjects to important concepts. As these terms were not all that was evaluated on the posttest, they may have provided a false sense of security in selecting what to study. Many seemed to put little effort into it at the time of the delayed posttest.

Experimental mortality was a problem, with twelve students not completing the first session, ten not returning to the second, and five dropped due to lack of SAT scores. Even with this problem, the groups ended up with almost equal numbers, although it is not known if the students lost were randomly distributed across all independent variables.

Generalizability or external validity threats were also present in this study, most notably the fact that volunteers who did this for extra credit, not as part of class content, were used.

Another problem was the length of treatment. The idea was to work within a constrained subject domain so that all the subjects had the possibility of going through all the material. Students not interested in a scientific topic may have found even the time spent boring. Twelve subjects chose to view only one or two screens before exiting. At the same time, the experience with the different types of structural knowledge representations may not have been enough to see an effect, nor were the students actively involved in generating the structural frameworks.

Multiple regression was used for exploring the data in this study. For the equation estimated for the immediate posttest the multiple correlation coefficient was fairly high, accounting for sixty percent of the variance in the dependent variable, but for the other equations, the multiple correlation coefficient was between thirty and thirty-five, accounting for only that percentage of the variance in the dependent variable. The low multiple correlation coefficients could be due to omitting relevant predictor variables, including irrelevant variables, and/or using variables in an incorrect form when the relationships are non-linear. All are possible in this study with the most likely being omission of relevant variables. Other individual cognitive differences, experience with hypertext, risk-taking behavior, and motivational factors might be likely predictors of performance.

Conclusions and Recommendations

This study suggests that users of hypertext require extended experience with such a system to become comfortable and proficient using it. Graphical browsers may provide a degree of structure for the user, but it was not evident from the results that all learners internalized this structural knowledge. Those with high prior knowledge did better on most variables and showed a greater increase in structural knowledge. The use of hotwords rather than a graphical browser resulted in lower achievement on the criterion test dependent measures and was a special problem for those with lower prior knowledge. Verbal ability was not a factor on most of the variables. Further research incorporating extended hypertext use may help to determine the best methods for aiding learners to acquire knowledge in a hypertext system.

Effect of Using Different Navigational Techniques

On both the immediate posttest and the change between immediate and delayed posttests treatment was a significant predictor. The Hotwords group was forced to generate their own framework for the knowledge because the words were embedded in the text, not arranged relationally. It was this group that consistently performed the lowest on all dependent measures. This group's performance was also the most influenced by degree of prior knowledge, most notably on the structural knowledge dependent variables. The Links and Detailed Links groups who used the two different forms of the graphical browser performed similarly on several of the dependent measures, perhaps due to the members of the Detailed Links group who did not consistently read the labels in the graphical browser.

Additional individual subject variables interacted with the treatments, indicating that no one treatment was best for all subjects. The contribution of these variables differed on the various dependent measures.

Influence of Prior Knowledge

Prior knowledge was a significant predictor of immediate posttest score, the difference between delayed and immediate posttest scores, and the difference between pretreatment and posttreatment ordered-tree task scores. It was not a significant predictor of the posttreatment ordered-tree task score itself.

Prior knowledge did not interact significantly with the treatment on any of the dependent measures except the posttreatment ordered-tree task. On this variable it was significant only in the Hotwords group. It was significant only in the Hotwords group for dependent variables representing the difference between posttest scores. This may indicate that learning using the Hotwords treatment which was less obvious in its portrayal of the content structure was more difficult for students with lower prior knowledge as evidenced by several of the dependent measures. The treatments that provided more structural knowledge support appeared to be less influenced by degree of prior knowledge. This study suggests further research on methods for compensating for low prior knowledge is warranted.

In an examination of the path information, students with higher prior knowledge tended to view more of the total number of screens. This may reflect a greater interest in the topic or the general unwillingness to skip screens, even if the information was known. Those with lower prior knowledge may have experienced more frustration and exited the lesson more quickly. Research on learner control has shown that learners often do not know what is best for their own learning, and, even if they do, may not act on this knowledge (Milheim & Martin, 1991; Jonassen, 1986). This is a special problem for those with low prior knowledge (Steinberg, 1977; Milheim & Martin, 1991). Even college students have difficulty with this self-assessment (Garhart & Hannafin, 1986).

In the interviews, less than half said they skipped any of the screens they already knew and of those, most skipped only a few. More common was the tendency to look at a screen and go over it quickly if the content was already known. A number of students indicated they used their prior knowledge to begin with familiar screens and then tie new screens to this known information.

Comparisons of subjects' and the "expert" ordered-trees showed no significant influence of prior knowledge, although it approached significance in the Hotwords group and appeared in a general positive direction in the Detailed Links group.

Influence of Verbal Ability

Verbal ability was not a major influence on most of the dependent measures, possibly due to its correlation with the independent variable Prior Knowledge. Only in the difference between the immediate and delayed posttests did it prove significant, and then only in interaction with the treatment.

Influence of Time on Treatment and Number of Screens Seen

Time spent on treatment and number of screens seen contributed to the variance in scores on the immediate posttest only. Treatment group interacted with both variables so that subjects in the three groups performed differently on the immediate posttest as influenced by these two variables. Number of screens seen contributed significantly only in the Links and Detailed Links groups, approaching significance in the Hotwords group, while time spent on treatment contributed significantly only in the Hotwords group.

Many subjects did not view all the screens due to fatigue or boredom, a choice of degree of effort to invest, or accidentally missed screens and an inability to find them again. Subjects viewing significantly under the sixtyscreens may not have covered all the information evaluated in the posttest. The number of screens seen made a difference on posttest scores for the Links and Detailed Links group, but not for the Hotwords group where there was a very slight negative influence from the number of screens seen.

Time spent could represent either persistence in finding all the screens and/or amount of time spent reading the screens. The latter may have been important only in the Hotwords treatment because more persistence may have been required to actually see all the screens. The screens covered were marked with asterisks within the text itself, but this indication may not have been as obvious to the subjects as the checkmarks used in the graphical browsers. It was surprising that those at the low end of the time variable did as well as they did on the test, considering they spent such a small amount of time viewing the screens. Some of the elapsed time was spent on navigation, as a number of students spent the last few minutes looking for screens they had missed rather than reading new material.

The effect of these two variables was not evident in the change from immediate to delayed posttest. Simply viewing the more screens quickly might influence immediate recall of the information, but not allow for integration of this information into long term memory. Viewing more screens did not translate into a proportionally long time spent on the treatment.

Changes in Structural Knowledge

The posttreatment structural knowledge scores in this study did not rise from the pretreatment scores for all subjects nor did they necessarily grow closer to an "expert" structure reflected in the lesson. Those with high initial structural knowledge showed the highest posttreatment scores, especially in the Detailed Links group. It is conceivable that some of these students may have used the pretreatment task as an organizer for the new information, particularly because the graphical browsers in this group spatially portrayed some of the same terms used in the task and indicated their relationships.

Those who showed greater pretreatment structural knowledge actually did not gain, but lost structural knowledge from the pre to posttreatment task. Some of this may be attributed to the statistical phenomenon of regression to the mean. There may also have been some problem with degree of effort expended on the posttreatment task. Another possible explanation could be that some students who had a structure before the task were caused to question that structure after exposure to the structure in the lesson but never integrated this new structure into their schema. On the other hand, those who did better on the immediate posttest tended to demonstrate more similarity to the "expert" ordered-tree, especially in the Links and Detailed Links groups. This reaffirms the idea that degree of structure is not synonymous with similarity to the "expert" structure. Students may have lost some of their original structure which was unlike the one in the lesson and moved closer to that portrayed in the lesson, but never reaching the same degree of structure shown initially.

Further research is needed on the relationship between declarative knowledge as measured in the immediate and delayed posttests and structural knowledge measured by the ordered-tree task. If declarative knowledge is embedded in structural knowledge, one would expect a closer correlation in all groups between the immediate posttest and the posttreatment ordered-tree and between the delayed posttest and the posttreatment ordered-tree. Students who learned the relationships between the concepts in the lesson would have also learned facts about those concepts. If, as Jonassen and Wang (1992) stated, one interferes with the other, e.g., the acquisition of the relationships between concepts interferes with learning details about the concepts, a negative relationship would be predicted between scores. In this study, the correlation between the immediate posttest and the posttreatment structural knowledge task was only .33 and between the delayed posttest and the posttreatment structural knowledge task only .36.

Problems in Learning from Hypertext

In general, students in all treatments expressed some confusion in going through the treatments. Complete learner control over the pace and path of information seen was new to most of the students. Many felt lost and frustrated as they tried to work their way through the many options on each screen and formulate their own structure. Only after sustained use of such a system for a period of time do users become comfortable with this control and develop the strategies needed to make selections and follow subject paths (Landow, 1990; Oren, 1990; Remde, Gomez and Landauer, 1987; Marchionini, 1988).

This study's subjects spent an average of only twenty-one minutes on the lesson. Many, in fact, spent as much if not more time on the testing. They viewed an average of forty-four of the sixty possible screens. This was not a long-term involvement with hypertext that would be needed for familiarization with the technique. Multiple trials with navigation through a hypertext system should better prepare the subjects to direct their own learning through such a system.

Hypertext use also can cause an additional cognitive burden by requiring users remember the links just made and connect all this information into a coherent whole. Users also had to discover and remember the consequence of following a certain path, where it led, and types of information it provided (Heller, 1990). Examination of path data showed a few students restarting the same section a number of times, only to terminate this path quickly, possibly because he or she decided it was something previously covered. Perhaps some way of indicating what percentage of the screens seen under any of the four main section headings would help in this decision making.

Although the counter in the upper right corner indicated how many of the total number of screens had been seen, there was no indication where the remaining screens were located. This may not be a problem if the system is used for locating information for a specific information need, but students intent on seeing all the screens in an instructional situation became frustrated and jumped around searching for a few missing screens.

This additional cognitive load can distract from the content of the lesson (Mayes, Kibby, and Anderson, 1990). Only one student interviewed specifically mentioned distraction from the use of the graphical browser, although several mentioned they found the browser difficult to use and found keeping track of where they had been a burden. The lack of normal reading cues added to the difficulty of using such a system, especially for less skilled readers (Charney, 1987, Horn, 1990). Only two of the students interviewed stated that the graphical browsers consciously indicated the structure of the content to them, and just a few said they used that structure to help them decide where to go next. This could indicate a lack of understanding of the maps themselves or a lack of attention to these cues presented in a fashion unfamiliar to the students.

The sheer amount of information presented and the number of decisions that needed to be made could also have been distracting to the user. A number of those interviewed mentioned the difficulty of dealing with so many options and this was listed as a reason for preferring lesson control by several. The students were given four major objectives on the first screen that formed the basis for the organization of the hypertext screens, but many did not appear to use these in their searching. The lack of a clearly evident structured path through the screens may have caused students who did not develop a strategy to wander aimlessly, miss relevant material, or form a wrong interpretation (Marchionini, 1988). Perhaps with such a short exposure, the subjects did not have the chance to develop the needed skills in navigating, absorbing layers of information, integrating new information with existing knowledge, gaining a comprehensive picture of the subject, self-management, searching, and manipulation of the interface needed for hypertext systems (Bourne, 1990; Jonassen, 1989b; Kinzie & Berdel, 1990; Wright, 1990; Marchionini, 1988).

Motivation could also have been a problem in this study, carried out with volunteer subjects who had no stake in learning the content. Their only extrinsic motivation was to show up for two sessions to get extra credit points as the content was not related to their classwork. The content of the heart was not of great interest to a number of those interviewed. With motivation an issue and the lack of focus on the objectives given, some students may have merely rambled through the system when given complete learner control (Hammond, 1989) and may have exited the program before covering all the material.

Milheim and Martin (1991) suggested that allowing the learner to control the sequence of the content may not be effective when the content has a specific prerequisite order. They also suggested if all topics must be covered to successfully complete the program or when topics have a hierarchical order, learner selection of content to be covered is not effective. The results of this study cannot strongly support or repudiate these claims, but the mean scores on the criterion-referenced posttest were equal to or slightly higher than those in studies using the linear, print form of the materials when adjusted for test length (e.g., Hodes, 1990; Cardinale, 1990). No comparable measures of structural knowledge are available.

This hierarchically structured content may not have been the most appropriate for a hypertext system. Duchastel (1990) and Spiro and Jehng (1990) have suggested that hypertext is not appropriate for highly structured learning tasks where students may benefit from having that structure explicitly provided to them. Students are not presented the information in the most logical sequence, nor are facts and lower level concepts mastered before higher level ones (Gagne, Briggs, & Wager, 1988). They are left to discover this structure on their own, a task especially difficult for those with no prior knowledge on the topic. The whole question of whether or not the structure of the system was ever conveyed to the subjects must be raised. The low mean scores on the posttreatment ordered tree task (M=17) indicated either a lack of understanding of the content structure, a lack of understanding of the task or frustration with the task.

Students interviewed expressed some difficulty in discovering the major concepts first. The system was structured so that the user could move down the hierarchy of concepts, but this may not have been obvious to all. Users could cover all the main concepts first and then delve into each in more depth as desired. This may be one type of recommended hypertext use strategy that requires more explanation or instruction for the user.

Learning the process of the blood flow through the heart was also an aspect of this lesson. Such a linear process can be less obvious in a non-linear system unless it is clearly delineated. If hypertext is to be used to learn the steps in a process, the steps need to be more clearly linked in the proper order.

Search Strategies

Students were asked about their search strategies, both in the survey and in the interviews and their path data was analyzed. In the survey, they said they returned to the previous screen, saw screens more than once, and missed seeing some screens they wanted to get back to "sometimes" to "often" on a five point scale (i.e., never, sometimes, often, most of the time, always). Analysis of the path data of a sampling of thirty-six subjects showed that they returned to the previous screen about ten percent of the time, going on to a new screen eighty-four percent of the time and returning to the main Objectives screen six percent of the time. A number of students never appeared to grasp the concept of moving back through a path.

The largest percentage of movement in all groups was down the hierarchy with hierarchical movement the most common overall. The highest percentage of options in the graphical browsers was down the hierarchy, so this was expected. The Links group performed slightly more hierarchical movements and fewer heterarchical movements when compared to the other two groups. The Hotwords group tended to move across sections more, possibly because the structure was less visible. Only twelve percent of the movements across all groups followed the flow of blood and much of this was just one screen to the next, not a long string of screens following the blood flow. Students either did not see this as an option or chose to follow the more obvious hierarchical framework of the lesson.

Movement across the hierarchy was largely confined to within a section rather than jumping across sections to related concepts. Even without a strict hierarchy indicated in the navigational technique, students tended to follow a natural hierarchy, although some students indicated in the interviews that they had a hard time perceiving the structure of the content. In learning a process such as the flow of blood through the heart, this hierarchical movement may be most useful for learning the parts of the heart, but not for learning the actual process. If students are to follow this blood flow, it must be more clearly delineated in the choices for navigation.

Where the students clicked on the screen was also recorded to determine if actual placement on the screen was a factor in choosing where to go next rather than the actual content itself. Those in the Hotwords treatment tended to choose the top three words in the text, although not selecting the top term any more often than the others. The groups with the graphical browser tended to select the term in the upper left corner most often, followed by the term at the top then the term in the upper right corner. This may indicate the tendency to start reading in the upper left corner and proceed to the lower right. In general, the terms on the left side of the graphical browser were selected more often that parallel terms on the right side. Placement on the map may be just as important in selection of the next screen as content. If the hierarchy were more evident in the browser, perhaps this would be less the case.

Implications for Instructional Design

No one technique proved best for all students. When compared to other studies by Dwyer using the same materials in a written form, the scores on the criterion-referenced posttests were not greatly improved, although results were better than some dissertation studies using print versions of the heart materials (e.g., Hodes, 1990; Cardinale, 1990), nor time saved by this instructional method (Dwyer, personal correspondence). No comparisons on the structural knowledge task were available. Individual differences, such as prior knowledge, accounted for much of the variance in learner achievement.

In general, the use of this hypertext-system was not intuitive for first-time users. Students not used to this degree of learner control often felt lost and confused. Many had trouble developing a viable strategy for moving through and organizing the information. Many used the indicators of screens already seen (i.e., asterisks or checkmarks) and number of different screens shown in the upper right corner, but still had trouble moving back through a path and selecting from the many options on a screen.

Several suggestions are made for structuring a hypertext system for learning.

1. Results suggest that the graphical browser would be a better navigational tool than the use of the Hotwords alone, especially for those with lower prior knowledge.
2. Students had difficulty getting back to where they came from. Techniques such as path histories of recent screens, an indication of the immediate previous screen, a thumbnail of the previous screen, or a "return" arrow to go to the previous screenmight be useful.
3. The graphical browser could be structured to better represent the types of relationships. Terms up and down the hierarchy might be differentiated from those that jump to other sections or those that follow the flow of blood.
4. A global map or web view showing areas covered and relationships beyond the immediate screen and its direct links could be made available with the ability to zoom in or out to a global map.
5. Some way of indicating what percentage of the screens seen under any of the four main section headings would help in deciding how much of each section has been covered.
6. Not all students work well with a graphical representation of the content structure or prefer this method of navigating, so providing some type of menu listing might be more appropriate for these users.It might be possible to give the user a choice, but this decision may be difficult for the naive user.

7. Users with low prior knowledge or those with little experience with this type of system may need additional guidance in their initial use of the system. Possibly a type of guided tour which would highlight the major concepts to be covered first would be useful for an overview (Oren, 1990). Such guidance could be available on demand in a menu or pop-up window to recommend a path, next step(s), and/or strategy. Novice and expert users of the system may prefer different degrees of guidance.
8. Some additional method for getting to missed screens is needed, perhaps integration of information on missed sections or screens into an overview map or diagram.
9. A keyword search capability would be useful for those looking for a specific piece of information.
10. Hypertext on its own is not necessarily instructional. Such a program might be best used as part of a large instructional system where learners are either given or develop specific objectives for using the system.
11. Highly structured information which might be easiest to learn in a specified order may best be taught in another fashion. Processes may also benefit from a more structured system with more limited hypertext features.
12. An online notebook could be used for taking notes, copying information from the screen, incorporating prior knowledge and information from other sources, and/or keeping track of the knowledge structure or path covered.
13. Students interviewed did not show a desire to provide their own labels on the graphical browsers, but this generative activity might be included as part of the instructional system. It would also draw students' attention to the graphical browser and its structural knowledge content.

Suggestions for Future Research

This was an exploratory analysis designed to determine some of the important variables in the use of hypertext systems for learning. Variables such as prior knowledge and number of screens seen warrant inclusion in future studies. Several suggestions for future research follow.

1. Improve the use of the ordered-tree technique for assessing structural knowledge or explore other possibilities for this assessment. Students need greater familiarity with the technique and practice in its use beforehand.
2. Compare the acquisition of structural knowledge in this technique to using the print form of the lesson. If there is no gain on any of the dependent measures using the hypertext version, there may be little reason to invest the effort in its development unless skills such as information-seeking and comprehension monitoring in a non-linear environment are to be developed.
3. Using the same basic research design, expand the study for use in a real life setting with content appropriate for class use.
4. Further explore the use of different types of graphical browsers.
5. Incorporate further investigation of search strategies both through

qualitative data and analysis of path data in long-term studies. Comparisons of novice and expert users could help describe the development of usable strategies.

6. Assess motivational and attitudinal issues in the use of these systems as well as other individual differences such as risk-taking behavior, field articulation, and metacognitive ability. Look at specific aspects of reading ability that may affect hypertext use.
7. Look at the relationship between structural knowledge, factual knowledge, and problem solving.
8. Study the use of hypertext systems for learning in younger students and the cognitive demands of such a systems.
9. Investigate other navigational methods for using hypertext systems and their relationship to structural knowledge. Study how these systems can replicate or replace traditional reading cues.

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Title:

Distance Education in Iowa: A Research Plan

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Two significant events are underway in Iowa. First, the Iowa Communications Network (ICN), a statewide, full-motion interactive fiber optic network, is nearing completion. The ICN is a 2800 mile system that connects sites in each of Iowa's 99 counties with a fiber optics network for distance education. The ICN is being funded entirely with state funds and is designed to enhance the educational opportunities available to students from Iowa's schools.

Second, a group of Iowa educational organizations prepared a proposal titled the Iowa Distance Education Alliance (IDEA), and in October 1992 received notification of funding from the US Department of Education's Star Schools Program. The IDEA's primary purpose is to infuse distance education into the schools and colleges of Iowa.

One component of the IDEA is to begin a comprehensive research plan that will investigate the use of the ICN and the activities of the IDEA. During 1993, twenty research studies were started. They are based on Rogers' (1983) Diffusion of Innovations Theory, and will provide a foundation for additional studies to be conducted in the future.

Few innovations have the potential impact that the ICN may have on Iowa education. The research plan of the IDEA will empirically examine the infusion of the innovation, "a statewide, full-motion interactive fiber optic network," and will provide information about the large scale adoption of distance education by an entire state.

PURPOSE

This paper describes distance education in Iowa, the Iowa Communications Network, The Iowa Distance Education Alliance, and the research plan underway in Iowa. Research and evaluation are central to the implementation of distance education in Iowa. The process used to rally educators to conduct research is explained.

DISTANCE EDUCATION IN IOWA: BACKGROUND

Iowa's approach to distance education is based on the belief that live, interactive instruction is fundamental to effective learning. Interaction is made possible by the Iowa Communications Network (ICN). The ICN is a statewide two-way full motion interactive fiber optic telecommunications network. It is designed to be used by teachers and students in learning situations where they not only can see and hear each other, but where they expect to see and hear each other. Distant and local students function together as a learning group. They learn from and with one another.

Key to Iowa's successful distance education system is the concept of sharing. Iowa's vision for distance education is being built around the development of partnerships of schools that share courses. For example, a physics class originating in Jefferson may have students in Sac City and Rockwell City, schools in two adjacent counties. French students in Sac City have distant classmates in Jefferson and Rockwell City, and a calculus class that originates in Rockwell City is shared with students in Sac City and Jefferson. All three schools provide courses to partner schools and receive instruction from neighbors. Classes are small with enrollments of 30-35 or less, and are taught by teachers prepared in the skills needed by distance educators.

Iowa's approach to distance education is based on several beliefs about education. The United States has historically been perceived as having the finest education system ever developed. Local control, small classes, rapport between teachers and students, and highly personalized instruction are hailed as important characteristics of this respected system. On the other hand, telecommunications-based education is often perceived as the antithesis to these attributes. Distance education and telecommunications create the image of a centralized curriculum, a single source of information, and large classes with little or no interaction between the teacher and students. Some feel that the traditional values of education and increased use of technology are incompatible with one another. Iowa educators are attempting to prove these critics are wrong.

Of the many projects of the last few years that have promoted the use of technology, few have been as successful as the US Department of Education's Star Schools Program. The Star Schools Program began in 1987 "to encourage improved instruction in mathematics, science, foreign languages, literacy skills, and vocational education for underserved populations through the use of telecommunications networks." Many star schools projects have used communications satellites to deliver courses to large numbers of students located in dozens of cities and states. In 1992, a new approach to distance education was recognized by the Star Schools Program when a proposal submitted by an alliance of educational organizations in the state of Iowa was funded.

Iowa's project demonstrates a distance education system that uses a statewide two-way full motion interactive fiber optic telecommunications network. The "Iowa Distance Education Alliance: Partnerships for Interactive Learning Through Telecommunications (IDEA)," the name of Iowa's Star Schools project, demonstrates that historically important characteristics of an effective educational environment can be combined with educational technology to bring the best of both to the student faced with the challenge of being a citizen of the 21st century. The use of fiber optic technology, because of its extensive capacities and flexibility, provides unique opportunities for augmenting the instructional process beyond what is possible using other distance delivery technologies. The IDEA demonstrates the use of a system that emphasizes:

- local control of the curriculum,
- active involvement by educators from local school districts,
- interactive instruction,
- statewide alliances and regional partnerships,
- preservice, inservice, and staff development activities,
- implementation using existing organizations and expertise, and
- research-based instructional decision making.

The Iowa Communications Network (ICN)

Central to the successful completion of the Iowa Distance Education Alliance project is the Iowa Communications Network (ICN; Figure 1). The ICN is a statewide two-way full motion interactive fiber-optic telecommunications network with at least one point of presence in each of Iowa's 99 counties. The ICN links colleges, universities and secondary schools throughout the state and was constructed entirely with state and local funds.

The plan for the ICN was completed and adopted by the Iowa legislature in 1987. Construction of the fiber optic backbone portion of the network was completed during 1993. The ICN will ultimately connect hundreds of schools, colleges, regional libraries, and governmental agencies. In addition to the capability of transmitting up to 48 simultaneous video channels, the ICN will carries data and voice traffic, and as demand increases the system is easily expandable without the need for "opening the trench" to lay more fiber. The IDEA Star Schools initiative is developing and enhancing the human and technical resources necessary to make effective use of the ICN.

The Iowa Distance Education Alliance

Partnerships of Iowa educational organizations are implementing the goals and objectives of the Iowa Distance Education Alliance. Partnerships in Iowa are also referred to as alliances because they are a "joining for a common purpose." which is the appropriate infusion of live, two-way interactive telecommunications into the educational systems of the state of Iowa.

The Iowa Distance Education Alliance was formed as the result of a collaborative effort of teachers and administrators from local school districts, the Iowa Department of Education, Iowa Public Television, Iowa's community colleges, area education agencies, and public (regent) and independent colleges and universities, with support from teacher and administrator professional organizations and the state's K-12 school boards. This alliance of Iowa's educational organizations is responsible for completing the IDEA project.

Educational organizations participating in the Iowa Distance Education Alliance are organized into several components to ensure that the activities of the project are completed (Figure 2). First, 15 regional partnerships, organized in accordance with Iowa's merged area education structure, were formed. The state's 15 area community colleges and 15 area education agencies which share common boundaries are collaborating with teachers and administrators from local schools to plan for staff development, inservice activities, and course offerings. Classrooms have been equipped. Teachers have been trained. Curriculum materials ere under development. Staff in-service activities were offered, and beginning Fall, 1993, courses began to be shared.

Second, a clearinghouse was established by the Iowa Department of Education. The clearinghouse provides quick and comprehensive access to information about interactive telecommunications, and it coordinates access for Iowa Distance Education Alliance partners to other computer and telecommunications networks, such as the Internet.

The third component of the project is the Teacher Education Alliance which is being coordinated by faculty from each of the state's three public universities working closely with teachers, teacher education faculty from the independent colleges and universities, and the area education agencies. The Teacher Education Alliance has developed a process for, and materials being used in, preservice and inservice teacher education experiences. Materials are being used to assist teachers in curriculum revision activities and to prepare them for instruction of students at a distance. Workshops have been held. Inservice sessions have been delivered, and curriculum plans for staff development are being made available. Finally, the staff of the Teacher Education Alliance developed and are completing a comprehensive plan for research and evaluation to determine the unique contributions of the Iowa approach to the theory and practice of distance education. Currently, twenty research studies are underway, and more are being planned.

The fourth component of the Iowa Distance Education Alliance is the project management structure which is coordinated by Iowa Public Television and the Iowa Department of

Education. The project manager's primary responsibilities are to administer the activities of the project and to interact for the alliance with organizations in Iowa and elsewhere.

Goals and Activities

The projects goals are listed in Figure #3. To accomplish these goals a number of activities were undertaken. Some of the more significant activities were:

1. During 1993, each of the 104 endpoints of the ICN were connected to a fully equipped distance education classroom.
2. During 1993, a public awareness program was planned and implemented that familiarized Iowa citizens with the concept of distance education, with the capabilities of the Iowa Communications Network, and with the purposes of the Iowa Distance Education Alliance.
3. The framework for sharing of distance education courses was developed.
4. Faculty from Iowa's colleges and universities collaborated to develop a curriculum implementation plan that is being used so that graduates of Iowa's teacher education programs are prepared to become distance education teachers.
5. During the Spring and Summer of 1993, hundreds of Iowa teachers were prepared to teach using the ICN.
6. Faculty from Iowa's universities and colleges collaborated with representatives from the state's area education agencies to ensure that distance education courses reflected current thinking and reform efforts in science, mathematics, foreign language, vocational education, and literacy education.
7. a comprehensive research plan based on the principles of diffusion of innovations was formulated and begun. This plan identified a number of action-research projects that dealt with local concerns in addition to studies that investigated more fundamental distance education issues.

Finally, the partners of the Iowa Distance Education Alliance established in Iowa the framework for the infusion of the principles and practices of distance education throughout the state. The Iowa Distance Education Alliance is a model for other states and regions that plan the large scale implementation of a distance education system that is based on the concept of local control of courses offered using live two-way interactive telecommunications.

THE RESEARCH SITUATION

The feelings in Iowa related to distance education have traditionally been volatile, and this presents the opportunity for many research studies. Specifically, the situation in Iowa is characterized by the following.

1. The ICN was planned for the educational community of Iowa by state government, most notably the administrative and legislative branches. No consensus of acceptance was sought from or given by Iowa's educators. In other words, the ICN is a top-down innovation that was built and now is available to Iowa educators.

2. Only a small percentage of Iowa educators and Iowa citizens clearly understand distance education and the ICN, but most are aware that the state is spending over $100 million to construct the ICN.

3. Many educators and citizens are skeptical of the concept of distance education, and

opposed the construction of the ICN.

4. Distance education has gained acceptance as a discrete category of education.

5. Fiber optics communication is the most effective transmission method for live, two way, full motion interactive telecommunication, even though it is not the only effective transmission method, or the most cost effective transmission method. In Iowa, fiber optics has been mandated by the legislature as the primary medium for distance education.

6. Most teachers are not familiar with the techniques of the distant educator, or the needs of the distant learner.

7. Distance education research is emerging, is largely anecdotal, is not empirically based, and usually is reported as individual studies with little or no relationship to an ongoing, large-scale research plan.

8. Theories of distance education have been proposed and are beginning to gain acceptance.

9. Rogers' Diffusion of Innovations Theory, one of several theories that provide a foundation for research in distance education, is considered an appropriate guide for a large-scale research agenda such as the diffusion of distance education in Iowa.

The Research Plan

First, a group of Iowa educators was identified to serve as a research and evaluation advisory panel (REAP). This group developed the plan for soliciting research proposals from those interested in investigating the distance education situation in Iowa. A Request for Proposals (RFP) process was used (Appendix 1). This RFP was sent to over 1000 Iowa educators from a cross section of academic disciplines and organizations. The RFP process was conducted in four phases. After each phase, proposals were reviewed by the REAP who provided authors of the proposals with suggestions for improving their studies. In some cases proposals were revised and resubmitted, based on suggestions made by the REAP. At the conclusion of the RFP process, twenty studies were selected for funding (Appendix 2).

Next, a comprehensive review of the distance education literature was commissioned. This document (Schlosser and Anderson, 1994), was published by the Association for Educational Communications and Technology, and included current information on the theories, research, and critical issues of distance education. This monograph was distributed to the researchers whose proposals were selected for funding to assist them in their research efforts. This monograph also is used to provide consistency among the research studies.

Late in 1993, the RFP process was concluded. In order to complete the research agenda and to fill gaps in coverage, additional studies were solicited from researchers. Two examples of new studies include a Delphi study that will attempt to develop a vision statement for how distance education in Iowa should evolve, and a study that will review and summarize the characteristics of the distance education classrooms connected to the ICN. This summary will include a photograph of the classroom, a summary of the classroom's capabilities, and a rating of the classroom's utility as a distant learning site. Finally, a synthesis of the most effective features of classrooms will be developed and a model classroom will be proposed.

Next, summaries of the funded research studies are being published widely. This is to inform Iowa educators of the scope of the project's research plan. As studies are completed they will be published as monographs and distributed to those who are interested. Finally, an Encyclopedia of Distance Education Research in Iowa will be published. The Encyclopedia will be published late in 1994 and will include the entire research agenda of the Iowa Distance Education Alliance project including:

- the research, theory, and issues monograph,
- the final reports of the project's research studies,
- a review of the project's research plan, and
- a summary of the findings of the research activities of the project.

CONCLUSION

"Finally, the most fundamental and most important characteristic of a profession is that the skills involved are founded upon a body of intellectual theory and research. Furthermore, this systematic theory is constantly being expanded by research and thinking within the profession . . . the practice of a profession cannot be disjoined from its theoretical understanding and vice versa . . . The antithesis to a profession is an avocation based upon customary activities and modified by the trial and error of individual practice. Such an avocation is a craft. . . The difference between the bricklayer and the architect lies right here." (Finn, 1953, p. 9.)

In Iowa, every attempt is being made to insure that the practice of distance education is based on theory supported by research. The results of the research plan described above will support the professionalization of distance education in Iowa, and nationwide.

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Appendix #1: Request for Proposals and Review Criteria

Appendix #2: Research in Progress - Annotated Listing

Title:

An Exploration of Closure as a Factor Influencing Group Member Satisfaction: Implications for Applications of Group Support Technology in Education

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Abstract

Research that identifies factors that facilitate information processing and enhance performance without reducing group confidence and decision satisfaction may influence future development of groupwork systems. The Cognitive Closure Model of Decision Satisfaction provides a framework for research that explores the relationships among need for closure, extent of information processing, and subjective certainty (cognitive closure), as contributing factors to decision satisfaction in group contexts. Improvement of current systems that facilitate group work used in business settings offers potential for the future development of such systems for educational applications.

Introduction

The importance placed on the construct "satisfaction" in groups is evidenced by the amount and variety of contexts in which it has been studied and measured. For example, Maier (1970) cited the importance of member satisfaction for decision adoption and implementation. Van de Ven and Delbecq (1974) operationalized group effectiveness to include performance and satisfaction. Keller (e.g. 1983) specifies satisfaction as one of four critical factors in his model for designing motivating instruction. Yet, despite its acknowledged importance the construct is not well understood.

Although their goals and contexts may be quite different, a close look at satisfaction in the group decision-making literature may provide useful insight into the design of computer-based systems that support group learning and problem-solving tasks. The research on and development of computer-based group decision support systems for use in business settings may have promising applications in educational settings.

This paper reviews the literature on cognitive and motivational issues in both group decision-making and learning contexts, due to their dual focus on task and process satisfaction, and examines the concept of closure as a possible contributor to group member satisfaction. This is followed by a presentation and description of The Cognitive Closure Model of Decision Satisfaction (Venkatesh, Small & Verville, 1993) and concludes with a brief discussion of potential applications to education.

Group Member Satisfaction

In learning situations, satisfaction is often described as the sense of accomplishment that learners feel at the conclusion of a learning event when outcomes of their efforts are consistent with their expectations (e.g. Keller, 1983). Keller maintains that instruction may be designed to help people feel good about their learning accomplishments, thereby resulting in learning satisfaction. This suggests that learning satisfaction occurs at or near the end of either each learning chunk or the total learning event.

Assessment of learning satisfaction often focuses on the individual's satisfaction with his or her learning accomplishments. McCombs (1982) and Keller (1983) mention intrinsic factors such as personal control and responsibility as contributors to learner satisfaction. Small and Gluck (in press) found that adults perceive external reinforcements such as feedback, encouragement, expectations, praise, and reward as factors closely related to satisfaction. Manteuffel (1982) cited both control and reward as major characteristics for a satisfied adult learner.

Frequently, satisfaction is tied to the completion of a learning task by an *individual* in a learning situation. However, often learners are required to work in *groups*, use *group* processes, accomplish *group* tasks, and be assessed according to *group* outcomes. In these situations, group member satisfaction may not reflect individual satisfaction; i.e. an individual could be satisfied that the group reached a group-level goal but lack personal closure on the efficacy of the result or the process.

Hecht (1978) has stated the need for theoretic work in the measurement of satisfaction. Exploration of the factors that influence satisfaction in group decision-making situations has led researchers to distinguish between *task-related* and *process-related* components of satisfaction. In relation to task-related factors, several researchers have reported a link between group task accomplishment and group member satisfaction. Heslin and Dunphy (1960) reported that groups scoring low on perceived task accomplishment tended to report low group member satisfaction, while Marquis, Guetzkow and Heyns (1951) found satisfaction to be higher in groups that reported a high degree of accomplishment. They determined that groups that completed a larger percentage of their agenda were more satisfied than groups that did not.

Other studies have identified process-related factors of task accomplishment as predictors of group member satisfaction. Hrycenko and Minton (1974) suggest that member satisfaction with the task-performance procedure chosen may contribute to overall satisfaction. The process dimension is implicit in Collins and Guetzkow's (1964) observation that perception of movement toward the task goal may be positively related to satisfaction. Preparing and adhering to the meeting agenda and keeping the problem in focus during the meeting have also been cited as factors promoting satisfaction (e.g. Kriesberg, 1950).

Closure

In the education literature, closure is often presented as a norm; i.e. that a learning task *must* be brought to closure (e.g. Phillips, 1987; Dubelle, 1986). McMillin and Newman(1991) cited closure as one of six important elements for effective instruction.

Closure is often associated with the idea of "completeness," as, for example, in Gestalt theory which proposes that one responds to a situation as a complete and unanalyzable whole rather than a sum or specific elements. Dubelle (1986) describes closure as the outcomes of an activity that brings the major points of a lesson into focus so they may be perceived as an organized whole and as the individual's need to smooth or complete what is unfinished. Stacey and DeMartino (1963) emphasize the importance of closure as striving for some form of completion of an activity.

Reigeluth (1984) prescribes a "zooming in and out" approach to instruction that allows students to study specific content or skills but always in the context of the larger body of knowledge in which they fit. Similarly, Keller (1984) emphasizes the need for learners to perceive various pieces of content as fitting into a whole, thereby experiencing closure and a sense of accomplishment. Brophy (1987) contends that students experience a sense of accomplishment when they complete meaningful tasks. Wlodkowski (1991) advocates attaining closure when insructing adult learners, stating that it "enhances learner motivation because it affirms the entire process, reinforces the value of the experience, directly or indirectly acknowledges competence, increases cohesiveness within the group, and encourages the surfacing of inspiration and other beneficial emotions within the learners themselves (pp 247-248). Therefore, closure may relate to subjective certainty or confidence related to the result (cognitive closure) or related to the completion of the process (process closure).

Cognitive closure. The motivation to attain cognitive closure has been examined in regard to subjective certainty; that is the need to closure may motivate people to prefer certainty and coherence over indeterminacy. Kruglanski (e.g. 1989) has examined the need for closure within a motivational theory of cognition. Cognitive closure occurs when a definite answer to a question is obtained, leaving no ambiguity or confusion (Kruglanski and Freund, 1983). Need for closure represents a need to attain assured knowledge that "affords predictability and a base for action" (Kruglanski, 1989, p. 14).

In a group context, the need for closure may be reflected in the group's motivation to collectively develop a genuine "social reality" (Festinger, 1950) or consistent problem representation. Such a motive may prompt the group to resolve differences so that authentic agreement may result. This drive for group consensus may be similar to an "individual's need for personal closure in his or her own cognitive system, that is, for intrapersonal consistency among the individual's cognitions giving rise to a sense of coherent knowledge or subjective reality" (Kruglanski and Webster, 1991, p. 223).

Process closure. Both activity predictability and completion of activity sequences may facilitate closure (Maier, 1970). Group task strategies facilitate both coordination of group effort and the determination of task progress and may help members generate expectations about when and how these activity sequences will conclude (Losada et al., 1990). In educational situations, learners engaged in a learning task strive for closure to an activity under way (Stacey and DeMartino, 1963). When closure is not achieved, learners may feel "left up in the air" and psychologically unsettled (Cutietta, 1984).

Satisfaction and Closure

The literature reviewed to date does not adequately address the possible relationship between satisfaction and closure. In the education literature, closure is commonly presented as a desired end state; i.e. that the learning task should be brought to closure for learning satisfaction to occur and that it may require more than one learning session to accomplish closure.

In the group literature, Hagen and Burch (1985) found that both perception of closure on a group task and attainment of closure for task direction promoted satisfaction. However, the factors behind closure were not adequately explored, nor was the concept of closure clearly defined. Furthermore, the psychometric properties of the instrument used to measure satisfaction were not adequately described.

Van de Ven and Delbecq (1974) compared groups using interacting, delphi, and nominal group technique (NGT). They found the NGT groups attained high closure while delphi and interacting groups members attained either low closure or "closure with detachment" (p. 619) but closure was implicitly (not explicitly) defined as task accomplishment. Furthermore, NGT groups also reported being significantly more satisfied than the other groups. Here, satisfaction was operationalized to include perceptions of both process and quality of the group's performance. They enumerate "facilitative characteristics" of the NGT: structured meeting process,, balance bewteen task and maintenance focus, problem-centeredness, opportunity for members to "think through and write down ideas" and so on (Van de Ven & Delbecq, 1974, pp 617-619). Although this result hints at a linkage between satisfaction and closure, Van de Ven & Delbecq do not explicitly make this connection. They also do not specify whether these facilitative characteristics are examples of more general underlying mechanisms that promote cognitive closure and, if so, what those mechanisms are. Therefore, while prior group research has addressed closure as an outcome measure, the construct is seldom explicitly defined and the components of closure remain unidentified.

Closure and Confidence

In group decision-making situations, satisfaction may be considered an *affective* response of group members toward the decision made, while confidence is a *cognitive* response. Wlodkowski (1991) asserts that confidence occurs once a person knows with some degree of certainty that he or she is capable or adept at what was learned.

While satisfaction and confidence are not the same (Sniezek, 1980), there is evidence that they are highly related constructs. Keller (1983) identifies four critical factors for motivation and describes them in relationship to expectancy-value theory, with both confidence and satisfaction linked to expectancy for success or failure. According to Keller, confidence is built on such factors as awareness of expectations, personal control, and a history of success while satisfaction depends on meaningful applications, positive outcomes, and consistency. In a study that explored the relationships of Keller's four factors and to identify the effective instructional strategies that are most closely related to each of them, Small and Gluck (in press) found a significant relationship between confidence and satisfaction.

Kruglanski (1989) notes that the need for closure represents a quest for assured knowledge. In this paper, closure is defined as a state characterized by confidence or subjective certainty (cognitive closure), terms often used synonymously (Sniezek, 1980). This relates to the characterization of closure as task accomplishment (Hagen & Burch, 1985; Van de Ven & Delbecq, 1974) because, in decision-making situations, a task is perceived as "done" when subjective certainty about the decision is deemed acceptable by the decision-maker (e.g. Corbin, 1980).

In their research, Kruglanski and his associates manipulated the need for closure as an independent variable. We examine closure (subjective certainty) as a dependent variable. Our work focuses on the effects of information processing on closure and whether attaining cognitive closure promotes decision satisfaction. The Cognitive Closure Model of Decision Satisfaction (see Figure 1) is based on the literature and our previous work in this area.

Place Figure 1 about here

The Cognitive Closure Model of Decision Satisfaction

The Cognitive Closure Model of Decision Satisfaction begins with the proposition that need for closure affects the extent of information processing (Kruglanski, 1989) and explores the implications of this proposition for closure (as a dependent variable) and decision satisfaction. The following sections of this paper describe this model through a discussion of each pair of posited relationships leading to final satisfaction; i.e. need for closure and extent of information processing; extent of information processing and cognitive closure (defined as confidence or subjective certainty), and cognitive closure and decision satisfaction.

Need for Closure and Extent of Information Processing

Knowledge is assumed to consist of propositions in which a person has a given degree of confidence (Kruglanski, 1989). As such, knowledge has two components--- *hypothesis generation* during which propositions are generated and *hypothesis validation* in which a given degree of confidence is attached to the hypotheses. Knowledge acquisition, involving epistemic activity, thus entails information processing.

The hypothesis generation-validation model might be considered a general characterization of the process by which knowledge is acquired. In a study that examined the impact of telecommunication system design and instructor style factors on student perceptions of learning and satisfaction, Walker and Hackman (1991) found that the *amount* of information received was the single greatest contributor. However, Hooper (1992) suggests that cognitive benefits associated with cooperative learning situations are more closely related to *giving* than to *receiving* information. He further states that "(t)he processes associated with generating explanations appear to force students to process information deeper than the processes association with listening to explanations of lesson content" (p.27).

Kruglanski (1989) differentiates between two "epistemically-relevant motivations" that affect the extent of information processing (both breadth and depth) in knowledge acquisition; i.e. high and low need for closure. Information processing may be less extensive (breadth) under high need for closure conditions than low need for closure conditions (Mayseless & Kruglanski, 1987) while it may be more intensive (in-depth) under certain conditions. That is, low need for closure subjects were more sensitive to alternative hypotheses, considered information that was inconsistent with prior opinions, and were more open to both global and specific information about the task than were high need for closure subjects (Kruglanski, 1989).

The cognitive motivation to attain firm knowledge may therefore be said to influence the extent of information processing. This model, however, does not address two important issues---how the process is regulated and how the knowledge that is acquired through the process is judged to be more or less firm. These issues are considered critical because the motivation to attain or delay cognitive closure entails, by definition, a characterization of the decision-maker as an active evaluator of the adequacy of the information processing. It also assumes the existence of a standard of appraisal against which knowledge is judged to be more or less firm.

Extent of Information Processing and Cognitive Closure

The model further posits that the decision-maker actively assesses the adequacy of information processing with reference to the need for closure (high vs. low) salient in the situation. That is, the need for closure may regulate the extent of information processing (including both hypothesis generation and validation) before a firm judgment is reached (Mayseless & Kruglanski, 1987; Kruglanski & Freund, 1983).

In general, it appears that high need for closure (induced by either reducing the cost to the subject of judgmental invalidity or by increasing the benefit of rendering an expeditious judgment) retards information processing. Conversely, low need for closure (induced by increasing the cost to the subject of judgmental invalidity) fosters more extensive information processing. Under either of these conditions, the decision-maker actively assesses the costs versus the benefits of increased information processing in conditions characterized by differing motivations to reach a firm decision. As a consequence, processing is judged adequate when such a motivation is high (high need for closure) and inadequate when the motivation is low (low need for closure). However, Kruglanski's work does not clarify how the decision-maker determines that the knowledge he or she possesses is more or less firm before deciding to decide; i.e. by what criterion or standard of appraisal the decision-maker makes this determination.

It is likely that cognitive closure (defined here as the minimum level of subjective certainty or confidence acceptable to the decision-maker) will function as such a criterion. Information gathering and deliberation are geared in part to reducing the subjective uncertainty inherent in a decision to a "comfortable" level (Cox & Rich, 1964). This implies that the decision-maker may not feel the need to decide until this level is reached.

Consistent with this line of reasoning, Corbin (1980) uses the "uncertainty cutoff" idea to discuss the timing of choice. This cutoff point is subjectively determined according to an acceptable level of certainty. When subjective certainty fails to reach that level, the decision-maker may choose to delay making a decision or avoid making a decision entirely. Intensive processing of available information or gathering more information may provide an alternative means "for decreasing uncertainty and for inducing the readiness to decide" (Corbin, 1980, p. 54).

In an attempt to define what constitutes an "acceptable level" of subjective certainty and how to determine the "uncertainty cutoff,"
we propose that the cutoff level may be a function of the need for closure. In high need for closure situations, the acceptable confidence level may be set relatively low if the cost of judgmental error is not perceived to be great and the reward is perceived to be high. However, in low need for closure situations, the decision-maker may feel a need to attain a relatively high level of confidence before making a decision if the cost of judgmental

invalidity is perceived as higher than the reward for possessing firm knowledge.

The model asserts that the decision-maker assesses both the adequacy of the extent of information processing and the subjective confidence level during the decision-making process. The previous discussion indicates that a determination of what is an adequate level of information processing may be influenced by cognitive and motivational factors. Decision makers may simply process more information in order to increase the subjective confidence level, terminating such processing when the confidence level exceeds the uncertainty cutoff. Decision makers may decide to halt processing and make a decision if they believe that they had put forth "enough" effort on the task and therefore believe the probability of being correct is high, resulting in high final confidence. Thus the model explicity indicates a reciprocal relationship between subjective confidence and information processing (see Figure 1); i.e. information processing helps increase confidence in general, although under certain circumstances increased processing may reduce confidence (Sniezek, 1991). Information processing would continue until subjective certainty is above the acceptable level of confidence (or reaches the uncertainty cutoff) which defines the moment of choice.

Information overload may negatively affect decision-makers' ability to "integrate and cope with all that information...lead(ing) to dissatisfaction" (Cummings, O'Connell and Huber, 1976, p. 234). In a study exploring the ways people approach the task of gathering information on a specific topic from a multimedia information source, Small and Ferreira (1994) found that some subjects expressed frustration and uncertainty about the amount of information available for access when using a multimedia information system. This phenomenon may have contributed to a lack of subjective certainty about the adequacy of the information search process or the information accessed, resulting in a perceived lack of closure.

Cognitive Closure and Decision Satisfaction

Although cognitive closure may lead to decision satisfaction, there is a need for research that investigates the effects of different levels of need for closure and extent of information processing on both factors. For example, when the need for closure is valued and attained (high), is decision satisfaction assured? If the need for closure is low (not immediately desired) but external constraints (e.g. time) force a decision, does this lead to lowered or lack of confidence and decision satisfaction? When each group member possesses different information, does the perceived necessity to share information influence interaction and the extent of information processing? When all group members possess the same information, does interaction decrease and is the extent of information processing affected? Our current research is exploring some of these issues.

Conclusions

Group decision support systems (GDSS) (e.g. GroupSystems, VisionQuest) are a set of networked electronic tools that facilitate group work, most often in business settings.. They typically include software that allows participants to conduct group activities, such as anonymous electronic brainstorming and organization and ranking of alternatives.

Research that identifies factors that facilitate information processing and enhance performance without reducing group confidence and decision satisfaction may influence future development of groupwork systems. The Cognitive Closure Model of Decision Satisfaction provides a framework for research that explores the relationships among need for closure, extent of information processing, subjective certainty, and decision satisfaction.

Although, the current model does not incorporate a feedback component, Small and

Gluck (in press) identified feedback as a unique term related to satisfaction. Hooper (1992) stated the need "to investigate the effects of feedback timing and the nature of feedback in group environments" (p. 36). Adding appropriate feedback loops to the model may increase the likelihood of confidence and satisfaction in group work. This is an area for future research.

Steeb and Johnston (1981) suggest that visual aid organizers may help decision-makers deal with information overload more effectively.
This type of intervention tool during the hypothesis generation *and* validation stage might promote confidence and satisfaction. However, application to one or the other (generation *or* validation) might decrease confidence and/or satisfaction.

Research on and development of effective support systems for groupwork in business settings holds promise for applications to education. Aiken (1992) recommends the use of GDSS technology in a wide variety of educational situations (e.g. foreign language instruction, classes for the deaf, group meetings) as an effective tool in group instruction. Adaptation of these tools to educational contexts could enhance problem-solving learning activities. For example, such systems would allow discussions of sensitive or controversial topics (e.g. as drug abuse, national health care, the environment, conflict resolution), allowing all students to participate actively while allowing their thoughts and ideas to remain anonymous. Exploration of applications of GDSS technology in education, as well as ways to improve current group work systems, are needed.

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Title:

Multimedia vs. Print Information Resources: Information Location and Use, Motivation, and Learning Patterns for Children and Adults

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ABSTRACT

In educational and training environments teachers assign their students independent research tasks that require locating, gathering, synthesizing, and summarizing information from one or more information resources containing large, and sometimes overwhelming, amounts of information. Often these tasks are poorly-defined, requiring learners to utilize resources that have not been tailored to meet their specific information needs. This may result in information overload and/or information anxiety. This study explored the information location and use activities, motivation and learning patterns of children and adults using either a print or multimedia resource to complete a research task. Results indicated some differences in engagement of text and nontext information, expectancy of success, and type of knowledge representation.

INTRODUCTION

Although there have been numerous studies comparing learning and performance with various instructional delivery systems, their results have been largely mixed (e.g. Clark, 1983). In addition, many of these studies center on a medium as an *instructional* rather than *informational* intervention to satisfy a learning need. Furthermore, research questions focus on whether one medium is better (i.e. results in higher learning and/or motivation outcomes) than another medium, rather than examining how learning occurs with a specific information resource.

In educational and training environments students may be assigned independent research tasks that require them to locate, gather, synthesize, and summarize information from one or more information resources containing large, and sometimes overwhelming, amounts of information. Often these tasks are poorly-defined, requiring learners to utilize resources that have not been tailored to meet their specific information needs. Furthermore, students, even as young as elementary and middle school age, are often expected to accomplish the major part of a research task independently (Kuhlthau, 1989). In addition, they may use multimedia information resources that require the processing of both print and non-print information simultaneously.

These issues become magnified as the use of information technologies (both stand-alone and distributed) allow students to gain access to information in contexts that are outside of traditional structured educational institutions (e.g. homes). This may result in information overload and "information anxiety," described by Wurman (1989) as a" black hole between data and knowledge" (p. 34). The purpose of this study was to explore the attitudes and processes that students activate when using different types of information resources to complete an independent research task. The study focused on three areas--- information location and use, motivation, and learning.

Information Location and Use

Traditionally, students have conducted information retrieval activities by locating relevant print resources (e.g. encyclopedias, reference books), searching through them one at a time, extracting bits of relevant information from each resource. Once they have extracted what they perceive as important information within one resource, they proceed to the next resource and repeat the process. Eisenberg and Berkowitz (1990) describe this process in the context of a larger information problem solving process. In this study we focused on three information *location and use* tasks consist of *finding* desired information within a resource either through using an organizational tool (e.g. index) or browsing (random or sequential), *engaging* the information by viewing, reading and/or listening, and *extracting* information within a resource through notetaking. Marchionini (1989) likens these activities to conducting the look up, examining the results, and extracting relevant information.

Current technologies that combine computer-based control and a CD-ROM or laserdisk storage device provide students with simultaneous access to integrated information resources that utilize a variety of media (Grabowski & Curtis, 1991). Theoretically, these multimedia information resources provide students with faster and easier access to potentially richer bodies of information than any single medium resource. As a result, information skills such as finding, selecting, and extracting become even more critical (Small & Ferreira, in press).

Several studies have investigated information location and use with computer-based and print resources. Mynatt et al. (1992) found that subjects using a hypertext, nonlinear book, even with minimal training, are as successful at an information seeking task as those using a conventional book. Shneiderman (1987) reported about equal performance on an information use task with a hypertext and print version. MacKnight and Baroni (1993) found that students using either print or electronic versions of a manual to complete a research task did not differ in their ability to recognize and extract important information from either source or in the number of times they bypassed or overlooked important information. The current study investigates differences in information location and use activities (finding, engaging, and extracting by children and adults using a print-based or multimedia resource to complete a research task.

Motivation

The attitudes or motives users harbor in regard to a particular information resource may influence their use of that resource which, in turn, could influence their perceptions about the accessibility of relevant information within that resource (Culnan, 1985). In this study, motivation is defined broadly in terms of the value and expectations of successful use of a resource, a theory known as expectancy-value theory (e.g. Porter & Lawler, 1968). *Value* refers to the perceived importance of or interest in the information resource, while *expectancy* refers to the perceived accessibility of needed information and successful completion of the task.

Taylor (1986) identifies a number of characteristics of an information system (e.g. accessibility, accuracy, currency, reliability, ease-of-use) that add value for the user of that system. For example, the most effectively and efficiently designed encyclopedia would be considered a poor learning resource if it contained inaccurate, outdated, or irrelevant information for meeting a learner's specific information needs.

Previous research indicates that computer-based systems that stimulate curiosity and interest and allow greater user control may result in more positive attitudes, greater engagement in, and less anxiety toward using these systems (Kinzie, 1990). Heroman (1990) found high student engagement to have a positive relationship with satisfaction with an overall learning situation. Stimulation deficit (information underload) or excessive stimulation (information overload) often result in boredom (Klapp, 1986). The learner's perception of his/her competence in successfully navigating this type of system and retrieving all of the relevant information may contribute to a positive motivation toward the system and successful accomplishment of learning goals (Kinzie, 1990). Keller (e.g. 1983) describes instructional motivation in terms of stimulating interest and curiosity and providing relevance, importance, and utility (value-related strategies), building confidence and competence, and promoting satisfaction through effort-success linkages (expectancy-related strategies).

In a study comparing computer-based to print-based instruction, Yang (1991-2) found that the computer-based instructional group showed significantly higher motivation on a post-treatment motivation survey than did the print-based instruction group and concluded that the computer had a strong motivational impact on students' learning, possibly resulting from the novelty and higher potential learner control of that medium.

Much of the current research has determined that students who use computer-based instructional resources are more highly motivated than those using print resources. The current study compared changes in motivation levels for subjects required to use a specific resource to complete a poorly-defined, independent research task where (1) the resource is learner-controlled rather than instructor-controlled and (2) the resource is informational rather than instructional (Grabowski & Curtis, 1991).

Learning Patterns

Studies comparing learning with print and non-print sources, often use traditional methods of evaluation such as multiple choice tests. These are appropriate when the body of content to be learned is tightly controlled, as in a textbook or computer-based instructional program. However, when the task is one in which the learner uses one or more resources which are *informational* rather than *instructional* in nature, the body of content is often not easily controlled and there is a lack of learning guidance.

Users of multimedia resources may independently select, process, and interrelate new pieces of information with information they already know to construct new knowledge (DeCorte 1990). They enjoy a new sense of empowerment by having control over format, type and amount of information, pace, and sequence of content (Small & Grabowski, 1992).

Regardless of the resource, students seek to find an order, structure and intellectual framework for the information. Wurman (1989) contends that the ways of organizing and structuring information are finite. He has identified five organizational schemes: category, time, location,alphabet, or continuum. A major advantage for the use of multimedia resources is that they are often organized in a way that mimics the associative properties of human memory, facilitating the user's ability to create personalized organizational schemata for the information presented (Jonassen & Wang, 1990). However, a major disadvantage is that without system control and learning guidance, there is a greater danger of users skipping over important information or exiting the system before relevant content is accessed (Milheim & Azbell, 1988).

Attempts to measure learning during research activities in which information access is not tightly controlled defy the use of traditional instruments (e.g. multiple choice tests). May of the studies that compare learning with multimedia or print resources compare *amount of information retained* rather than exploring how learners *cognitively structure learned information.*

Users of multimedia resources may select, store, and organize information in their memories in a variety of ways. They may choose to attend to some information while ignoring other information. This means that methods for assessing both prior knowledge and knowledge acquisition when learning from information sources must be used that "map" the knowledge of users to better understand their cognitive schema. The current study used a technique similar to cognitive mapping known as "pattern noting" (Buzan, 1974) to determine users' prior and subsequent knowledge when using multimedia versus print information resources.

Research Questions

1. What information location and use activities (i.e. finding, engaging, extracting) are utilized when accessing information using a print or multimedia information resource and do they differ due to the age of the learners?

2. Are there differences in motivation (values and expectancies) when completing a research task using print or multimedia resources?

3. In what ways do resulting learning patterns differ when using a print or multimedia resource?

These questions were explored for children using either a print or multimedia resource. Additional data were gathered from adults using the multimedia resource only.

METHODS

Instruments

In order to determine information location and use, motivation, and learning, patterns for subjects using print or multimedia resources, three types of instruments were used.

Observation Checklist. An observation checklist was developed to record information location and use activities exhibited by subjects for both multimedia and print treatments. These activities corresponded to computer program menu choices or print resource options (e.g. using the index, using the table of contents, random browsing, searching by topic or keyword). In addition, each of these activities was classified according to the information location and use skills defined by Eisenberg & Berkowitz (1990): (1) *finding* information within an information source (browsing), (2) *engaging* information within an information source (viewing, listening, and reading), and (3) *extracting* information from an information source (notetaking).

Motivation Questionnaire. The Information Resource Attitude Survey (IRAS) (Small, 1992) was used to measure subjects' motivation in using a specific resource. Motivation is further defined as value (how interesting and relevant is the information and resource) and expectancy for success (amount of confidence in the resource and its information and how satisfied the user is with the information and resource). This survey, adapted from Keller's Instructional Materials Motivation Survey (1987), was used to assess subjects' motivation toward using a specific information resource (i.e. a book or an interactive videodisk program) to complete an assigned task.

The IRAS consisted of a 24-item Likert-type scale with two subscales of twelve items each related to value and expectancy. Subjects were required to rate their motivation toward the resource from 1 (not true) to 5 (very true). All items were identical for pre- and post-treatment instruments for print subjects and multimedia subjects, except for the words "book" and "multimedia" on both instruments and change in verb tense from pretest to posttest (future to past tense). Some examples from the pretest are:

"I expect that the information that I find in this book will be useful to me." (value)

"I believe the information will be presented in an exciting and stimulating way." (value)

"I believe that this book will be easy for me to use." (expectancy for success)

"I believe that I will have control over the type and amount of information I use in this resource." (expectancy for success)

A Cronbach coeffficient alpha was used to test the reliability of the motivation instrument. The overall reliability levels for the pretest was .91 and for the posttest was .95. The reliability levels for the two subscales were .73 (value pretest) and .87 (value posttest) and .74 (expectancy pretest) and .82 (expectancy posttest) which were deemed sufficiently high to consider both subscales reliable (Nunally, 1978).

Pattern Noting. When completing research tasks, learners access different types and amounts of information, as well as different subject matter. Therefore, there is little control over what should or will be learned and traditional tests (e.g. multiple choice) do not adequately assess learning in these situations. One method that has been advocated for assessing learning under these circumstances is a concept mapping approach called pattern noting.

Pattern noting is a technique used to assess both prior knowledge and learning by determining changes in knowledge structures (Jonassen, 1987). Pattern notes require the individual to free-associate with a topic that has been represented by a word or phrase within a box centered on a blank sheet of paper, by drawing lines containing related ideas (words, phrases, or sentences). Secondary ideas are linked to primary ideas and connections may be made by drawing a connecting line between any two terms that are perceived as related. Ideas may be represented as words, phrases, or complete sentences. Changes from pre-treatment to post-treatment pattern notes are interpreted as indicators of learning (Small & Grabowski, 1992).

The number of main terms the individual writes indicates the breadth of information that individual has associated with the given topic in memory, while the branch terms are an indication of depth of knowledge. Links (connected terms) drawn between terms indicate perceived interrelatedness of terms (Jonassen, 1987). An example from the current study appears in Figure 1.

Place Figure 1 about here

Subjects

Eighty-nine middle school (grades 6, 7, and 8) students served as initial subjects for this study and were randomly assigned to one of the two treatments. An additional multimedia treatment group consisting of 36 adult graduate students at a large northeastern university was included to explore potential differences in results due to age of subjects. All subjects completed the pretest and posttest motivation scales and pattern notes. Each subject received the treatment individually while being observed by one of the researchers.

Treatment

A topic in the area of art was selected as the content area for the materials used in this study because this was thought to be an area in which subjects would likely have limited knowledge and the task would be considered relatively novel for all subjects. *Van Gogh Revisited*, (Voyager Company, 1988), a Hypercard-based program with video laserdisk, was selected for the multimedia treatment. This program contains text information with slides, photographs, graphics (timeline), and full motion video. The program requires two monitors, one for text information contained within the HyperCard stack and the other for nontext information contained on the videodisk, a format that facilitated observation of information location and use strategies. The program also offers an index as a "find" mechanism, a "catalog" which simulates a table of contents, and arrows that allow users to progress backwards and forwards one screen at a time which approximates browsing through the pages of a book. In addition, this program was selected because researchers believed that subjects would have little or no prior knowledge of the content.

The book *Vincent Van Gogh: Art, Life and Letters* (Zurcher, 1985, Rizzoli Publishers) was chosen as the print treatment because it was closest (except for full-motion video and audio) in formats, content, and amount and type of information to the multimedia resource. It contained full-page, full-color art prints opposite full-page text, a timeline, an index, and a table of contents. The vocabulary level used was deemed generally equivalent in both resources.

Procedures

Prior to the conduct of the study, all subjects were trained in use of multimedia hardware and software using a CD-ROM -based software package (*Compton's Multimedia Encyclopedia*) similar in formats (e.g. sound, moving images, color, graphics, still images, text) and functions (e.g. mouse-driven, buttons, icons) to the one used in the treatment. They were also trained in the pattern noting technique. Prior to the treatment, subjects were administered the motivation pre-treatment questionnaire and were asked to complete an initial pattern note on the life and art of Vincent Van Gogh to determine their prior knowledge of the topic.

Subjects were given the task of using an assigned resource (either book or multimedia) to gather information about the life and art of Vincent Van Gogh. All subjects were given a workspace in which they could work individually and undisturbed for 30 minutes. An observer sat with each subject and recorded all keystrokes and eye movements on the observation checklist. Immediately following the treatment, subjects were asked to complete a final pattern note and motivation post-treatment questionnaire.

RESULTS

This study investigated the information location and use activities. motivation, and learning patterns of subjects using either a print or multimedia resource to complete a research task. The dependent variables in this study were:

- number and type of information location and use activities
- responses on a 24-item motivation survey, and
- the number and type of post-treatment pattern noting terms.

Information Location and Use

Data obtained from the observation checklists were analyzed for amount and type of information location and use activities (finding, engaging, extracting). In a comparison of children's treatment groups using Scheffe's test, those using the multimedia resource performed significantly more finding ($F=8.1$; $p<.0001$) and engaging ($F=6.4$; $p<.0001$) activities but those using a print resource performed significantly more extracting activities ($F=22.6$; $p<.0001$) (see Table 1). Analyses that determined percentages of total activities in each category revealed that at least half of the activities in both treatment groups involved engaging activities. Print subjects spent about half their time divided between finding and extracting activities while multimedia subjects spent more time in engaging activities and most of the rest of their time in finding activities, browsing through the information.

Place Table 1 abcut here

A comparison of the two multimedia treatment groups found that adults performed significantly more finding and engaging tasks than children but not more extracting tasks (see Table 2). However, a closer look at the data by percentage of total activity revealed that the results were quite similar for both groups.

Place Table 2 about here

A further analysis of engaging activities by type of information (text or nontext) indicated that children in the multimedia treatment group engaged significantly more nontext information than children in the print treatment group but that both groups engaged a similar amount of text (see Table 3). However, an analysis by percentage of total information engaged revealed that about the same proportion of text (55%) and nontext (45%) was engaged by print subjects but three times as much nontext (75%) than text (25%) was engaged by children in the multimedia treatment. It is likely that the availability of video in the multimedia treatment contributed to this result.

Place Table 3 about here

A comparison of both multimedia groups revealed that although adults engaged significantly more of both text ($F=8.6$; $p<.0001$) and nontext ($F=5.8$; $p<.001$) than children, each group engaged a similar ratio of nontext to text (about 3-1) by percentage (see Table 4).

Place Table 4 about here

Motivation

Because the novelty effects of the multimedia treatment might have influenced motivation scores, all analyses were performed on the basis of pretest-posttest change scores. An analysis of variance on IRAS scores indicated that there were no significant differences in total motivation or value subscale change scores between children's treatment groups. There was a significant decrease on the expectancy subscale for the print treatment group ($F=5.2$; $p<.02$). (See Table 5) Actual mean scores decreased from pretest to posttest and both subscales for print treatment subjects but increased on total test and value subscale for those in the multimedia treatment group. Multimedia treatment group had significantly higher total test means ($F=7.4$; $p<.05$) and value subscale ($F=8.4$; $p<.05$).

Place Table 5 about here

An analysis of variance for adult and children's multimedia treatment group scores found test mean scores were significantly higher for adults on total test and value subscale (see Table 6). An analysis of pretest to posttest change scores found adult change scores approached significance (decrease) on the expectancy subscale ($F=3.7$; $p<.06$). Actual scores showed a decrease on total test and expectancy subscale for adults and increased on total test and value subscale. Adult mean scores on the total test score means ($F=6.7$; $p<.05$) and value subscale ($F=19.9$; $p<.01$) were significantly higher than children's scores.

Place Table 6 about here

As they were leaving the treatment location, some adult subjects expressed frustration and uncertainty about the amount of information available for access when using a multimedia information system. Information overload may negatively affect ability to "integrate and cope with all that information...lead(ing) to dissatisfaction" (Cummings, O'Connell and Huber, 1976, p. 234). This phenomenon may have contributed to a lack of subjective certainty about the adequacy of the information search process or the information accessed, resulting in a perceived lack of closure.

Learning

For the children's treatment groups, two one-way analyses of variance of the posttest scores were conducted separately for grade level and gender and found no significant differences. Multivariate analysis of variance revealed no significant differences between treatment groups in terms of scores on the Stanford Achievement Test, 8th edition, Form J, a standardized achievement test. Therefore, posttest differences between treatment groups could be considered a function of treatment conditions. Pre-treatment and post-treatment pattern notes were analyzed for total number of terms, number of main terms (i.e., those connected to the topic term) and number of branch terms (i.e., those connected to the main terms).

An analysis of pattern notes for both children's treatment groups indicated no significant difference in total number of terms, main terms, and branch terms (see Table 7). A closer look at the proportion of main to branch terms by percentage showed about half of the terms were main and branch terms on both the pretest and posttest for both groups. However, further analysis by type of information (words, phrases, sentences) revealed that on the posttest, for children using a print resource, 25% of the terms they used were words while most (75%) were phrases and sentences while on the same test, 40% of the terms used by children in the multimedia group were words and a majority (60%) were phrases and sentences. However, although both groups had more words than phrases or sentences on the pretest, the print group used more phrases and sentences than words on the posttest while the multimedia group continued to use more words than phrases or sentences, although their percentages were much closer for all three types.

Place Table 7 about here

In a comparison of pattern notes for subjects in both multimedia treatment groups, adults had a significantly higher number of terms on the pretest. A comparison of pretest and posttest results showed within-group increases (i.e., the total number of terms, main terms, and branch terms from pretest to posttest) for all treatment groups. As expected, adults used a significantly greater total number of terms ($F=3.8$; $p<.03$) and number of branch terms ($F=10.2$; $p<.0001$) while number of main terms approached significance ($F=2.5$; $p<.06$) on the posttest (see Table 8). Since adults had significantly higher scores for both pretest and posttest, further analyses of pretest to posttest change scores was conducted. They indicated a significant change for branch terms only ($F=22.77$; $p<.0001$) with an adult mean change score of +10.1 and children's mean change score of +2.8.

Place Table 8 about here

Additional analyses of the data were performed to determine the percentage of knowledge levels (i.e., main and branch terms) and knowledge representation (i.e., words, phrases, sentences) on both the pre-and post-treatment pattern notes. Results indicated that for knowledge representation, both groups showed an increase in percentage of phrases and sentences and a decrease in percentage of words. On the posttest, 40% of the terms used by children were words, while 60% were phrases and sentences, while for adults, 63% of the terms were words and 37% were phrases and sentences. For the levels subscales, adult subjects showed a larger decrease in main terms (42% to 26%) than children (53% to 50%) and a larger increase in branch terms (58% to 74%) than children (46% to 49%) from pretest to posttest. On the posttest, both children's groups had about the same percentage of main and branch terms on pretests and posttests but on the posttest, adults represented about 3/4 of their acquired knowledge as branch terms.

DISCUSSION

The primary research questions for this study explored the information location and use, motivation, and learning patterns for young and adult subjects. Subjects were given a research task using either a print or multimedia resource. Researchers recorded information location and use strategies (finding, engaging, extracting) on an observation checklist. The Information Resources Attitude Survey (IRAS) evaluated subjects' motives and values related to the resource used. A pattern noting technique was utilized to assess prior knowledge and learning outcomes.

More finding and engaging activities were performed by multimedia treatment groups than print treatment group. More extracting activities were performed by print subjects. The majority of activities were engaging activities for all groups. Subjects using the print resource located and used about the same amount of text and nontext information while those using the multimedia resource located and used about three times as much nontext as text. Although adults engaged significantly more nontext than children, the ratio of nontext to text was about the same for both multimedia groups.

One adult subject commented after the treatment that with a book, she could tell how much information she had *not* accessed but with multimedia because she could move around freely, she did not know how much information she had accessed, if she had accessed all the information, and felt dissatisfied because she had not achieved closure. Closure has been considered as a possible contributing factor to satisfaction (Small & Venkatesh, 1994).

Results indicated that both children and adults have about the same motivation toward both resources. Actual differences indicated that motivation increased for children following the multimedia treatment but not for adults nor for children using a print resource.

As in previous studies, book users, although they have much more training and experience in using print materials, learned no more than those using a computer-based multimedia resource. There were some differences in learning patterns in ways knowledge was represented ; i.e., multimedia subjects used a greater percentage of single word terms while print subjects used a greater percentage of phrases and sentences. This may be the result of a more fragmented engagement of information when using a multimedia resource since those subjects tended to do more browsing , reading, and viewing. Future research may reveal that users of multimedia resources spend less time on any one screen and more time moving around in the information, leading to more of a "sound bite" learning experience. These results indicate the need for better methods that assess knowledge acquisition in situations where much of the information learned is visual and/or auditory. Text-based, verbal methods may not adequately measure learning in these situations. Perhaps more qualitative methods would be appropriate.

Some differences between adult and child subjects may be attributed to relevance of the task. In addition, children were randomly assigned, while adults were a convenience sample.

Another interesting outcome was that subjects in the multimedia treatment group repeated more inaccurate information (e.g., "Vincent Van Gogh invented the helicopter" or "Vincent Van Gogh painted the Mona Lisa") on both pattern notes, perhaps indicating that they found no information to refute these ideas, therefore they considered them accurate.

Research that explores both affective and cognitive outcomes from using single format and multiple format (multimedia) information resources may help designers of multimedia resources and teachers provide appropriate guidance for their use. The models for conducting independent research tasks using print resourcews may not be appropriate for the use of multimedia research tools. This has implications not only for multimedia designers, but for teachers and school library media specialists who are charged with the responsibility of preparing our future researchers.

(Figures and tables found in Appendix G)

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Title:

The Use of Humor in a CBI Science Lesson to Enhance Retention

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Abstract

This research experiment studied the effect of humor versus non-humor on learning and retention of a computer-based-instructional lesson on tick identification. The experiment also surveyed the subjects' enjoyment of the lesson material, their personal experiences with ticks and their concerns about ticks and tick-borne diseases. Undergraduate students from a statistics class (N=115) were randomly assigned to one of two treatment groups or the control group. The subjects were given a delayed post test one week after the treatment. The control group received the test only. The results indicated no significant difference between treatment groups in terms of learning and retention or in terms of enjoyment. However, the humor group was significantly more worried about ticks than the non-humor group. Implications of these results are discussed.

INTRODUCTION:

"The young have it too easy nowadays. In my days you were thrashed until you learnt something. Why can't they learn things the hard way, as we used to?" Fleming (1966). In response to such pronouncements, the authors of this paper wish to take issue. We think it is possible to provide effective instruction in ways that encourages students and makes the learning process enjoyable, especially in these days of emerging technologies. The strategy we focused on to test this opinion was the effect of humor on learning.

Before the mid-1970's few books were written on humor as a topic for serious research, and the majority of published works focused on humor of youngsters and adolescents. In 1976 the first International Conference on Humor and Laughter took place in Cardiff, Wales. This was met with considerable amusement and ridicule by the British press and others who pointed out the absurdity of scholars studying humor. They felt that to analyze humor, like analyzing love, was to risk destroying it (McGhee,1989).

However, subsequent international conferences followed in cities around the world, including the first annual WHIM Conference (Western--later called World-- Humor and Irony Membership Conference) in Arizona in 1980. Specialty conferences and weekend workshops also emerged bringing public awareness to the value of humor as therapy and providing techniques to develop "humor skills" (McGhee,1988).

Powell and Anderson (1985) cite more than 70 studies covering various aspects of humor and teaching, such as the value of humor, managing undesirable behavior, building self confidence, enhancing the quality of students' lives. However, in their review, the authors found few empirical studies. Those that do exist investigate the effect of humor on a variety of dependent measures with mixed results.

In general the literature on the use of humor in education can be categorized into three main areas of investigation--achievement, attention and interest, and positive attitudes:

Achievement:

Studying the cognitive "demands" of humor on children Zigler, Levine and Gould (1967) suggest that there is much gratification in the cognitive process involved in responding to humorous stimuli. There is a sense of achievement by "seeing the joke." This suggests an intrinsic motivation for humor in learning.

Hauck and Thomas (1972) found with elementary school children there was an increase in recall of incidental but not intentional material; however, intentional learning was found by Clabby (1979) to be significantly higher among "low creative" students using humorous captions. Studying the effect information acquisition in textbooks using humorous illustrations, Bryant, Brown, Silverberg and Elliot (1980) found no differences.

Kaplan and Pascoe (1977) found overall test performance in university students was not significantly different between humorous treatment and serious treatment groups, but there was better recall of humorous examples. Davies and Apter (1980) studied 285 primary grade school children who were shown a series of tape-slides. The material incorporating humor resulted in the greatest recall of information. However, in a similar experiment with university students Clark (1983) found non-significant results on retention.

Ziv (1988a.,1988b.) found significant differences in favor of learning with relevant humor compared to no humor in two studies of university students (the second replicated the first) . In each case his research was based on one-semester courses as opposed to studies by others whose experiments ranged from seven minutes to one hour.

Attention and Interest:

The effects of humor in educational television as an influence for programming selection by first and second graders was explored by Zillman and Bryant (1983). The study demonstrated that "fast-paced interspersion of humor proved more effective in attracting and sustaining an audience...than the interspersion of humor at a(n intermediate or) slow pace" (p.175). Schleicher and Bryant (1982) obtained similar results in their study of high school seniors.

Gruner (1970) and Markievicz (1974) found the effect of gaining audience attention and interest in a particular topic is enhanced with humor, although humor did not appear to affect comprehension and acceptance of a message. Warnock (1989) emphasized that humor is a good means of keeping students attentive. "Unchecked boredom can make the best of us mediocre. A timely joke or recounting an amusing happening can go a long way toward freshening up a dull meeting and putting students' minds back on track..."(p.23.)

Positive Attitude:

Fleming (1966) rationalized that humor in pictures and text can aid in developing positive attitudes and learning in students of modern languages, much like political cartoons can "sway an entire election campaign." Testing this theory, Bryant, Brown, Silverberg and Elliot (1980) studied the effects of humorous illustrations in textbook material on undergraduate students. The findings based on various dependent measures were mixed. However, the material with humorous illustrations was considered to be more enjoyable.

Sewell (1979) determined that "if comprehension is the only goal of instruction, the less expensive printed text is just as effective as the more expensive illustrated text or audio-visual presentation." (p.508.) However, his study indicated increased student enjoyment of material that incorporated humor, and he concluded that the decision of which presentation format to use should be based on personal preference and budget constraints.

Ziv (1979) found that humor plays a significant role in creating a positive class atmosphere. One of the qualities students would most hope to find in their teachers is humor. According to Hill (1988), "One of the most important functions of humor (in the classroom) is to create a positive learning environment."...When students can relate what they learn to a memorable context, whether it is visual or emotional, they are more likely to remember the information. Using jokes and anecdotes to enhance stories provides such an association." (p.20).

PURPOSE OF THE INVESTIGATION:

Much research has been conducted on various aspects of the traditional teaching and learning methods; however, with the emergence of sophisticated technologies new questions arise. Computers are increasingly integrated into total learning programs-- as a means of accessing data bases, providing additional practice and guidance for various learning objectives, and as stand-alone lessons for independent learning and distance education.

Unfortunately, up till now, much computer courseware design has been less than innovative. The results and presentations are simply electronic workbooks, emphasizing rote learning rather an aid to higher level thinking. In addition, some people are reluctant to use computers for any purpose because they feel the technology is alien and unfriendly.

One strategy used by some educators to create a pleasant, inviting atmosphere in traditional learning environments is humor. However, humor as a topic for serious research has been minimal, and there have been no studies on humor as a strategy in Computer-Based-Instruction to enhance learning and retention.

We hypothesized that a strategy incorporating a humorous theme and humorous comments relevant to the content would help create a positive learning atmosphere, motivate students to attend to the material and aid in encoding facts and concepts better than material presented in a standard, non-humorous way.

DEFINITION:

What is humor? And what is it to be humorous? McGhee (1979) traces the Latin term "humor" to ancient, medieval and Renaissance physiology when it referred to one of four bodily fluids associated with temperament. To be in a "good mood" meant the fluids were balanced; otherwise, one would be "out of humor." (p.5). Later the term "humorist" was applied "to anyone who was highly skilled at producing amusing, incongruous, ridiculous or ludicrous ideas and events." (p.5). Freud believed humor to be important as a coping mechanism (MacHovec 1988). Freud further maintained that humor permitted adults to enjoy a childlike release from societal restrictions on behavior (Keith-Spiegel, 1972). Sorrell (1972) states "laughter lifts man above his animalistic state, sets him free, and gives his spirituality another dimension." (p.2). According to MacHovec (1988) humor is a universal characteristic.

From ancient to modern times, regardless of culture, religion, geographic location, language, ethnic identity or gender, laughter is a part of everyone's experience. MacHovec (1988) calls it "a complex psychological-emotional phenomenon." (p.3). Although what is considered funny for one person or group may not be so for another, still there are classic stories and situations that transcend cultures and time.

Definition of Humor used in this study::

In reviewing the literature, a broad range of definitions of humor was uncovered. However, to best operationalize the term, so as to distinguish the differences between treatments, the following specific attributes were selected:

A light-hearted presentation of material, rather than a facts-only scientific presentation; inclusion of whimsical, content related cartoons and animation; the use of a theme that is ridiculous, exaggerated and narrated by a character using an informal, conversational style.

METHOD:

Subjects and Setting

One hundred and fifteen volunteer undergraduate students of various majors enrolled in a statistics course at a major state university participated in this study. Each subject was randomly assigned to one of three groups.

A. Computer-Based-Instructional (CBI) Lesson on tick identification presented with humor
B. CBI Lesson on tick identification presented without humor
C. Control

Various lab times were scheduled for student conveniences. The subjects were randomly assigned to one of two treatment groups or control when they arrived at the lab. Attendance varied at the lab sessions from as many as twenty people to fewer than two.

Treatment

A computer based instructional lesson (CBI) entitled "The Anatomy of a Hard Tick" was used as the treatment basis for this investigation. The rationale for selecting this topic was that it provided a rich source of facts and concepts; it also was a relevant topic to a health problem of growing importance--Lyme and other tick-borne diseases.

The CBI lesson was presented to two of the treatment groups. The first group, comprising 43 students, received the lesson with the inclusion of a humor as defined above. The second group, comprising 32 students, received the CBI lesson without the inclusion of any humor. A third group, comprising 40 students, served as a control and received no lesson.

Validation of Material and Test

To assess the degree of correspondence between the delayed post-test questions and the treatment content, four college science educators compared each of the fourteen test questions in terms of their appropriateness and clarity and whether or not the questions should be changed. The types of questions included matching, multiple choice and short answers. The panelists were in basic agreement on all questions. Disagreement occurred only as to whether to include more terms than numbers on questions requiring matching terms to numbers.

Validation of the Treatments

A panel of four impartial individuals who were either faculty members of the university or graduate students, assessed 55 screens of the material to be used in the humor treatment group for the degree of humor they contained based on the definition of humor described earlier. A Lickert-type scale of one to three was used with three being the highest amount of humor. The mean average of these screens was 2.4. Screens having identical material for both the humor and non-humor groups were not evaluated.

Dependent Measures

ACHIEVEMENT: One week after the initial treatments were administered, all three groups were given identical print-based tests on factual and conceptual knowledge of tick anatomy.

There were 36 responses required comprising short answers, multiple choice and matching numbers to parts.

ATTITUDE: In addition the subjects were also given an 8 item background and opinion survey to assess the influences of their background and experiences with ticks on their knowledge acquisition of the treatment material and their response to the lesson. Questions included college major, place of residence (2 items), personal "relationship" with ticks and'or Lyme disease (2-items), fear of insects, worry about ticks and tick-borne diseases and enjoyment of the lesson.

RESULTS:

Delayed Post-Test Performance

Statistical one factor analysis of variance was used to determine the difference between groups in terms of total scores on the delayed post-test. No significant difference was found between the humor and non-humor groups, only between the control group and treatment groups. Both treatment groups were equal in terms of enjoyment of the lessons. (See Figure 1.)

A two-factor analysis of variance was used to determine the differences in total scores based on having been bitten by a tick or having contracted Lyme disease. The prediction for this comparison was that personal experience with ticks may increase interest and attention in the lesson material. However, no differences were found. In addition, whereas certain regions of the country are more vulnerable to ticks and tick-borne diseases than others, the location of the participants' home residence also did not factor into the results.

On the affective measure, the extent to which participants were afraid of insects, spiders and ticks, no significant difference was indicated between any of the three groups; however, in terms of the degree to which subjects were worried about ticks and tick-borne diseases, there was a significant difference at p.<.05 with the humor group being more worried. (See Figure 2.)

TABLE 1. Comparison of Treatment Groups for Achievement

Treatment	N	Mean	sd
No Humor	32	28.37	6.83
Humor	4328.60		6.22
Control	40	13.90	6.40

TABLE 2. Comparison of Treatment Groups for Worry about Ticks and Tick-borne Diseases

Treat	N	Mean	sd
No Humor	32	2.63	1.39
Humor	43	3.51*	1.28
Control	40	2.85	1.37

* p.<.05

DISCUSSION:

The results of this study indicate that there were no significant difference found between treatment strategies in terms of learning and retention. These findings are supported by Sewell (1979). His study compared comprehension and evaluation of five different treatment strategies using cartoons that accompanied textual material.

The authors speculate, however, that the scientific, sequential use of graphics was sufficiently meaningful to produce highly positive results equivalent to the humor group. These results are encouraging in that allowing the learner to choose the type of instruction would not compromise the quality of learning.

In terms of the affective results of the study, the humor group indicated significantly more worry about ticks and tick-borne disease. This finding is important since being concerned about potential dangers may imply that precautions are more likely to be taken in areas prone to high numbers of ticks and medical advice sought, if bitten. These data also may imply that another form of learning took place as a result of more humorous reinforcement of concepts. There are further have implications in terms of developing strategies for consciousness raising on various important topics.

IMPLICATIONS for FUTURE RESEARCH:

Questions are raised as a result of the current study. Would separating the groups into humor and non-humor meeting times make a difference to learning and retention? During this study only one third of the subjects received humorous material at any session. However, when there were fewer subjects in the room, or only one subject in the room, there was more outer expressions of amusement observed, such as smiles and laughs. In a group situation, perhaps there is a need for a "critical mass" attending the same types of humorous information to be amused.

Would a "warm-up" presentation help set the tone? This is a standard technique in the entertainment industry to put audiences in a receptive mood. Should humor be combined with other enhancements, such as sounds? Would learners, who have specific and direct need for the knowledge, show significantly different results in achievement and attitude? For instance, in a lesson on tick identification, would health care workers, campers and/or field workers score higher on the test than casual learners?

Would treatments that were more diverse be a better means of assessing of the effect of humor? In attempting to keep both treatment groups as equal as possible, memory aids were presented to both groups--with text only for the non-humorous mnemonic and text with cartoons in the humorous mnemonic. Normally, a traditional science lesson would not have memory aids provided.

Would it make a difference in achievement and/or attitudes, if learners were given a choice of presentation styles; thus allowing for learner control. Finally, is there a significant difference in knowledge acquisition and retention, between scientific drawings presented in a complete form rather than in a developmental sequence? The use of developmental progression of graphic displays for both treatment groups in this study may have influenced the results. Follow-up investigations are planned to address some of these questions.

CONCLUSION:

The theory behind designing computer-based-instructional courseware with the inclusion of humor was an attempt to recreate the feeling one might experience in a warm and inviting classroom. Creating a friendly atmosphere is important for general appeal, and for learners wary or emerging technologies and computers in particular, increasing the comfort level of CBI could contribute to learner acceptance of the medium. Learners are more apt to use and enjoy CBI programs that meet individual preferences, and incorporating humor can affect attitudes and may enhance some types of knowledge acquisition.

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Title:

The Role of Perceptions in Instructional Development and Adoption

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The purpose of this paper is to report the results of a study that examined the role of perceptions in the instructional development and adoption process. According to the theories developed by Rogers (1983), if potential adopters have favorable perceptions of an innovation's attributes, then they are more likely to adopt the innovation. Many researchers (e.g., Clinton, 1972; Kivlin, 1960; Weinstein, 1986; Wyner, 1974) have examined the role that perceptions play in the adoption of an innovation. The present study was unique because it examined not only the role of perceptions in the adoption of an innovation, but also the role that perceptions played in the development of the innovation.

The attributes of an innovation are the basis upon which potential adopters form their perceptions of the innovation (Rogers, 1983). According to Rogers, all innovations can be thought of as having five general attributes. These attributes are relative advantage, complexity, compatibility, observability, and trialability. This study examined the perceptions of potential adopters and instructional developers in regard to the attributes of three computer-based learning modules. In addition, the role that perceptions played in the development and adoption of the modules was examined.

Statement of the Problem

Many of the products and practices of instructional technology have failed to make a major impact on education. Burkman (1987) writes that many endeavors that use the research-development-diffusion (RDD) paradigm suffer from a lack of utilization. Instructional technology is an endeavor that makes extensive use of the RDD paradigm. Burkman (1987) writes that instructional technology has experienced a lack of utilization in all fields, including primary and secondary schools, colleges and universities, and even in industry and the military. One reason for this lack of utilization could be that instructional developers do not understand and account for the perceptions of potential adopters during the development process. Referring to educational technologists in general, Dalton (1989) writes that "although we can fill instructional gaps with fervor, we never seem to examine our solutions in light of the wants of the implementors" (p. 22). Instructional developers commonly believe that products which result in more "effective and efficient" instruction will automatically be attractive to potential adopters (Burkman, 1987). Ralph W. Tyler (1980) writes "many developers of technology accept the view that as time passes, there will be increasing use of the innovation until it has become a common element in school practice" (p. 11). From these statements, we can see that many developers have the assumption that if they develop more effective instruction, adoption and diffusion will follow in time. This might be a false assumption.

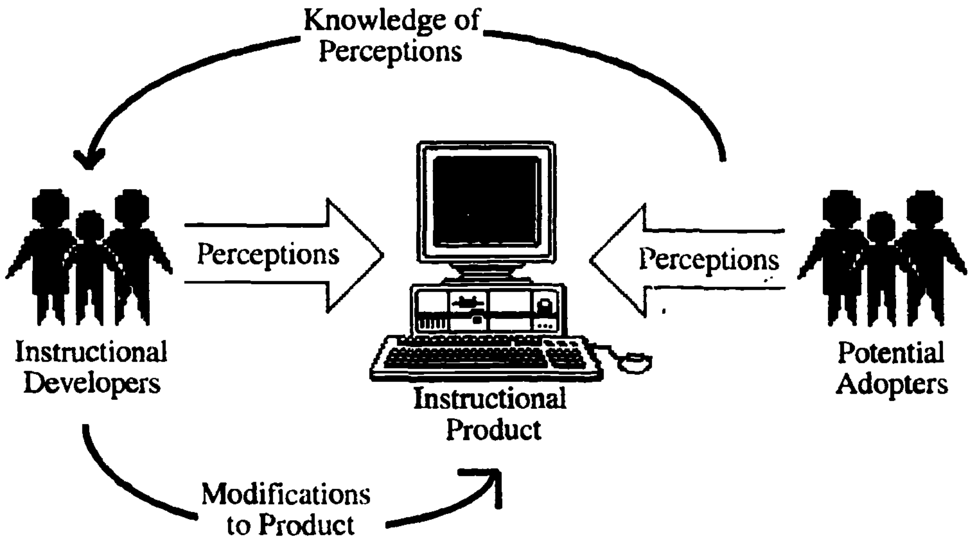

Figure 1. A model showing how knowledge of perceptions can affect development of a product.

Burkman (1987) feels a more user-oriented approach to instructional development is needed to increase utilization. He also believes that, as part of this user-oriented approach, instructional developers must seek to understand and positively manipulate the perceptions of potential adopters in regard to the attributes outlined by Rogers (1983). A more user-oriented approach, one that seeks to understand and take into account the wants of the implementors, might lead to the increased use of instructional innovations.

Figure 1 is a model showing how knowledge of the perceptions of potential adopters might result in modifications to an instructional product. These modifications, in turn, might lead to changes in the perceptions of potential adopters in regard to the product. This process of development, knowledge gaining, and modification would result in the circular model depicted in Figure 1. The use of such a model by instructional developers could lead to the increased adoption and use of their instructional products

The Adoption Situation in This Study

The study described here was part of a larger evaluation study of three multi-media computer-based learning (CBL) modules. The three multi-media. CBL modules were developed for use in three weather forecasting agencies. The modules represent the first in a series of twenty-one modules to be developed for the agencies. The modules are to be used as on-site training for operational forecasters at multiple sites in each of the three agencies. The computer delivery method and the independent study provide enhanced opportunities for realistic study of forecasting knowledge and skills. The modules are an innovative method of training offered on-site to weather forecasters. The purpose of the overall evaluation was to determine how the content, strategies, procedures, and implementation of the modules might be modified to enhance cognitive and affective outcomes. Information gathered in the evaluation of the first three modules will be used to inform the design of succeeding modules.

The adoption situation examined in this study is somewhat unique because there were two groups of potential adopters. The operational forecasters in the field who will use the modules were one group of potential adopters. The organizations that commissioned the production of the modules were also a group of potential adopters. In order for the CBL modules to be fully utilized, it was necessary for both groups to adopt the modules. The forecasting organizations, for their part, had to commission production of the modules, accept delivery of the finished products, make the completed modules available at the field sites, and encourage their forecasters to use the modules. The individual forecasters, for their part, had to routinely use the modules, devote time and effort to studying the modules, and incorporate the CBL modules into the daily work environment of the forecasting sites. Either the organizations or the forecasters could have prevented the adoption and full utilization of the modules by failing to perform the activities listed above.

For purposes of this study, the forecasters were the potential adopter group whose perceptions were examined by the researcher. The forecasters were selected for study because they were the intended end users of the modules. Examining the perceptions of the end users linked the present study more directly to Burkman's (1987) theory that a more user-oriented approach to instructional development could increase adoption of the innovation.

Research Questions

This study sought to answer four research questions:

1) What were the perceptions of instructional developers in regard to relative advantage, complexity, compatibility, trialability, and observability during the development of the computer-based learning modules?

2) What were the perceptions of potential adopters in regard to the relative advantage, complexity, compatibility, trialability, and observability of the computer-based learning modules?

3) If instructional developers were aware of the perceptions of potential adopters, how did that awareness affect the development of the modules?

4) How did the perceptions of instructional developers and potential adopters compare in regard to the relative advantage, complexity, compatibility, trialability, and observability of the computer-based learning modules?

Limitations of the Study

There are two key limitations to this study. The first limitation is that this study did not attempt to determine the importance of perceptions relative to other factors which influence adoption. Rogers and Shoemaker (1971) write that five variables influence an innovation's rate of adoption These variables are perceived attributes, type of innovation-decision, communication channels, nature of the social system, and the extent of the change agents' promotion efforts. The present study examined only the perceived attributes of the innovation.

The second key limitation of this study is that this study did not attempt to determine how perceptions influenced the long-term retention of the modules after their adoption. As Burkman (1987) points out, while the decision to adopt an innovation is based, in part, on subjective perceptions, "once an innovation has been adopted . . . perception tends to be displaced by reality." This study was concerned with how perceptions affected the initial decision (i.e., adoption or non-adoption).

Review of the Literature

This study is based upon two key literature sources. The first, and primary source, is E.M. Rogers' writings related to the communication and diffusion of innovations. Chief among these writings are Rogers (1983) *Diffusion of Innovations* (3rd edition) and Rogers and Shoemaker (1971) *Communication of Innovations: A Cross-Cultural Approach* (2nd edition). These books provide the theoretical basis for many of the studies cited in this review, especially those studies primarily concerned with the perceived attributes of an innovation.

The second literature source upon which this study is based is Ernest Burkman's (1987) chapter entitled "Factors Affecting Utilization" that appears in *Instructional Technology: Foundations* (Gagné, 1987). In this chapter, Burkman calls for a more user-oriented approach to instructional design. Part of this new approach calls for instructional designers to determine the attributes most important to potential adopters and, based upon that knowledge, to design products that present positive perceptions of those attributes (Burkman, 1987).

Research Related to Perceived Attributes

Hurt and Hibbard (1989) write that "it is well-documented in the diffusion research that the characteristics of innovations as perceived by potential adopters play a critical role on the rate of acceleration of the adoption curve" (p. 214). Many studies of perceived attributes have been based directly on Rogers' theory of perceived attributes. A variety of fields, ranging from agriculture to sociology, are represented by these studies.

The first large-scale studies to examine the relationship between perceptions and an innovation's rate of adoption took place in the early 1960s. The chief investigators of the relationship at that time were Joseph Kivlin and Frederick Fliegel. Kivlin's (1960) study of the perceptions of farmers in Pennsylvania in regard to numerous agricultural innovations is the earliest exploration of perceived attributes found in the literature. Although this study predated Rogers' theory, Kivlin's attributes are largely analogous to the attributes developed Rogers.

Kivlin found that relative advantage, complexity, and mechanical attraction were the attributes most significantly related to adoption for the Pennsylvania farmers. Also in this study, Kivlin determined that the characteristics of an innovation accounted for 51% of the variability in rate of adoption. Kivlin's (1960) study presents the strongest and earliest-found evidence that the assumption which underlies the present study is valid.

In 1966, Fliegel and Kivlin studied the perceptions of the same 229 farmers as Kivlin's 1960 study. In the 1966 study, Fliegel and Kivlin found that trialability was the most significant attribute related to adoption. Relative advantage, one of the most significant attributes in the earlier study, emerged as the second most significant attribute in the 1966 study.

Kivlin and Fliegel (1967a) also studied the different perceptions that small-scale farmers and middle-scale farmers had in regard to various agricultural innovations. They found that small-scale farmers were slower to adopt new practices than were the middle-scale farmers. The researchers concluded that the difference in the rate of adoption was not only a "function of production scale but also . . . a result of differences in perceptions" (p. 90). Kivlin and Fliegel's (1967a) study is important because it is the first example of a study concluding that differences in the perceptions of two groups account, in part, for differences in rate of adoption. Another study by Kivlin and Fliegel during this period (1967b) also found that relative advantage was the most influential attribute related to rate of adoption.

Gurmeet Singh Sekhon (1968) studied perceptions of farm innovations in Punjab, India. The population for Sekhon's study was made up of professional advocates of an innovation and their clients. Clients were divided into those who had a high degree of contact with the professional advocates, and those who had low contact. Sekhon hypothesized that professional advocates and their high contact clients would share similar perceptions of innovations. Sekhon found, however, that the two groups had highly dissimilar perceptions. The results of Sekhon's study are similar to the results of Ross' (1983) study. Ross discovered that change agents and non adopters in his study shared perceptions which were more similar than the perceptions shared by change agents and adopters. It is possible to hypothesize, in view of the studies by Sekhon and Ross, change agents and potential adopters do not have to share similar perceptions in order for an innovation to be adopted.

Clinton (1972) studied the role that perceived attributes played in the acceptance of innovations by 337 teachers in Canada. He found that teachers categorized innovations according to the attributes they perceived and that the actual acceptance of the innovation depended upon the perceived attributes. Clinton arrived at two major conclusions. The first was that how teachers perceived an innovation was as important as the innovation itself. The second was that innovation is, during its early stages, a mental process not a physical act.

In 1974, two studies (Wyner; Hahn) that examined the theory of perceived attributes were published. Wyner (1974) used attributes to study teachers' perceptions in regard to an educational innovation in an elementary school. She concluded that the perceptions of those who use an innovation can provide valuable data to change agents. Hahn (1974) studied the perceptions of over 200 high school teachers in regard to educational innovations. Observability was the attribute that was most significantly related to the adoption of an innovation in Hahn's study. Hahn's conclusion is fairly unique because no other study located in this review of the diffusion literature found observability to be the primary attribute related to adoption.

Keeler (1976) and Holloway (1977) published studies related to perceived attributes in the middle 1970s. Keeler studied how to increase the rate of adoption of a solar energy product. He hypothesized that a better understanding of the perceived attributes held by potential adopters in regard to the product would aid in the development of effective marketing strategies. Holloway studied the perceptions of high school principals in regard to an educational innovation. He found that relative advantage and compatibility were the attributes most influential in the principals' adoption decisions. Holloway's results are similar to Moallemian (1984) who found that perceptions of relative advantage and trialability had significant influence upon the innovation's rate of adoption.

Allan and Wolf (1978) analyzed the perceptions of 100 innovative educators. Their study suggests that the attributes of Rogers and Shoemaker (1971) may not be applicable to educational settings. Allan and Wolf found that only complexity had a significant influence on the likely adoption of educational innovations. That is, the less complex an innovation is perceived to be, the more likely that innovation is to be adopted. They conclude by writing: "Results of this investigation . . . suggested innovation attributes selected for study provided marginal insight into adoption of educational innovations" (p. 336).

Rogers, Daley, and Wu (1982) studied the diffusion of home computers. They determined that perceptions of relative advantage, compatibility, observability, and trialability were important, positive influences on their subjects' adoption decisions. Complexity and cost were found to be important, negative factors in the adoption decisions. That is, the more complex and expensive computers were perceived to be, the less likely they were to be adopted.

Eads (1984) used a unique method to examine how perceived attributes might influence the rate of adoption of an educational innovation. While most such studies have employed questionnaires and interviews in an ex post facto design, Eads used written descriptions of the innovation's attributes. In all, thirty two sets of descriptions were used to encompass all possible combinations of favorable and unfavorable attributes. Students, teachers, and administrators were included in the study. Respondents were asked to rate each description set using a semantic differential scale. Eads discovered that compatibility was the most influential attribute for students and administrators. No influential attribute emerged for the teacher group.

In 1985, Dozier examined how the perceived attributes of electronic text might influence the diffusion and adoption of that innovation. Dozier writes, based on his own review of the literature, that "prior research indicates that perceived attributes are powerful predictors of adoption" (p.18). He hints that electronic text could offer faculty members "significant relative advantages over conventional methods of scholarship" (p. 60). He adds that perceived attributes of an innovation "particularly its relative advantage, provide the energy needed to overcome thresholds or barriers to adoption" (p. -9).

Two studies published in 1986 (Kehr; Weinstein) examined the role that perceptions played in the adoption and diffusion of educational innovations. Kehr studied the diffusion of personal computers among 412 full-time faculty members in college level business administration and teacher education programs. He found that the groups shared similar judgments in regard to the adoption of personal computers. Cost was the most important consideration for both groups, followed by the perceived attributes of the product. Weinstein studied the perceptions of civilian and military educators. The subjects for this study were 244 public school teachers in Florida and 397 educators in the U.S. Marine Corps. He found that, for both groups, the attributes of relative advantage, trialability, compatibility, and observability were positively correlated with adoption, while the attribute of complexity was negatively correlated. Weinstein concluded that perceptions play an important role in the adoption decisions of both military and civilian educators.

Norris and Briers (1988) studied how agricultural science teachers in Texas perceived a proposed change in the curriculum. Their study is different from the others included in this review because Norris and Briers looked at perceptions in regard to the *change process*, not in regard to a specific product. The sample for their study was 933 teachers who were attending an agricultural science convention. Norris and Briers found that perceptions of the change process were the best predictor of a teacher's choice to adopt or reject the changes. They also found, however, that only 16% of the adoption or rejection of the changes could be explained by a teacher's choice. Other factors accounted for most of the variance in the adoption or rejection decision process.

Rogers' Model of Innovation Diffusion

The model described by E.M. Rogers is the most comprehensive model of innovation diffusion discovered in this review of the literature. Rogers explains his theories in two editions of a book. These editions are Rogers (1983) *Diffusion of Innovations* (3rd edition) and Rogers and Shoemaker (1971) *Communication of Innovations: A Cross-Cultural Approach* (2nd edition). These two books, containing slightly different material, outline the basic theories of diffusion and state hypotheses related to rate of adoption.

Rogers and Shoemaker's (1971) *Communication of Innovations: A Cross-Cultural Approach* (2nd edition.) is important for two reasons. The first reason, mentioned above, is its large bibliography cross-referenced by each of 103 generalizations. The second reason is that it is among the first works to comprehensively discuss the many factors which influence an innovation's rate of adoption.

Rogers' (1983) *Diffusion of Innovations* is important to the current study because it presents an informative account of the process of innovation development. Rogers, in *Diffusion of Innovations*, is the first author found by this review to state that pre-diffusion activities, such as development, play an important role in the diffusion of an innovation. The general premise of the present study, that instructional developers can take actions to identify and account for the perceptions of potential adopters during the development of an instructional innovation and, as a result enhance the subsequent adoption of the innovation, is based upon Rogers' theory of the innovation development process. Rogers also writes that more research is needed into the effects of development and other pre-diffusion activities upon the subsequent diffusion of an innovation.

Methodology

The research design for this study involved the use of questionnaires and interviews. Questionnaires and interviews are two of the most commonly-used methods of data gathering in studies related to diffusion research in the field of education (Rogers and Shoemaker, 1971). Instructional developers and potential adopters were asked to report their perceptions of the innovation at the time the training modules were being developed or considered for adoption.

Seven instructional developers who played a significant role in the design and development of the instructional modules were selected and interviewed for this study. The seven developers who were interviewed for the present study performed a variety of tasks during the development of the three modules. An interview guide was used to focus the content of the interviews. One developer interview took place in a face to face setting, the other six interviews were conducted over the telephone.

Potential adopters at each of the six forecasting sites visited by the researcher were selected for the interviews. The forecasting sites represented a geographically diverse sample and included both military and civilian settings. A total of twenty-nine potential adopters were interviewed for this study. An interview guide was used to focus the content of all the interviews. All interviews were conducted in person by the researcher at the forecasting sites.

All potential adopters at each of the six forecasting sites were selected to complete the potential adopters' questionnaire. Questionnaire data were collected from a total of 32 potential adopters of the CBL modules. While thirty-two questionnaires represent a minority of all the forecasters who work at the six sites included in this study, they represent a majority of the forecasters who had used the modules at the time for the study.

Results of the Study

Potential Adopter Questionnaire Data

Questionnaires were distributed at six operational forecasting sites included in this study. Completed questionnaires were received from five of the sites. A total of thirty-two completed questionnaires were received.

Relative Advantage

Table 1
Responses to Statements Related to Relative Advantage

Statement	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
The modules are a better way to do on-site training than the way we used to do on-site training.	11 34.4%	16 50%	4 12.5%	1 3.1%	0 0%
I enjoy on-site training a lot more now than I did before we had the modules.	6 18.8%	18 56.3%	7 21.9%	1 3.1%	0 0%
I am really looking forward to using future modles.	5 15.6%	19 59.4%	7 21.9%	0 0%	1 3.1%
I think the modules are effective training tools.	8 25%	18 56.3%	5 15.6%	1 3.1%	0 0%
The modules are valuable training tools.	6 18.8%	21 65.7%	5 15.6%	0 0%	0 0%
I think computer-based training is the best way for us to receive on-site training.	5 15.6%	13 40.6%	9 28.1%	4 12.5%	1 3.1%

Relative advantage is defined as the extent to which an instructional innovation is seen as being superior to, or an improvement over, existing or competing products. The questionnaire contained six items related to relative advantage. The responses to the six questionnaire items referring to relative advantage are reported in Table 1.

As shown in Table 1, responses to the questionnaire items on relative advantage were mostly positive. For example, 84.4% of the forecasters reported that they agreed or strongly agreed the modules "are a better way to do on-site training than the way we used to do on-site training." Also, 75.1% of the forecasters agreed or strongly agreed with the statement "I enjoy on-site training a lot more now than I did before we had the modules."

Complexity
Table 2
Responses to Statements Related to Complexity

Statement	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
The modules are user friendly.	7 21.9%	15 46.9%	3 9.4%	6 18.8%	1 3.1%
The directions are adequate for me to figure out what I am supposed to do.	9 28.1%	21 65.7%	2 6.3%	0 0%	0 0%
I had no trouble learning how to use the modules.	11 34.4%	19 59.4%	1 3.1%	1 3.1%	0 0%
I knew when I was supposed to read, watch a video clip, or answer a question.	13 40.6%	16 50.0%	0 0%	3 9.4%	0 0%
Sometimes I felt lost and didn't know how to get to the next screen.	0 0%	6 18.8%	7 21.9%	14 43.8%	5 15.6%
It took me a long time to figure out how to use the	0 0%	1 3.1%	5 15.6%	21 65.7%	5 15.6%
The best thing about the modules is that they are easy to use.	3 9.4%	17 53.1%	11 34.4%	1 3.1%	0 0%

Complexity is defined as the extent to which an instructional innovation is seen as easy to use and user friendly by potential adopters. Seven items related to the perception of complexity were included on the questionnaire. The items refer primarily to the complexity of the user interface of the modules. The responses to the seven questionnaire items referring to complexity are reported in Table 2.

As shown in Table 2, responses to the questionnaire items on complexity were mostly positive. For example, 68.8% of the forecasters reported that they agreed or strongly agreed the modules "are user-friendly." Also, 93.8% of the forecasters agreed or strongly agreed with the statement "I had no trouble learning how to use the modules." The responses of the survey items related to complexity show that the potential adopters in this study perceived the innovation to have a low degree of complexity.

Compatibility

Compatibility is defined as the extent to which an instructional innovation is seen as consistent with the existing values, beliefs, environment, and tools of potential adopters. Six items related to compatibility were included in the questionnaire. The items related to compatibility deal primarily with the how the modules are compatible with the forecasters' work schedule and content knowledge needs. The responses to the six questionnaire items referring to compatibility are reported in Table 3.

Very strong positive responses were given in regard to the work schedule compatibility of the modules. All 32 respondents agreed that breaking the modules into 20 to 30 minute segments was a good way to organize the modules. In another item related to work schedule compatibility, 66% of the respondents agreed that the format of the modules made the modules easy to fit into the forecasters' schedule and workload.

All 29 respondents who expressed an opinion agreed that the best thing about the modules was that they could be used whenever the forecaster wanted. Generally speaking, the responses to the items related to work schedule compatibility were the most strongly positive responses given in regard to any of the perceived attributes.

Table 3
Responses to Statements Related to Compatibility

Statement	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
The modules cover topics I need to know about for my job.	7 / 21.9%	18 / 56.3%	3 / 9.4%	3 / 9.4%	1 / 3.1%
Breaking the modules into 20 - 30 minute segments is a good way to organize them.	12 / 37.5%	20 / 62.5%	0 / 0%	0 / 0%	0 / 0%
The modules provide realistic training for my job.	3 / 9.4%	24 / 75%	2 / 6.3%	3 / 9.4%	0 / 0%
The format of the modules makes it easy to fit training into my schedule and workload.	6 / 18.8%	15 / 46.9%	4 / 12.5%	5 / 15.6%	2 / 6.3%
I enjoy working with computers.	9 / 28.1%	14 / 43.8%	6 / 18.8%	3 / 9.4%	0 / 0%
The best thing about the modules is that I can use them whenever I want.	5 / 15.6%	24 / 75%	3 / 9.4%	0 / 0%	0 / 0%

Trialability and Observability

Trialability is defined as the extent to which potential adopters may test or experiment with an instructional innovation prior to adoption. Five items related to trialability were included in the questionnaire. Observability is defined as the extent to which the benefits and outcomes of an instructional innovation can be seen by potential adopters. Seven items related to observability were included in the questionnaire.

Many potential adopters expressed "No Opinion" responses to questionnaire items related to observability and trialability. For example, 84% of the respondents expressed no opinion when asked if they had seen an impr. 7ement in their own forecasting as a result of using the modules. Half of the respondents (16 of 32) expressed no opinion when asked if they had noticed that their co-workers seemed to enjoy working with the modules.

The short period of time that the modules had been in use at the work sites is the most likely reason for the high "no opinion" responses in regard to the perception of observability. At the time the forecasters completed the questionnaire, most of the modules had only been in use at the work sites for less than a year. At several sites, in fact, module three had been in use for only a week or two at the time of this study. As for trialability, the forecasters had little say in whether the modules were tried at their worksites. The forecasting organizations selected the sites where the modules would be used. As a result, from the forecasters' view, there was no perceived trialability associated with the modules.

Potential Adopter Interview Data

Twenty-nine weather forecasters from 5 sites were interviewed for the present study. A cross case analysis, grouping the responses of the forecasters in regard to each of the five attributes, is used in this section to summarize the interview data.

Relative Advantage

The relative advantage of the computer-based learning modules was mentioned by all of the twenty-nine potential adopters interviewed for this study. Responses related to relative advantage can be grouped into two categories of advantage. The first category is that the modules are advantageous because they can be used at any time by the forecasters. The second category is that the modules are advantageous because they are more motivational and interesting than other means of training. The first category is a merger of the perceptions of compatibility and relative advantage. Simply stated, many potential adopters felt the modules were advantageous because the modules were compatible with the work schedule of the forecasting office while other forms of training were not. The issue of compatibility will be discussed in greater depth later in this paper.

The second category of relative advantage (Motivational and Interesting) was commonly cited by potential adopters as an important issue. Whenever any of the forecasters discussed the CBL modules in comparison to other methods of on-site training, they always mentioned that the modules were advantageous because they were more motivational and more interesting than the training alternatives. The following statements, taken from the interviews, are representative:

> I enjoy working with the modules. They're more interesting than the manuals. Reading the manuals . . . you talk about dry, that's dry! But this is interactive, more interesting, that's what I like about it.

> I think this is a better alternative than just sitting and reading a manual because this gives you a chance to participate. You have the pictures and animations whereas if you were reading a manual, you would get tired a lot quicker and get bored at a much quicker pace.

> I think they're outstanding. These modules are different, they're interesting, you don't get bored like the other types of training.

> The different types of training we've had, they're boring. These modules, they have a mix - video, animation, text. I like the mix, it makes it much more interesting.

Complexity

When given the opportunity to respond to open-ended questions about the modules, about half of the potential adopters interviewed for this study mentioned complexity as an important issue. Two typical responses are included here:

> Complexity is a big issue, because when you're here on a midnight shift and something goes wrong - if you don't know how to fix it, if you hit a roadblock, then you would tend to shut the thing off and not come back to it for a couple of weeks.

> What I like most about them is you can sit down and start using the

training. You don't have to know how to use computers. They're very easy to use the first time - you don't have to learn how to use the modules.

One of the forecasters interviewed for this study used the open-ended questions to mention complexity as the worst aspect of the modules. This forecaster did not have substantial previous experience using computers. As a result, the forecaster found the modules to be somewhat complicated. A sample of this forecaster's comments are included:

> Well, for me, they're very complicated. I'm not part of the computer generation. I'm just not comfortable with computers. I'm still learning to use them so I have that problem in addition to learning the material.

Compatibility

When given the opportunity to respond to open ended questions about the modules, all of the twenty-nine potential adopters interviewed for this study mentioned compatibility as an important issue. All twenty-nine mentioned that it was important for the modules to be compatible with the work schedule of the forecast office.

The weather is an unpredictable and capricious force. The workload in the forecasting office is largely dependent upon the current weather conditions. When the weather is favorable, forecasters can devote relatively long blocks of time to training. During times of severe weather, it maybe impossible for the forecasters to devote any time to training. Several forecasters mentioned that the weather has a major influence on how often they are able to use the modules. Sample comments related to the importance of compatibility to the forecasters are included here:

> The forecaster has the opportunity when the weather is benign. When it's kind of quiet is a good time to work on the modules. He can spend 2 or 3 hours working on them.

> If you have good weather (good weather evening shifts, especially) it's not too bad, you can get back there and use them. We only get scheduled about 4 extra shifts a month and we're lucky if we keep those. So, if you're going to use the modules, the best time is good weather evening shifts.

> That's one of the strong points of the modules, that you can use them in 30 minute chunks of time. Most days you can keep an eye on the weather, take 30 minutes, and do the modules on shift. They're well geared to the type of job we have.

> Fitting them into my schedule is a big thing, the schedule prevents me from using them as much as I'd like. When I get some free time, to be honest with you, I enjoy using them.

Trialability and Observability

When given the opportunity to respond to open ended questions about the modules, none of the twenty-nine potential adopters interviewed for this study mentioned trialability as an important issue. None of the forecasters mentioned the desire or the need to use the modules on a limited basis. When asked specifically about trialability, most of the forecasters reported that they were required to use the modules as part of their work and that they were not given the opportunity to experiment with the modules on a limited basis. There was, in effect, no trialability from the forecasters' standpoint.

When given the opportunity to respond to open ended questions about the modules, none of the twenty-nine potential adopters interviewed for this study mentioned observability as an important issue. When asked specifically about the attribute of observability, none of the forecasters reported that they had seen any observable outcomes resulting from use of the CBL modules.

The reason that most forecasters gave for not observing any outcomes from the modul was that the modules had not been in use for very long. The modules had been in use for less than a year at most sites included in this study. Several forecasters reported that they anticipated that the modules would eventually result in observable benefits. The statement included here is representative of most responses related to the attribute of observability:

> I anticipate seeing a change but I haven't seen it yet and that's really because we just haven't gotten into it very much. At this point, it hasn't really gotten into our forecasting but it's just a matter of time.

Instructional Developer Interview Data

Seven developers who contributed to the design and production of the three CBL modules were interviewed for the present study. The purposes of the interviews were to determine the perceptions of instructional developers in regard to the attributes identified by Rogers (1983), to determine if the developers were aware of the perceptions of potential adopters, and to determine how perceptions affected the development of the modules. Data gathered from each of the seven interviews are reported and summarized in the following section.

Organizational Perceptions vs. Individual Perceptions

Instructional developers interviewed for this study tended to discuss the modules in terms of how the modules fit into the overall weather forecasting organization, not in terms of how the modules affected the perceptions of individual forecasters. This is perhaps the most interesting finding of the interviews. In effect, the developers viewed the forecasting agencies, not the individual forecasters, as the potential adopters of the modules.

When asked about any of the perceived attributes identified by Rogers (1983) the developers tended to discuss that attribute from an organizational perspective. For example, when asked to describe the relative advantage of the modules, several developers mentioned that the modules were advantageous because they could be used on-site, allowing forecasters to stay at the worksite instead of traveling to a training center. Having the forecasters train on-site was advantageous to the organization for two reasons, according to the developers. The first is that on-site training relieved staffing and funding issues associated with sending forecasters away for training. The second advantage of on-site training is that it allowed many more forecasters to receive training. Developer #1 made the following comment when asked about the relative advantage of the modules:

> There was a clear advantage in that the National Weather Service runs the training school and they would have 60 or fewer persons per year trained in Kansas City. The need for training is far wider than that . . . there are literally thousands of people who can benefit from the training.

Based upon the seven developer interviews, it is possible to conclude that the developers tended to base the development of the modules more closely on the perceptions of the forecasting organizations than on the perceptions of the individual forecasters. However, the developers' tendency to focus on organizational perceptions is not necessarily improper or worthless. As mentioned above, the adoption situation examined in this study was fairly unique because there were two sets of potential adopters -- the forecasting agencies and the operational forecasters. The developers saw the forecasting agencies as the primary potential adopters of the modules. As a result, the developers concentrated on determining and accounting for the perceptions of the organizations.

Relative Advantage

The instructional developers interviewed for the present study generally discussed the attribute of relative advantage in regard to the organization into which the computer-based training modules would be implemented. Several of the developers mentioned that the modules were advantageous because they provided training at the forecasting site, thereby eliminating the need to send forecasters away for training. Providing training at the forecasting site eliminated many staffing and funding problems associated with sending forecasters away for training. The reduced staffing and funding problems were a major advantage of the modules from the organizations' perspective.

The developers commonly discussed the modules in terms of how they would benefit the organization. When asked how the CBL modules were advantageous to other training products available to the forecasters, Developer #3 discussed how the modules were advantageous to the organization.

> I visited forecast offices, reviewed some of their materials. They've done a variety of things. They've had workshops, which are very expensive and very hard on staffing. I had some knowledge of other products, but really not enough. There were some areas of overlap with other products - we would have been better off looking more into some other products to reduce the overlap.

Three of the seven developers did discuss the attribute of relative advantage in terms of the how the modules were advantageous to the forecasters who would use the modules. Developers #2 and #5 mentioned that they thought forecasters would find the modules more interesting and entertaining than other forms of training. Instructional Developer #2 described his feelings related to the relative advantage of the modules this way:

My feeling was that this had the potential to be a more effective method of training, but equally, I felt it had the potential to be a better received method in the field. I felt people who taking the modules would say "This beats the classroom" or "This beats the videotape."

Developer #3, conversely, mentioned that he felt parts of Module 1 were boring. When discussing the ability of the modules to gain and maintain the users' interest, Developers #2, #3, and #5 were discussing the attribute of relative advantage in terms that closely resembled those used by the forecasters.

Complexity

The complexity of the user interface used in the modules was an important consideration for most of the developers interviewed for this study. Developers #1, #4, and #7 described the process of formative evaluation through which the developers gained information about the interface from the users. Changes were made to the user interface based, in part, upon information gained from the users during the formative evaluation process.

When asked about the complexity of the modules, many developers discussed complexity in terms of the user interface. Developer #4 worked on Module 1 and played a major role in the conceptualization and development of the user interface. Major elements of the user interface developed for Module 1 were incorporated into succeeding modules. The complexity of the user interface was an important consideration for Developer #4 during the development process:

> We did lots of formative evaluation because of the nature of the hypertext system we were developing, the interface became crucially important. We had done what I thought was a very nice interface. We had done some formative evaluation and tested it out with the users.

Developer #1 also mentioned that formative evaluations were an important source of information about the complexity of the modules:

> Based on the evaluations, we changed drastically the presentation of some of the content that was considered too complex or too lengthy. The nature of the changes was to simplify and, in some cases, remove things to try to make the content more understandable

Developer #7 reported that feedback from the potential adopters was used to guide the development of the user interface. During development, the developer perceived that the user interface had a low degree of complexity. Developer #7 had this comment related to the complexity of the user interface:

> The interface is probably one of the best things that we did. We went back to existing workstations and borrowed a lot of the good concepts. We went through a whole series of Formative evaluations with several evaluators coming in. That's how the user interface evolved. It was a very methodical process.

Instructional Developer #3 made an interesting point about how modifications were made to the modules based on input from the formative evaluation groups:

> In the early stages, there are a lot of changes. You get lots of feedback from peers, subject matter experts, and formative review from users. In the later stages, it gets more and more difficult to make changes and the changes you can make have smaller and smaller impact on the overall product. In the early stages, 75 - 90% of the product is changed based on feedback you get from other people.

The statement above points out the need to determine and account for the perceptions of potential adopters early in the development process. In order to effectively account for the perceptions of potential adopters, changes must be made early in the process when changes are easier to make.

Compatibility

Most of the instructional developers interviewed for this study mentioned compatibility as an important issue. All of the developers were aware of the erratic work schedules at the forecasting sites. The developers generally understood that training at the forecasting site had to be designed to allow for short periods of use. Several developers reported that their understanding of the work schedule influenced many development decisions. Developer #4, for example, reported that computer-based instruction was selected as the delivery medium for the training in order to provide maximum flexibility to the forecasters. Developer #7 reported that compatibility was one of the main reasons for selecting the computer-based instructional medium. Several developers also reported that tracking and bookmarking functions were added to the modules in order to allow the forecasters to leave and return to the modules as their schedules dictated, thereby making the modules more compatible with the forecasters' erratic work schedule..

In addition to their background knowledge of the forecasting site, instructional developers formed their perceptions of compatibility through a series of formative evaluations. According to the Developer #1, the evaluations used forecasters from each of the three forecasting agencies. One or two forecasters from each agency were asked to respond to mock-ups and paper representations of the modules. From the formative evaluations, the developing agency gained information related to the compatibility of the modules from the users' viewpoint. Based on input, changes were made to the modules. Instructional Developer #1 described the changes:

> The decision to break up the modules into shorter segments came directly from the tryouts. When they came in for the tryouts, they were put off by the long, detailed, laborious sections and they let it be known that they didn't like that and were quick to say that they didn't believe other people would go through it.

Developer #4 also reported that compatibility was an important consideration for the development team:

> Compatibility was a major reason for going with the computer-based instruction approach. The forecasters were obviously not going to be able to sit down on a consistent basis and use the materials. It was going to be a catch-as-catch-can basis. We built tracking facilities into the design so they could track what parts of the modules they had accomplished. The compatibility to a large extent drove a lot of the development process.

Compatibility was also an important issue for Developer #7. Included here is a representative response made by Developer #7 in regard to compatibility:

Compatibility was one of the main reasons that CBL was the medium of choice. You couldn't bring all the forecasters in for training. The other option that we've tried many times is to take the experts out to the field offices. You got out to the field office for 2 or 3 days, talk to the forecasters, then you leave. You have to ask yourself 'What kind of impact did that have?' CBL was the answer to that.

From the above statements, we can see that changes were made to the module based upon knowledge that developers gained related to the perceptions of the potential adopters. We see that potential adopters, when shown representations of the module, perceived that the content module was too complex. In the second statement, we see that potential adopters felt the representations were laborious and overly detailed. Based upon that information, the developers shortened the segments and made them less detailed.

Trialability and Observability

Trialability and observability were not mentioned by any of the seven instructional developers interviewed for the present study. None of the developers mentioned that the needs for potential adopters to try the modules on a limited basis or to observe the benefits of the modules were important considerations during the development process.

Developer #6 was one of the few developers interviewed for this study who discussed the attribute of observability in detail. Other developers, when asked directly about observability, either gave short responses or responses that didn't deal closely with observability. The responses of Developer #6 in regard to the attribute of observability serve as an excellent summary and synthesis of the responses of the other developers interviewed for this study. The following response best summarizes the view of all the developers in regard to the role that observability played in the development process:

[Observability] is probably the most difficult aspect of developing the modules. The performance of the forecasters in the field is so complex that it is very difficult to make any kind of precise, direct correlation between a specific module and a specific reduction in errors. What we wanted is that the effect will be cumulative over time. To say that one module had a specific effect on forecasting would be very, very difficult.

Conclusions and Recommendations

Research Question One

What were the perceptions of instructional developers in regard to relative advantage, complexity, compatibility, trialability, and observability during the development of the computer-based learning modules?

Instructional developers generally did not relate the attributes defined by Rogers (1983) specifically to the forecasters. The relationship between relative advantage, complexity, compatibility, trialability, and observability and the forecasters' opinions of the modules was not commonly discussed by the instructional developers in this study. The instructional developers in this study more commonly discussed the process by which the modules were developed and the implications of the attributes for the organizations in which the modules were used.

When asked directly about the attributes of the modules, instructional developers commonly related the attributes to organizational or systemic issues rather than to the potential adopters of the products. For example, when asked to describe the relative advantage of the modules, most of the forecasters in this study stated that the modules were advantageous because they eliminated the need to take forecasters away from the work site for training.

Research Question Two

What were the perceptions of potential adopters in regard to the relative advantage, complexity, compatibility, trialability, and observability of the computer-based learning modules?

Compatibility, complexity, and relative advantage were important perceptions in the forecaster's decision to adopt or not adopt the computer-based learning modules. Trialability and observability did not emerge as important perceptions to the potential adopters.

Research Question Three

If instructional developers were aware of the perceptions of potential adopters, how did that awareness affect the development of the modules?

The awareness that instructional developers had of the perceptions of potential adopters had a mixed effect on the development of the modules. The developers' awareness of the perception of compatibility had a profound effect on the development of the modules. From the very beginning of the development process, instructional developers knew that compatibility was an important issue to the operational forecasters. They knew this because key members of the development team had experience with the operational forecasting setting. The computer-based learning method was selected because it would allow the forecasters to use the modules at their convenience, when time was available. Also, as a result of their knowledge of compatibility, the developers broke the modules down into shorter, digestible segments to make the modules more compatible with the forecasters' work schedules.

During the development process, instructional developers were aware of some of the perceptions of potential adopters and unaware of other perceptions. Developers were aware of the perceptions of potential adopters in regard to complexity and compatibility. Most of the instructional developers were unaware of the perceptions of potential adopters in regard to relative advantage. Trialability and observability were not important perceptions for either group.

Most of the instructional developers interviewed for this study reported that they knew the potential adopters had positive perceptions of the CBL nodules in regard to complexity. Instructional developers in this study knew that the potential adopters perceived the user interface and the content of the modules to have appropriate levels of complexity. Instructional developers also knew that the potential adopters would perceive the modules as being compatible with their needs and work schedule.

Formative evaluations and personal experience were the methods by which the developers became aware of the perceptions of the potential adopters. Instructional developers became aware of the perceptions of potential adopters in regard to complexity through a series of formative evaluation sessions. Instructional developers became aware of the perceptions of potential adopters in regard to compatibility because key members of the development team had personal experience with the operational forecast setting

The developers' awareness of the perception of complexity had a limited effect on the development of the modules. During the development process, instructional developers determined the perceptions of forecasters in regard to complexity through the use of formative evaluations. The knowledge that the developers had about the potential adopters' perception of complexity had a limited effect on the development process, however. Based on the knowledge of complexity from the users' viewpoint, the developers simplified or eliminated some of the content of the modules.

<u>Research Question Four</u>

How did the perceptions of instructional developers and potential adopters compare in regard to the relative advantage, complexity, compatibility, trialability, and observability of the computer-based learning modules?

As stated in Research Question One above, the instructional developers interviewed for this study did not commonly relate their design activities to the perceptions of the end users. The developers discussed their perceptions related to Rogers' attributes only after being asked about them directly by the researcher. Even then, the developers tended to relate the attributes more closely with the perceptions of the forecasting organizations than to the individual forecasters. The forecasters, conversely, readily and consistently used the attributes of compatibility, complexity, and relative advantage to describe their reactions to the modules. It is difficult to compare the perceptions of the two groups because perceptions played a much more prominent role in the potential adopters' discussions of the modules than in the discussions of the instructional developers.

Recommendations

The findings resulting from the analysis of interviews with potential adopters, interviews with instructional developers, and the potential adopter questionnaire lead to the following recommendations.

1. When diffusion is an important consideration, instructional developers should seek to determine the perceptions of potential adopters in regard to the attributes of complexity, compatibility, and relative advantage.

2. When diffusion is an important consideration, instructional developers should consider the perceptions of potential adopters early in the development process.

3. When diffusion is an important consideration, instructional developers should develop products which create a favorable perception of relative advantage for the potential adopters.

4. When diffusion is an important consideration, instructional developers should develop products which create a favorable perception of compatibility for the potential adopters.

5. When diffusion is an important consideration, instructional developers should develop products which create a favorable perception of complexity for the potential adopters.

6. Instructional developers should use formative evaluation as a tool for determining the perceptions of potential adopters in regard to the attributes of complexity, compatibility, relative advantage.

Questions for Future Research

This study examined the role of perceptions in the development and adoption of an instructional innovation. The present study provided insights into six research questions related to perceived attributes. The researcher has identified seven questions arising from the present study which, if studied, could provide valuable additions to the literature related to how perceived attributes affect the development and adoption of instructional innovations.

- *Is there a research methodology for the study of adoption and diffusion that is more efficient and practical than the interview / questionnaire recall methodology?*

- *What are the perceptions of other groups of instructional developers in regard to the relative advantage, compatibility, complexity, trialability, and observability of their products?*

- *How do the perceptions of potential adopters and instructional developers influence the development and adoption of other instructional products?*

- *How do the perceptions of instructional developers and potential adopters compare in situations where the developers and adopters are separated?*

- *Are trialability and observability important perceptions for the potential adopters of other instructional innovations?*

- *Do the attributes of an innovation as identified by Rogers (1983) adequately represent all the attributes of instructional innovations?*

Conclusions

One of the major problems that instructional technologists face is that the products of instructional technology have not found wide acceptance. The underlying assumption of this study is that instructional developers can increase the acceptance of their products by determining and accounting for the perceptions of potential adopters in the development process.

The perceptions identified by E.M. Rogers were important to the potential adopters in this study. All of the potential adopters interviewed in this study used at least one of the attributes identified by Rogers to describe the modules. The language of Rogers was very much a part of the language of the potential adopters. The fact that potential adopters used the attributes identified by Rogers to describe the modules is an important result of this study. This result shows that the perceived attributes of an innovation can be important considerations for those attempting to facilitate the adoption and diffusion of instructional innovations. This conclusion agrees very closely with Wyner's (1974) conclusion that the perceptions of those who use an innovation can provide valuable data to change agents.

Another major conclusion of this study is that instructional developers most often discussed the process by which the modules were developed or the learning strategies used in the modules. Instructional developers very often described the modules in terms of technical or instructional characteristics. When asked directly about the attributes of the modules, developers discussed the attributes in terms of organizational factors, not in terms of how they might affect the individual potential adopter.

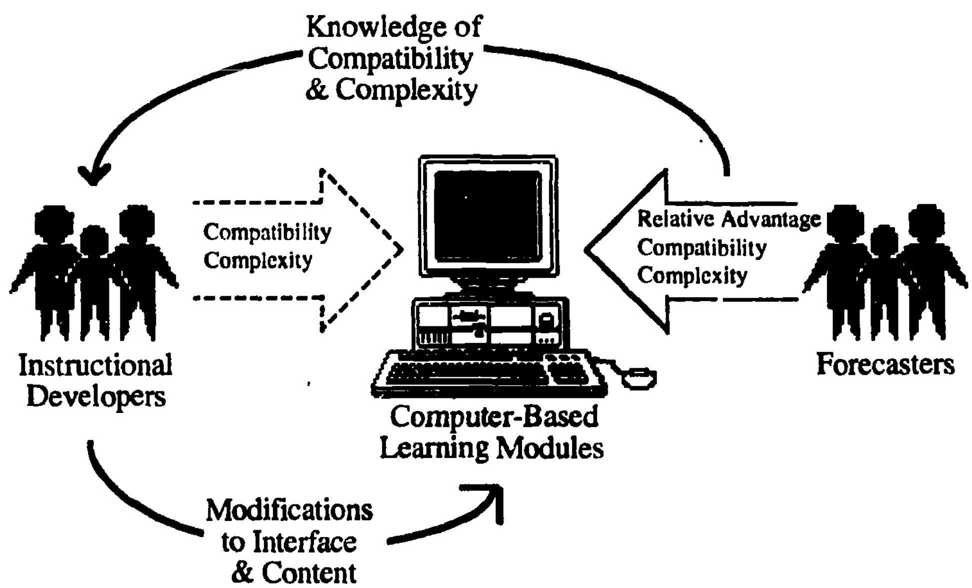

Figure 2. A model showing the findings of the present study.

The theoretical model at the beginning of this paper can be modified to represent the relationship that was found to exist between the instructional developers, perceptions, and potential adopters in the present study. Figure 2 above is a model representing that relationship. As shown in Figure 2, relative advantage, compatibility, and complexity were important perceptions to the potential adopters in this study. Instructional developers had no strongly held perceptions in regard to the attributes defined by Rogers but did consider the compatibility and complexity of the CBL modules during the development process. The developers used formative evaluations and personal experience to gain knowledge of the perceptions of potential adopters in regard to compatibility and complexity. Based in part upon their knowledge of the potential adopters in regard to compatibility and complexity, the developers modified the content and interface of the modules. Trialability and observability were not important perceptions for either group.

In conclusion, the present study sought to determine the relationship between perceived attributes, instructional developers, potential adopters, and the adoption of an instructional innovation. The relationship is a very complex one and requires much additional study. However, the results of this study indicate that the perceived attributes identified by E. M. Rogers do have the potential to offer valuable insights to instructional developers and change agents. The reader is invited and challenged to formulate additional research questions, arising from their own experiences and interpretations of the present study, that might further contribute to the literature related to the importance of perceived attributes in the development and adoption of instructional innovations.

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Title:

The Tenure Decision: A Readers Theater on Constructivism

Authors:

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(Dean's conference room. Four people sit around a table, shuffling papers.)

THE DEAN: We're only waiting for Dewey. I hope he remembered the meeting.

MICHELE: I saw him in the hall a moment ago. He's on his way, I think.

DEWEY: (entering quickly, and sitting down) I apologize for being late. I stayed after class to discuss some issues with a few students.

HARRY: Very commendable.

THE DEAN: Well, now that we're all here, let's get started. The purpose of this Appointments Committee meeting, as you know, is to decide whether or not to recommend a faculty appointment for Linda Esteban. We've talked about this matter before at some length, and you've all had a chance to look over the file. The evaluations, both of Linda's teaching and of her scholarship, are very good. I'd have to say that this looks like quite a clear-cut decision to me. Do we need further discussion?

HARRY: I'm afraid so. I'd like to raise an issue that's troubled me all year—but I think it's particularly pertinent to this candidate. Let me come right to the point: I have very serious doubts about this candidate's scholarship—hers in particular, but also about the way we evaluate scholarship in general. Do we even have any criteria or standards anymore for distinguishing good scholarship from bad scholarship?

THE DEAN: Well, I've certainly assumed that we do.

HARRY: I've assumed the same thing, but I'm beginning to wonder. At our last meeting, Dewey and Michele reported on Linda's articles, and they both said her scholarship was excellent. I decided to look at a couple of the articles, and my reaction was different. In fact, it's hard for me to imagine how a reasonable person could say this work is good. That's what leads me to wonder about our standards—if we have any.

Here's how I would characterize the articles. There was a lot in them that seemed calculated to convince readers that the author is a good, moral, compassionate person who is deeply grieved by the injustices that Western civilization has inflicted upon racial minorities and women. I'll concede—although I can't really know—that these expressions were perfectly sincere. There was also a lot in the articles that seemed designed to establish the author's credentials as a member of a class that has been victimized or oppressed. All of this presumably relates to the question of "voice"—the author assures us that she speaks with the proper "voice."

I'll concede that much too; the author has the right "voice" (whatever that means). But it still seems to me that a scholar has an obligation to use her voice to say something coherent and significant. And that's where the articles fail. They have the right "voice," maybe; and they use the right postmodern/critical/feminist vocabulary. But they just don't say anything significant.

MICHELE: Getting a little carried away, aren't we, Harry?

HARRY: Okay, I've overstated my point. I agree that the articles make a number of claims that, if true, would be very significant. The basic problem is that there is almost no effort to back up those claims with anything like evidence or careful analysis. There are also what I take to be some philosophical positions implicit in the articles; but once again, far from articulating those positions and then making serious arguments for them, the author doesn't appear to understand what they are or where they come from. In the end, the articles seem more like ventilation than reasoned argument. It's as if she's saying, "Look, I'm a sensitive person, and I've been oppressed, and here's my opinion"—and we're supposed to just accept it. But if you forget for a moment about the "voice" and the indignation and just look at the substance—the arguments made and the way they are or aren't supported—these articles would barely get "Bs" in a freshman writing course. I ought to know; I used to teach freshman writing classes before I went to Florida State.

MICHELE: Frankly, Harry, it strikes me that your own speech shows that these articles have more to them than you give them credit for. In fact, you're acting as Exhibit "A" for Linda's thesis in her most recent article. You're applying traditional white male criteria to an author who takes a different perspective, and as a result you're dismissing her without really even hearing what she's trying to say.

HARRY: I knew someone would say that; in fact, that's why I've kept quiet about these issues up until now. Anyone can use that rhetorical trick. Just call something "white male," and it doesn't matter what it is—traditional classrooms, teachers, instructional-design models, why not computers?—you think you've discredited it. For some reason—I can't quite figure it out—no one ever seems to remember that Marx, Nietzsche, Freud, and Rousseau were all white males too.

ARIEL: So were Gadamer, Habermas, Derrida, and Foucault.

HARRY: No offense intended, but I think that argument is just a cover for intellectual laziness. And I'm not buying it anymore. When I say that these articles are vacuous, I'm not applying "white male" criteria. I'm judging them by their merit—or by their lack of merit.

MICHELE: A kinder, gentler term for the same thing. "Merit" according to white male standards.

HARRY: That's not true. When someone says that scholars ought to back up claims with evidence, or that they ought to reason and analyze instead of just emoting, or that they ought to follow through on the logic of what they've said without contradicting themselves, those are not in any sense "white male" standards. They are simply objective standards for good scholarship, no matter who's doing it.

DEWEY: Let me jump in here, if I may. This discussion has all been very interesting. And I think Harry's last statement is especially revealing; it's also ironic, in view of his earlier complaint about Linda Esteban's lack of philosophical sophistication or self-awareness. Because it seems that Harry has his own tacit philosophical assumptions that he may not have examined very carefully. He has a sort of metaphysics and epistemology that we might describe as "realist."

HARRY: I don't accept that. As a matter of fact, I don't even know anything about philosophy, except for the little—very little, I assure you—that I remember from the survey philosophy course I took as an undergraduate. So I don't have any particular philosophical views at all. We instructional designers manage quite nicely without any, thank you.

DEWEY: You're being too modest, Harry. Actually you're more of a philosopher than you realize.

HARRY: Me—a philosopher? Now that's really hitting below the belt.

MICHELE: I was under the impression that the purpose of this meeting was to discuss whether Linda Esteban should be appointed—not whether Harry is a closet philosopher.

Perhaps we could get back to business?

HARRY: And just leave Dewey's slanderous accusation unexplained and unanswered?

ARIEL: I'm interested. What did you mean, Dewey?

DEWEY: Just this—and I'll be succinct about it, Michele.
It's true that Harry hasn't explicitly endorsed any metaphysical position, of course. But think about what's assumed in his notions of "merit," "reasoned argument," and especially his insistence on supporting assertions with "evidence." Harry has been less than clear about what would count as evidence, but it seems pretty obvious that things like "voice" and personal perspective aren't evidence. Those first person aspects are entirely distinct from what Harry calls the "substance" of the articles, and they don't count towards establishing the "truth" of what an author like Linda asserts. Other things—like controlled experiments with lots of statistics—apparently do count. But what are the background assumptions that would lead Harry to take a position like this?

HARRY: I don't know. Since Dewey seems to understand my philosophical views better than I do, maybe he'll explain to me what they are.

DEWEY: I'll be happy to try. Harry assumes that there is some sort of reality "out there"; it exists independent of the person who is talking about it. And a statement is "true" if it accurately describes, or corresponds to, that reality. That's why Harry can think that his standards of merit are "objective." The scholar is not trying to impose anything, any values or goals or biases, onto reality; she is just trying to describe it. And she shows that she has given a correct description by supporting her statements with evidence, with careful logical analysis, and so forth. Just "emoting," or "ventilating," aren't helpful; they tell us nothing at all about the "object" being described, whatever that is; they only tell us about the subject, or the speaker. So as far as objective description goes, these kinds of expression only clutter things up. Am I getting your position right, Harry?

HARRY: I don't want to be pinned down to any philosophical position, particularly one supplied by you, Dewey. But in this case, I'll have to admit that what you said sounded pretty much correct. That's just common sense; everyone acknowledges that a "true" statement is one that accurately describes what it's talking about.

DEWEY: No, not everyone does. But let me continue. Harry's unreflective metaphysical and epistemological assumptions—which I think we can refer to collectively as "realism"—express one possible philosophical position. And of course that position, in its various versions, has some venerable names associated with it: Descartes, Bacon, Locke. It probably also expresses the view that ordinary people typically take, at least when they haven't given much thought to the philosophical issues involved. And a realist position can support certain criteria of "merit" for judging scholarship. That's the good news (for Harry).

But here's the bad news. The realist understanding of truth is only one possible philosophical position—not the only one. And I would say that today, very few philosophers or academics interested in these issues accept the "realist" position. In fact, I would go further and suggest that the "realist" position has been thoroughly discredited. So it turns out that while Harry criticizes Linda Esteban for, among other things, not understanding her philosophical presuppositions, his own criticisms arise out of philosophical assumptions that *he* doesn't seem to have examined —and that in fact are thoroughly outdated.

THE DEAN: Well, Harry, I guess you've been put in your place.

HARRY: I don't think so. Dewey hasn't shown what's wrong with the standards that I (and, until recently, all of us) want to apply—with standards that suggest that you should back up your assertions with evidence, with careful logical analysis, and so forth. All he's done is attribute to me a particular philosophical position and then report that the position isn't popular with philosophers at the moment. As far as I'm concerned, that's *their* problem—and Dewey's. Unless, that is, he can show me some plausible philosophical position other than the "realist" one and explain how under that alternative position something like supporting assertions with evidence isn't a valid standard.

ARIEL: That sounds like a challenge.

MICHELE: Yes, I'm afraid it does. And of course it would be unmanly to let a challenge go unanswered. So if you'll excuse me, I'll be back in a moment. It's clear I'm going to need some caffeine.

THE DEAN: There's some soda in the fridge. Help yourself.

MICHELE: I'm very grateful. I'm sure I wouldn't have wanted to miss out on any of this discussion.

II

DEWEY: Well, I can't accept the challenge in quite the terms that Harry used just now, but I'll try to deal with the problem he raises. Let's start with Harry's notion of what it means for a statement to be "true" and see where things lead. Harry thinks that a statement is "true" if it accurately describes—or agrees with, or corresponds to—some independent reality. Now if we think about it, isn't it clear that this can't be what "truth" means?

HARRY: I don't see why it can't.

DEWEY: For a number of reasons. But the main problem, I think, is that if the realist notion of truth were the correct one, we'd never be able to know whether a statement is really true. And a conception of "truth" that leaves us completely unable to know whether any given statement *is* true wouldn't be too helpful, would it?

ARIEL: I'm not following. Why does a realist definition of truth leave us unable to know whether a given statement is true?

DEWEY: Mainly because of what you might call the "no getting out of your own skin" problem. Let's take a very simple example—the kind of example, in fact, that's most favorable to Harry's view. Suppose I say something like "The chair in the corner is brown." By Harry's account, my statement is true if, independent of me, there is in fact a chair in the corner and it is in fact brown. (We'll leave aside for now the additional problem that the very ideas of "chair" and "brown" are human constructs.) Now, in order to verify those facts—i.e., that there is a chair "out there" and that it is brown—I'd need to be able somehow to step outside myself, set my statement about the chair alongside the chair itself (or whatever there may be "out there"), and see if they match. Obviously, I can never do that. Like it or not, I'll always be stuck inside myself.

ARIEL: That's certainly true. But you could, if you were really worried about this, ask me to check out the chair for you. I'm outside your skin. I could verify your statement for you.

DEWEY: We could do that, yes. But notice that your suggestion doesn't solve my problem.

If you tell me that the chair in the corner is brown, then I would have two things to work with: my own initial perception, and now your report as well. What I wouldn't have—never could have—is the ability to match my perception and my statement of my perception against the chair itself. And you can't do that for me, because you can't get outside your skin either.

ARIEL: So then we're right back where we started?

DEWEY: Not quite. I do have something else to check my statement against—Your statement. Now suppose we bring ten more people in here, and they all say, "Yes, the chair in the corner is brown." We'd be pretty confident then in saying that my initial statement—"The chair in the corner is brown"—is "true." But here's the crucial point: We would say the statement is true not because we (individually or collectively) could match the statement against the chair itself. What we match up, rather, is our statements. In other words, what we would really mean in saying that my statement is "true" is that it fits well—coheres, we might say—with other people's statements and beliefs, not that it matches or agrees with the object itself. Truth, we might say, is a product of dialogue—a sharing and comparing of statements and beliefs—and the working criterion of truth is dialogical coherence, not objective correspondence.

ARIEL: So instead of a "realist" theory of truth, we have a "dialogical coherence" theory. Is that what you're saying?

DEWEY: That's about right. Of course, what I've given here is only the skeleton of a theory. Different people would flesh it out in lots of different ways. But I think it's fair to say that most philosophers today, and most educational theorists who have thought seriously about these issues, subscribe to some version of a dialogical coherence theory. The common element lies in the recognition that we don't discover truth by reading it off of an objective reality; instead we construct truth—through dialogue.

HARRY: And it follows, I suppose, that in a dialogical coherence theory of truth, standards like "Support your assertions with evidence" have to be discarded?

DEWEY: Not at all. That's what always happens; someone hears that a "realist" theory of truth has been criticized, and they immediately attribute all kinds of dire consequences and outlandish implications to an alternative position. Actually, standards like Harry's would still have their place in a dialogical coherence theory. But their significance would be a little different.

HARRY: You'll elaborate, I'm sure.

DEWEY: Of course. Once we understand that truth is a product of dialogue, then we can also see that within any particular community that engages in dialogue, there will be certain practices that govern the making and acceptance of statements. These practices might vary from one community to another. In one community, the practice might be that statements ought to be consistent with some sacred scripture. In another community—one heavily influenced by the methodologies of empirical science, for instance—practice might demand that statements be supported by evidence gained through sensory perception. Since these practices determine the kinds of statements that can be made and accepted, they will naturally determine what, for that community, can be accepted as "true." In our own community, it happens that we have developed a practice that expects people to make statements that can be supported with "evidence,"—usually empirical—although I'd suggest that we're not too clear about what counts as evidence. Still, the standard Harry invokes is perfectly understandable and even, in the sense I've been describing, legitimate.

But there is a lot more to be said now. In the first place, the standards accepted by a given dialogical community reflect the practices of that community. So it would be misleading to assume that these practices or standards are "neutral" or "objective" in any larger or universal sense.

Also, the practices of a community will make it difficult for someone coming from a different community governed by different practices to speak, or to be understood, in the first community. In that sense, the standards of truth that are grounded in those practices will operate to exclude. So when Michele refers to Harry's standards as "white male" standards, she has a valid point. Harry doesn't need to take offense; Michele isn't saying that Harry's standards are wrong in any ultimate sense. Indeed, she couldn't say that, because to say it would presuppose the same kind of untenable objectivist, universalist assumptions that Harry himself is implicitly using. But Harry's standards are based on practices that happen to have prevailed in a dialogical community composed mainly of white males.

Harry: So everything's relative? How then can we say anything is really true?

Dewey: Oh, I can say it all right. It's true that we're all sitting here talking. I believe it's really true. But the meaning of 'true' means something a little different to me than it means to you. If you mean "True"—with a capital "T"—then I'm not sure anyone's got a handle on that completely.

Another thing—Once standards are understood to be grounded in practices that are contingent—by that I mean that the practices might be different, and in fact are different, from one community to another—then it also follows that the practices and standards become eligible for reexamination and, possibly, for change. And something else follows that is vital to the general question Harry raised about evaluating scholarship. If we understand that truth results from dialogue, from talking together, not from comparing statements with some independent reality, then we will naturally be much more concerned with the participants in the conversation. Who gets to participate? What kind of people are doing the talking? How do these people perceive and describe things? What kind of language, or what kinds of conceptual schemes, do they use? I could put it differently: Once we realize that truth is constructed, we naturally become interested—primarily interested, I might even say—in who's doing the constructing. So all of these "first person" questions about "voice" and who the speaker is— questions that in Harry's realist view can be quickly brushed aside because they don't bear directly on the objective "truth" of what is said—come to be vitally significant.

THE DEAN: So, Harry, are you ready to concede the point?

HARRY: Very amusing. No, I'm not convinced. I think Dewey's just given us a fine example of sophistry to try to get us to relinquish what we all know. But I can't articulate off the top of my head just what the mistake in Dewey's argument is; I'm not a philosopher, after all.

III

THE DEAN: Well, then, perhaps we can get back to business and consider the question of Linda Esteban's appointment. Any further discussion?

ARIEL: Actually, before we discuss the specifics of Linda's candidacy, I'd like to explore Dewey's argument a little further. Would that be appropriate?

THE DEAN: Well, you realize this is supposed to be an Appointments Committee meeting, not a gathering of the Socratic society.

MICHELE: Couldn't you and Dewey resume this discussion later?

ARIEL: We could, and if no one else wants to continue this discussion, I'll just drop it. But Dewey did tell us that these philosophical questions bear directly on the standards that we should apply in evaluating scholarship. If that's right, and since the issue has been raised, it seems to me that we ought to pursue this a little further.

THE DEAN: I'll defer to the other members of the Committee. But remember that some of us may have to leave. The more time we spend on metaphysics, the less likely it is that we'll be able to make a decision on Linda Esteban today. And if we don't move quickly, we're likely to lose her.

DEWEY: I share the Dean's concerns. But I'd hate to truncate discussion if some people think it's relevant to our decision.

HARRY: I'm willing to listen a little longer. Especially if this discussion will spare me from reading all the articles that ought to be in philosophy journals but have somehow gotten into the Ed Tech journals.

THE DEAN: I wouldn't count on it. But it sounds like you have leave to go ahead, Ariel. Let's just try to be as efficient as possible.

ARIEL: I will. This is my difficulty: I can accept some of what Dewey said, but not his relativism or his total rejection of truth as correspondence. He insists that "truth" is constructed; and in one sense that seems right. After all, truths have to be expressed in language, and language is socially constructed. (Although I have to admit that "constructed" doesn't seem to be quite the right word; it implies that we have more conscious control over the process than we actually do, I think.) And our statements about what we think is true will naturally use the concepts and categories and theories that are available to us, and those are also constructed. If that's all that Dewey means, then I could probably just agree with him.

Dewey: What I mean is that the meaning of things is within us, not within the things themselves.

ARIEL: Well Dewey, I still don't see why you have to reject the realist view of truth. It seems to me that I can admit that truth is "constructed" in the ways I've mentioned and still maintain that a statement is true if it accurately describes the thing it's talking about.

DEWEY: But it's like an endless circle, trying to figure out what 'accurately describes' means in any purely objective sense.

ARIEL: Let me give an example: Suppose Dewey says, "The Dean weighs 180 pounds."

THE DEAN: Now I'm getting interested. And if Dewey can come up with a theory that makes that statement true, I'll see to it that he gets an instant promotion.

HARRY: I'm afraid that would be beyond even Dewey's sophistical powers. Philosophizing is never going to replace dieting.

ARIEL: It's a purely hypothetical example. My point is this. In some senses, the truth of Dewey's statement—we'll fantasize that it is true—might be said to be "constructed." After all, the statement doesn't even mean anything except in a language that is socially constructed. And it uses concepts— 'pounds,' for instance—that are socially constructed. 'Pounds' as a term of measurement is a human invention; we might just as easily talk about 'kilos' or something else. The Dean doesn't come with a number of pounds written on him.

DEWEY: I'm with you so far.

ARIEL: My point is that none of this seems to mean that we have to abandon a realist notion of "truth." It seems more sensible to say that what a statement means is a matter of convention or social construction; but whether the statement is true still depends upon whether it accurately describes or agrees with its object. In this case, unfortunately, it probably doesn't.

But Dewey apparently believes that because in certain senses all true statements are "constructed," we therefore have to give up the idea that truth depends upon agreement of a statement with the "reality" it describes. Instead, a statement is true if it coheres with—I'm not too clear on just what that means—other statements and beliefs commonly expressed and accepted in the dialogue of a given community. Isn't that more or less what you were saying?

DEWEY: More or less. But I don't think you can take the meaning out of a statement and judge it purely on its 'truth' value. What does it mean for something to be true if the meaning of it is unclear? You're using 'truth' in a very narrow sense that robs it of its richness; I'm not sure what you've got left after meaning is separated out.

ARIEL: Well, it seems to me that your understanding of truth clashes in all sorts of ways with what everyone understands 'truth' to mean.

DEWEY: It very well may. But can you be more concrete?

ARIEL: For instance, most people would think, to use your example, that you can say "The chair in the corner is brown" and your statement is true or false regardless of whether anyone else comes into the room and agrees. Suppose you yourself placed the chair in the corner on Monday morning and observed that the chair in the corner was brown, and then the building burned down so that no one else ever saw it. According to your theory of "dialogical coherence,' it seems, your observation would just be hanging out there; it would never be true or false because there would never be any dialogue to confirm or disconfirm it. But that seems crazy; no one believes that.

DEWEY: But whether we like it or not, we are in the world, and in conversation with people past and present. Our culture is the context within which we perceive chairs and everything else in this world. I may never have talked to anyone about the chair, but my actions, beliefs, and thoughts about it are all conditioned by my participation in the world.

ARIEL: OK, I'm starting to see your point. But let's take a different example that's close at hand. The Dean says, "There's pop in the refrigerator." What that statement means depends, I agree, upon conventions of language and and practice that are socially constructed. But does the truth of the statement depend upon coherence within a cultural context? I don't think so. It would be just as "coherent" to say, "There isn't any pop in the refrigerator." The truth of the statement depends on whether there is in fact a fridge "out there," and whether it in fact has pop in it.

Or suppose I say, "The Yankees will win the pennant this year," and nobody else agrees. Does that mean my statement is false? Even the people who think the Yankees don't have a chance wouldn't say that. They would say that my statement is probably false, but that we won't really know for sure until we see who actually does win the pennant. And even then, if my statement turns out to be false, it won't be because other people disagreed with it. It will be because the Yankees didn't win.

DEWEY: I think I can see at least part of your point, Ariel. There seems to be a part of what we mean by 'truth' that depends on correspondence with the way things are, with the outside world. That's the common sense view of things, I admit, and it's often useful. But let me make two points. First of all, you will never really know whether the Yankees win the pennant except by comparing your prediction with what other people say about who won the pennant. You'll always be comparing your statement not with some objective reality, but rather with other people's statements. Just as you would in the case of the chair.

ARIEL: True, but I think that misses the point. It seems to me that you're confusing two separate questions. One question is what it means for a statement to be "true." To put it differently: What is it about a statement that makes the statement true or false? And the answer to that question, I submit, is that a statement is true if it accurately describes what it is talking about.

DEWEY: I would prefer "faithfully." True statements faithful describe or interpret to what they're talking about. They do justice—not violence—to the subject at hand.

ARIEL: The second question is how do we verify, or how do we go about deciding, whether a statement is true. We can't, as you say, step out of our skins and lay our statement alongside the object itself—and I very much doubt whether anyone ever thought we could. So we use other methods. One of those methods—although certainly not the only method—is to compare our beliefs and perceptions with other people's beliefs and perceptions. That's a method for determining whether a statement is true. And I agree that dialogical coherence makes good sense as one method of confirming or disconfirming statements. But another legitimate method is to look for a correspondence between the thing and what's said about it.

DEWEY: So we're headed towards a dual—or multiple—theory of truth are we? Truth can mean different things, and we use different methods to show it. I guess I'm not strong enough to resist you.

IV

MICHELE: Now that's one point I've got to agree with. But it seems to me that both of you have absorbed too much philosophy.

DEWEY: What do you mean?

MICHELE: Just notice what's happened. The question we started off with was whether it's appropriate to judge Linda Esteban's scholarship by "white male" standards. Dewey thought he was taking the open-minded, liberal, enlightened view by arguing that we shouldn't, and that the standards Harry holds so dear are not really "objective" or "neutral." If he had stopped at that, things would have been fine. But instead, he had to go ahead and offer a full-blown philosophical analysis of what was wrong with Harry's position, and then to suggest a philosophical alternative. And you can see where that leads; Dewey just set himself up to be taken apart. In the meanwhile, we've made no progress toward answering the initial question.

DEWEY: I beg your pardon. Mea culpa. Although what I offered was hardly a "full-blown philosophical analysis." Anyway, what should I have done, Michele?

MICHELE: You should have noticed that Harry's insistence on applying "merit" criteria wasn't a PhilosoPhical position at all—as he himself made clear. Harry was taking a political position. And the proper response, therefore, is a political response. Turning the issue into a matter of philosophy just diverts attention from the real problem—and dignifies Harry's position at the same time.

DEWEY: I'm still not sure what you mean. It seems to me that Harry's belief in a particular set of "merit" criteria does reflect some implicit philosophical assumptions—and that it's useful to bring those assumptions out into the open. How else are we supposed to decide whether Harry's position is correct?

MICHELE: And I suggest that you've gotten trapped in a philosophical approach to the world. And the result is that however good your intentions may be, you'll wind up endorsing something like Harry's position, even if you do it unwittingly. As Ariel has just shown. And, in fact, as the statement you just made reflects. After all, identifying and examining an author's underlying assumptions is precisely the kind of thing that Harry thinks good scholarship ought to do. Isn't that right, Harry?

HARRY: It's one thing good scholarship often does, yes. And I'm glad to see that whichever route we take, we seem to end up back at something like my position.

MICHELE: Oh, no. I haven't admitted that. There is another alternative—quite an obvious one, really.

HARRY: Which is?

MICHELE: To appreciate, as I said a moment ago, that Harry's position is really political in nature, and that we should respond accordingly.

DEWEY: Could you explain that a little more clearly?

MICHELE: Well, I agree with Dewey, of course, that it isn't appropriate to judge all scholarship by Harry's so-called "merit" standards. And I also agree that Harry's standards probably reflect (even though he doesn't realize it) a "realist" or "objectivist" understanding of truth. But what we need to ask about Harry's standards, and his realist understanding, is not whether they are "true"—even to who knows what exact that means!—but rather what political consequences follow from them.

When we ask that question systematically, it soon becomes apparent what the actual significance of realism is. It's a device for justifying structures of power and oppression. People in power have always used it that way. The medieval church that tortured and persecuted heretics, the New England Puritans who executed witches and Quakers, the "enlightened" Founders who defended slavery and wrote it into the Constitution and who left women dependent and disenfranchised—the ruling powers have always justified their position and their oppressive practices on the basis of a realist metaphysic. What they were doing was always in accordance with some "objective" truth. And the use of "objective" academic standards today to denigrate the scholarship of women and scholars of color is just one more example of this venerable practice. It's just one of the little ironies of history that the most articulate defender of "realism" in this room today happens to be a woman.

ARIEL: Alright, then let's play your game for a while. We won't talk philosophy, just politics and power. You say that people in power have always used realism to justify their position; they've defended their practices on the basis of so-called "objective" truths. I admit that—cheerfully. But isn't it also true that people who have resisted or opposed power and oppression have also done so on the basis of what they believed to be "objective" truths? The abolitionists invoked—fiercely—what they believed to be an objective higher law. When they said slavery was morally abominable, they weren't just saying that they didn't have a taste for it, or that their own power would be enhanced by the elimination of slavery; they were saying it was wronq. The same was true of those who worked for civil rights in this century. When they argued that segregation was unjust, or that blacks were the physical and intellectual and moral equals of whites, they weren't just making a power grab. Nor were they reporting on the outcome of a search for dialogical coherence; on the contrary, what they said often was not compatible or coherent with views and beliefs widely accepted in American culture. They were asserting what they believed to be true—in a realist sense. Am I wrong?

DEWEY: Michele, is it OK if I act like a male and butt in on this? I know you don't like philosophy, but this question needs a philosophical answer.

MICHELE: Go ahead, Dewey, but my turn next.

DEWEY: Ariel, I'm afraid you're confusing a realist position with a person being committed to the belief that certain things are true. Realism is not the only path to truth or to a person believing they're right. Non-realists aren't sitting out there with no principles, no beliefs, and no truth. Believe it or not, there are postmodern thinkers out there who are social activists, religious and political reformers, persons totally engaged in the affairs of this world.

ARIEL: Still, it seems to be true that both those in power and those who are resisting power have been realists.

MICHELE: Historically that's been true, but realism has been the dominant worldview of past centuries. I think that's changing, though, with more dissident and activists groups showing a variety of views about the world. But that's probably beside the point. The point is that an objectivist realism tends to favor those in power over those out of power.

ARIEL: Well it also seems true, almost by definition, that people with power will more often prevail over people without power. But I'm not sure what that tells us about realism. In fact, I'm not sure whether there's much of a connection at all between realism and struggles over power. You might as well say, "Human beings breathe air," and "The world is unjust." Both statements may be true, but there's not much connection between them. And it would be just plain silly to link the statements and then conclude that we ought to take a stand against breathing air.

MICHELE: I'm afraid that's a rather poor analogy. The difference, obviously, is that there is a connection between realism, or a belief in an "objective truth," and power. And if we could dissolve realism, if we could expose the fallacy of "objective truths," then at least one weapon that the powerful typically use to their advantage would be eliminated.

ARIEL: Yes, I suppose you're right that there is a connection between realism and power. I retract my analogy. But I still think that abandoning realism would hurt the powerless more than the powerful.

MICHELE: But just a moment ago you said the opposite. You agreed that realism favors the powerful more often than it favors the powerless. "Almost by definition," you said.

ARIEL: Let me explain. What I said was that almost by definition those with power will usually prevail over those without it. That's what it means to have power. But it doesn't follow that realism is what allows the powerful to prevail. Quite the opposite, in fact. The powerful don't need truth. After all, they already have power: they have clubs, or bullets, or money. It's the powerless who need truth because, to use your metaphor, it's the only weapon they have.

MICHELE: That's wonderful idealistic rhetoric. Unfortunately, it doesn't work very well in the real world. Fundamentalists, for example, are surely realists, yet they tend to be among the most militant of peoples. Realism and power tend to go hand in hand. You say the powerful don't need truth since they have power. But their biggest fear is that they might lose power, so they take great pains to control how the story is told. And since they believe in only One True Story, they have a vested interest in realism as a vehicle for preserving the status quo.

The logic goes something like this:

—There is only One True Way of seeing things.
—The Ruling Society tells things that way—the way things are.
—If you don't conform to the Ruling Society's story, then there is something wrong with you.

DEWEY: So here we are back to a healthy pluralism. Out of our little dialogue some truths seem to have emerged. Ariel has persuaded me to admit a role for correspondence in thinking about truth, and Michele has shown the pragmatic and political dangers of an objectivist view that discourages multiple perspectives. I'm not sure if I'm postmodern, but I can definitely see some value in pluralism.

THE DEAN: I'm sorry to have to interrupt at this point. This has been an illuminating discussion, I'm sure. However, I mentioned that some people might have to leave, and in fact I have a meeting with the Vice-Chancellor in about five minutes, so I'm afraid we're going to have to adjourn without reaching a decision on the matter at hand. And I don't think we should wait too long on this. Can I just ask: How soon do you all think you may be ready to make a decision on this matter?

MICHELE: I'm ready to vote right now.

HARRY: I'm not. But I do have a request. If Dewey and Ariel would make up a reading list naming what they each regard as the ten most important books on the nature of "truth," I'll study those just as soon as I find the time. Then I'll be prepared to vote.

ARIEL: And by then the rest of us will have passed into the realm of higher truth.

MICHELE: You see where philosophy leaves you.

THE DEAN: Seriously, could we meet tomorrow at noon for about an hour? I'll provide lunch. That will give Harry almost 24 hours to figure out the nature of truth.

DEWEY: That should be plenty of time for him. Even though he'll have to interrupt his ruminations for a half-hour to catch "The Simpsons."

HARRY: It won't be an interruption. That's probably where I'll find the answer.

ARIEL: If it comes to that, then on this issue—and only on this issue—I'd advise you to trust Bart's judgment. Not Lisa's.

HARRY: Don't worry. I'd have done that anyway.

MICHELE: We know.

THE DEAN: I'll see you all tomorrow. At noon.

(Meeting concludes.)

Author Notes

Brent G. Wilson is associate professor of instructional technology, University of Colorado at Denver. Steven D. Smith is professor of law, University of Colorado at Boulder. This paper is based on an earlier manuscript written by Steven for a law audience. Brent has adapted the paper to suit an educator audience, and has adapted the content to reflect more of a postmodern orientation. Brent Wilson assumes responsibility for this version of the paper. Paul Campos, Richard Delgado, Ann Estin, Chris Mueller, Bob Nag[illegible], Gene Nichol, and Pierre Schlag provided valuable observations, recommendations, and protestations.

Title:

Under What Conditions are Embedded versus Generative Cognitive Strategy Activators Effective? Two Prescriptive Models for Designing Instrution

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The propositions of those models have raised important questions among educators generally, and instructional designers specifically. For example, " What is the best instructional system that should be used for inducing learners' cognitive strategies? is it a system in which learners should be directed to generate their own cognitive strategy activators (GS), or a system in which teachers (researchers, or designers) should prepare those activators and give them to learners (ES)? What is the best position of cognitive strategy activators should be inserted in, Is it before instruction, during, or after instruction? What is the best mode of cognitive strategy activators that should be used, is it a visual (concrete) mode, or verbal, written (abstract) mode?

To address the above questions, researchers have conducted numerous experimental studies to investigate the effectiveness of cognitive strategy activators in terms of their instructional systems delivery, positions, and modes. In those studies, the cognitive strategy referes to intellectual functioning of the human mind and the abilities to use one's knowledge through such activities as remembering, comprehension, focussing attention, and processing information (Babbs, & Moe, 1983); whereas the cognitive strategy activators have been used to mean as instructional strategy components which either request or force students to use a cognitive strategy such as adjunct questions, organizers, underlining etc... (Reigeluth & Darwazeh, 1982).

With respect to the cognitive strategy activators' system, resrearchers have investigated two kinds of system:

1- The first system was known as an Embedded Cognitive Strategy System (ES) in which learners are forced to use a given cognitive strategy activator that was prepared by the teacher (instructor, designer, or researcher). For example, requesting learners to answer questions that are given to them by the instructor to help them to acquire, retain, and retrieve different kinds of knowledge is an embedded cognitive strategy procedure.

2- The second system was known as a Generative Cognitive Strategy System (GS) in which learners are directed to generate a certain cognitive strategy activator by themselves. For example, requesting learners to generate questions to help them to aquire, retain, and retrieve different kinds of knowledge is a generative cognitive strategy procedure.

With respect to the position of cognitive strategy activators, researchers have investigated mainely two positions of cognitive activators:

1- Before (or Pre) instruction in which the cognitive strategy activators are presented before beginning instruction.
2- During and After (or Post) instruction in which the cognitive strategy activators are presented during instruction or after instruction.

With respect to the mode of cognitive strategy activators, researchers have also investigated two kinds of modes:

1- Visual (or Concrete) cognitive strategy activators in which information of it is presented in figures, maps, flow chart, diagrams, trees, etc..
2- Written (or Abstract) cognitive strategy activators in which information of it is presented in a narrated language.

The results of previous studies concerning either system of cognitive strategy activators, positions, and modes have been inconsistent. This inconsistency was due to the effect of different instructional variables (or conditions) that existed during experimentation. These variables were centered around three major elements:

1- Learner characteristics (i.e., high vs. medium vs. low ability learners ; field-dependent vs. field-independent learners).
2- Content characteristics (i.e., organized, vs. random; familiar vs. unfamiliar; content sequenced from

specific to general vs. from general to specific information).
3- Levels of learning (i.e., high vs. medium vs. low level of learning).

Research Problem:

Despite the fact that there were a tremendous number of studies that have been conducted on cognitive strategy activators, there was no single research that synthesizes the results of those studies to see whether there is a common trend of those results that helps us, as instructional designers, to design insturction based on them.

On the other hand, the cognitive strategy activators are still not considered in the models of instructional design (e.g., Dick & Carey, 1990; Gagne, Briggs, & Wager, 1992), except for an attempt by West and his colleagues (West, Farmer, and Wolff, 1992) to put a template of instructional design based on cognitive science principles. Their attempt was a good trial, but still did not specify a clear and comprehensive prescriptive model for designing instruction with respect to cognitve activators. Thus, the general aim of the current research is to try to create two prescriptive instructional design models based on the general trend of the results of those previous studies which were conducted on cognitive strategy activators between 1960's-1990's.

Research objectives:

The objectives of the current research are the following:

1- Specifying conditions for the best use of cognitive strategy activators in terms of their systems (ECS vs. GCS), positions (Pre vs. Post), and modes (Visual vs. or Written), with their relation to three instuctional variables: (a) Learner characteristics, (b) Content characteristics, and (c) Levels of learning.

2- Proposing two prescriptive instructional design models of cognitive strategy activators to be used as a guideline for either instructional designers, developers, or teachers. The model could also be used as a guideline for learners on how to develop effective learning strategies during studying.

3- Giving recommendations for future research.

Significance of the research:

The current research represents a small but hopefully important cummulative contribution to our understanding of how cognitive strategy activators can best be used to improve students learning. The suggested models of this research may be of immediate use to instructional designers and classroom teachers who, in addition to making the best use of existing prose materials and software programmes, are also concerned with fostering effective independent study skills in students. Instructional developers, including those at all levels and in all contexts of education and training, stand to benefit through an increased understanding of the role of cognitive activators in enhancing learning and instruction.

Research questions:

The current research is trying to answer the following three broad questions:

Question 1. Under what conditions are Embedded versus Generative cognitive strategy activators effective?

Question 2. Under what conditions are Pre versus Post cognitive strategy activators effective?

Question 3. Under what conditions are visual versus written cognitive strategy activators effective?

Question 4. How can we design instruction with a consideration of cognitive strategy activators?

Research hypotheses:

Based on the reveiw of the literature on cognitive strategy activators, the author proposed the following hypotheses. These are:

Hypothesis 1.

Having learners generate or use cognitive strategy activators would lead them to a better achievement, hence, to a better understanding and learning (Peper & Mayer, 1986; Rothkopf, 1966, 1970; Rigney, 1978; 1980; Wittrock, 1974a, 1974b).

Hypothesis 2.

The preference for using a certain system of cognitive strategy activator (Embedded or Generative), using a certain position (Pre or Post), or using a certatin mode (visual or written) depends on its interaction with different the instructional variables that may exist in the instructuonal situation, such as: learner's characteristics, content's characteristics, and levels of learning.

Rationale for H1 :

1- Having learners generate or use cognitive strategy activators will lead them to pay more attention to the presented materials to be learned, so the learner can process the information more deeply and store it in long term memory (Barry, 1974; Frase, 1970; Norman & Lindsay, 1977; Osborne & Wittrock, 1983; Peper & Mayer, 1986).

2- Having learners generate or use cognitive strategy activators will lead them to get involved in additional cognitive processes, and to actively relate the materials to be learned to their existing knowledge (Ausubel,1960, 1968; Mayer, 1979; Peper & Mayer, 1980; Shreger & Mayer, 1989; Wittrock,1974a,1974b, 1990).

3- Having learners generate or use cognitive strategy activators will increase their levels of motivation (Attendance, Relevence, Confidence, & Satisfaction), hence, to acquire, retain, and retrieve different kinds of knowledge on different levels of learning (Keller, 1983; Reigeluth, 1983; Wittrock,1990).

Rationale for H2:

Since teachers (or instructional designers) are using different kinds of instructional systems, different positions, and different modes of cognitive strategy activators, and dealing at the same time with differnet learners characteristics, different content characterestics, and different levels of learning; it is logical to get different effects of cognitive strategy activators on learining. What we intended to find in this research is whether there is a general trend of those previous studies' results with respect to those instructional variables. The aim of doing such job is to create general prescriptive design models. Hopefully, these findings can also stimulate other researchers to conduct more studies, hence, to derive more principles and add them to the suggested models for the better use of cognitive strategy activators.

Research Methodology

While the author has been at different Universities in the USA as a doctoral student, then as a visiting professor, she sleuthed information and collected data about cognitive strategy activators which is within her research interest. The information was collected from different resources at different times. These resources were basically the following:

1- The Bird Library at Syracuse University.
2- The Randall Library at the University of North Carolina at Wilmington.
3- The Main Library at the University of Georgia at Athens.
4- ERIC Documentation at SU, UNCW, and UGA.
5- Papers presented at different Annual meetings for education held at USA at different times.
6- Conducting few studies on cognitive strategy activators by the author herself (See the reference section).

From those resources, the author was able to find approximately one hundred and fifty experimental studies and theoretical research on cognitive strategy activators. They were found in different books, periodicals, dissertation abstract International, microfiche, working papers, papers presented at different annual educational meetings that were held in the United States of America. Thus, the author considers those studies as the ad-hoc sample of this research. The methodolgy she followed in this research was the descriptive methodology of research.

The procedure that the author used in conducting this research consisted of the following steps:

1- Reviewing a number of previous theoretical and experimental studies that were avialable to the author, which were conducted between 1960s - 1990s on cognitive strategy activators in terms of their instructional systems, positions, and modes.

2- Classifying those previous experimental studies into three major categories:

a- The studies that have manipulated the instructional system of cognitive strategy activators: Embedded versus Generative Cognitive Strategy Activators' Systems (ECS vs. GCS).

b- The studies that have manipulated the position of cognitive strategy activators: Pre- versus Post-position).

c- The studies that have manipulated the mode of cognitive strategy activators: visual (concrete) versus written (abstract) modes.

Therefore, any experimental study or theoretical research that did not fit in these categories was excluded, regardless its relation to cognitive strategy activators.

3- Summarizing the results of those studies according to: the author's name, published year, the aim of the study, the sample size, and the indepependent and dependent variables and then the results.

4- Synthesizing (or categorizing) the results of the experimental studies according to cognitive strategy activators systems (ECS vs. GCS), positions (Pre vs. Post Instruction), and modes (visual vs. written).

5- Drawing a conclusion from each cognitive strategy activator's studies. Then, a general conclusion of all studies' results was drawn at the end of each category. The general conclusions represented the general trend of the results of the previous studies. Consequently, two prescriptive instructional design models were proposed on cognitive strategy activators to be as a guide for instructional designers, developers, teachers, and learners, in their designing instruction, teaching, or studying.

The author found from the review of the literature that the most frequent cognitive strategy activators which have been examined by researchers were alphapetically the following : Adjunct questions, Advanced organizers, Analogies, Diagrams, Heading, Mental images, Information mapping, Meaning generation, Note-Taking, Outlines, Pictures, Stories, Summaries, Synthesis, Titles and Sentences. Thus, they were chosen to be the core of the current research.

For AECT presentation within a limited time, we will be satisfied to present just the name of the authors who conducted those studies and the year of publication, plus the general trend of their results. A full report of this research containing the detailed reviews of each of the previous studies will be submitted to the "Review of Educational Research" Journal.

Literature Review and Conclusions

1- Embedded versus Generative Cognitive Strategy Activator Studies:

Much of pervious studies have manipulated the usage of cognitive strategy activators as (ECS) only. Several studies have manipulated these activators as (GCS) only. But a limited number of studies have made a direct comparison between (ECS) versus (GCS).

In the current research, we are concerned mainly with the third category of studies which compared

(ECS) with (GCS) by using various kinds of cognitive strategy activators. The review of previous studies coverd the following cognitive strategy activators alphapetically:

- Adjunct Questions (e.g., Andre & Anderson.1978-1979; Crouse & Idstein,1972; Darwazeh,1982; Davey & McBride,1986; Dreher & Gambrell, 1982; Duell,1977; Fraze & Schwartz,1975; Helfeldt & Lalik, 1976; King, 1991; Manzo, 1970; Owens, 1977; Seretny & Dean, 1986).

- Advance Organizers (e.g., Ausubel,1960; Ausubel,1964; Ausubel & Fitzgerald,1961,1962; Ausubel & Youssef, 1963; Darwazeh,1988; Dinnel & Glover,1985; DiVesta & Peverley, 1984; Doctorow, Wittrock, & Marks, 1978; Jonassen & Cole, 1993; Jonassen, Cole, & Bamford,1992;Kenny, 1992; Kozlow & White, 1980; Luiten, 1980; Mayer, 1978,1979; Schmid & Telaro, 1990; Snapp & Glover, 1990; Wittrock, 1974a, 1974b; Wittrock & Carter, 1975).

- Heading and Sentences (e.g., Dee Lucas & DiVesta, 1980; Jonassen, et al., 1985).

- Images vs. Pictures (e.g., Anderson & Kulgavey,1972; Bull & Wittrock,1973; Carrier, et al., 1983a, 1983b; Essen & Hamaker,1990; Pressley, 1976).

- Information Maps (e.g., Ally & SZabo, 1992; Dansereau, et al., 1979; Mayer, et al.,1984; McCagg & Dansereau, 1991; Lenz, 1992; Ragan, 1991).

- Note-Taking (e.g., Bretzing, et al., 1987; Darwazeh,1993; Kiowra & Frank,1988; Peper & Mayer, 1986; Simbo, 1988; Shrager & Mayer, 1989).

- Outlines (e.g., Tuckman, 1993).

- Summaries (e.g., Annis, 1985; Harris,1992; Hooper , dt al. 1992; Spurlin, et al., 1988; Wittrock & Alesandrini, 1990).

- Underlining (e.g., Blanchard & Mikkelson, 1987; Idestein & Jenkins,1972; Rickards & August, 1975).

General Conclusions:

After reviewing the above cited studies on cognitive strategy activators, we found that the generative system is generally more effective in increasing students' learning than the embedded system. At the same time, each system has privileges over the other under certain conditions. In other words, the effectiveness of embedded versus generative cognitive system or vice versa interacts with different instructional varialbles such as, learner characteristics, content characteristics, and levels of learning.

In short, we can state according to the above studies that the Embedded Congnitive Strategy Activators are effective under these condintions:

1- Low and medium ability students (Ausubel & Fitzgerald,1961, 1962; Lenze, 1992; Mayer, 1978, 1979; Schmid & Telaro, 1990; Seretny & Dean, 1986;).
2- Field-dependent students (Carrier, et al. 1983; Kiewra & Frank, 1988;).
3- Un-trained students (Kiewra & Frank, 1988; Simbo, 1988).
4- Organized learning content (DiVesta & Perverly, 1984; Wittrock & Carter, 1975).
5-Familiar learning content (Peper & Mayer, 1986; Sharger & Mayer, 1989).
6- Low and medium levels of learning (Ally & Szabo, 1992; Davey & McBride, 1986; Darwazeh, 1982; Darwazeh, 1988; Jonassen, et al. 1992; Jonassen & Cole, 1993; Jonassen, et al. 1985; Kiewra & Frank, 1988; Lenze, 1992; Manzo, 1970; Peper & Mayer, 1986; Ragan, 1991).

Whereas the Generative Cognitive Strategy Activators are effective under these conditions:

1- High ability students (Annis, 1985; Blanchard & Mikkelson, 1987; Bretzing, et al. 1987; Doctorow, et al. 1978; Lenze, 1992; Wittrock & Alesandrini, 1990).
2- Field-independent students (Carrier, et al. 1983; Kiewra & Frank, 1988).

3- Trained students (Andre & Anderson, 1978-1979; Essen & Hamaker,1990; King,1991; Mayer, et al. 1984; McCagg & Dansereau,1991; Pressley, 1976; Simbo, 1988; Tuckman, 1993).
4- Random learning content (DiVesta & Peverley, 1984; Wittrock & Carter, 1975).
5- Unfamiliar learning content (Peper & Mayer, 1986; Shrager & Mayer, 1989).
6-Low, medium, & high levels of learning (Blanchard & Mikkelson, 1987; Bretzing, et al. 1987; Bull & Wittrock, 1973; Carrier, et al. 1983; Davey & McBride,1986; Dee-Lucas & DiVesta,1980; DiVesta & Perverley, 1984; Dinnel & Glover, 1985; Doctorow, et al. 1978; Duell, 1977; Essen & Hamaker, 1990; Fraze & Schwartz, 1975; Helfeldt & Lalik,1976; Hooper & Rysavy, 1992; Idestein & August, 1975; Jonassen, et al. 1985; King, 1991; Kulhavey, 1972; Manzo, 1970; Mayer, et al. 1984; Peper & Mayer, 1986; Pressley, 1976; Richards & August, 1975; Snapp & Glover, 1990; Simbo,1988; Shrager & Mayer, 1989; Spurlin, et al. 1988;Tuckman,1993; Wittrock & Carter, 1975; Wittrock & Alesandrini, 1990) (See Figure 1).

------Insert Figure 1 about here------

2- Position of cognitive strategy activator Studies:

A good number of studies have investigated the effect of the position of cognitive strategy activators on learning especially by using adjunct questions or advance organizers. The aim of those studies was to see whether pre position is more effective than post position or vice versa, and when. The review of previous studies coverd the following cognitive strategy activators alphapetically:

- Adjunct questions (e.g., Ander, et al.,1980; Anderson & Biddle,1975; Darwazeh, 1982; Felker & Dapra,1978; Frase, 1967,1968; Hedgins, et al.,1979; Memory, 1980; Rickards,1976; Rickards & Hatcher, 1978; Sanders, 1973; Shavelson, et al., 1974).

- Organizers (e.g., Alexander, et al.,1979; Anderson,1973; Bauman, Glass, & Harringtom,1969; Darwazeh,1988; Graber, Means, & Johnsten,1972; Mayer,1978; Simmons, et al. 1988; Woodward, 1966).

- Synthesizer (e.g., Careson & Reigeluth, 1983; Frey & Reigeluth, 1981).

- Pictures (e.g., Carrier, et al., 1983).

General Conclusions:

The major conclusion of the previous studies on pre and post cognitive strategy activators was that the post cognitive strategy activators are more effective in increasing learning than the pre ones. However, each position has privileges over the other under certain conditions. In other words the effectiveness of pre versus post cognitive strategy activators or vice versa interacts with different instructional variables. In short, we can state according to the above cited studies that the pre CSA 's are effective under these conditions:

1- Low ability students (Darwazeh, 1982; Memory, 1983; Sanders, 1973;) .
2- with learning content sequenced from specific to general information (Frey & Reigeluth, 1981).
3- Low levels of learning (Anderson & Biddle, 1975; Andre, et al. 1980; Darwazeh & Riegeluth,1982; Fraze,1967,1968; Rothkopf,1966; Rothkopf & Bisbicos, 1967; Sanders, 1973; Simmons, et al. 1988).

Whereas the post CSA's are effective under these conditions:

1- Medium and High ability students (Darwazeh, 1982; Hudgins, et al. 1979; Richards & Hatcher, 1978; Sanders, 1973).
2- With learning content sequenced from general to specific information (Careson & Riegeluth, 1983; Frey & Riegeluth, 1981).
3- Low, medium, and high levels of learning (Anderson & Biddle,1975; Andre, et al. 1980; Bauman, et al. 1969; Careson & Riegeluth, 1983; Darwazeh & Riegeluth, 1982; Darwazeh, 1988;Fraze, 1967, 1968; Rothkopf, 1966; Rothkopf & Bisbicoa, 1967; Sanders, 1973; Sagaria & DiVesta, 1978) (See Figure 2).

----- Insert Figure 2 about here -----

3- Mode of cognitive strategy activator studies:

The studies on the mode of cognitive strategy activators have manipulated mainly the visual (concrete), versus written (abstract) cognitive strategy activators. The review of previous studies coverd the following cognitive strategy activators alphapetically:

- Advance Organizers (e.g., Barnes & Clawson,1975; Barron,1971; Corkill, et al.,1988; Kenny, 1992; Lucas,1972; Weisberg, 1970).

- Synthesizers (e.g., McLean, et al. 1983; Chao & Reigeluth, 1986; Rigney & Lutz, 1976; Holmes, 1987; Beentjes & Van der Voot, 1992).

- Analogies (e.g., Dean, et al.,1980; Newby & Stepich,1991).

- Maps & Diagrams (e.g., Cha & Dwyer,1991; Lambiotte & Dansereau, 1992; Lambiotte, 199; Winn & Sutherland,1989; Winn, et al., 1991).

General Conclusions:

According to the review of the above studies, we found that using visualized cognitive strategy activators are more effective than using verbal or written cognitive strategy activators. On the other hand, varying the mode of cognitive strategy activators depends on different instructional variables that might interact with the mode. Therefore, the verbal cognitive activators are effective under certain conditions which are different from the conditions that the written cognitive activators are effective under.

Generally, we concluded according to the above results that the visual cognitive strategy activators are effective under the following conditions:

1- Low ability students (Holms, 1987; Winn & Sutherland, 1989; Winn, et al. 1991).
2- With unfamiliar learning content (Lambiotte & Dansereau, 1992; Lambiotte, 1993).
3- Low and medium levels of learning (Barnes & Clawson, 1975; Beenties & Van Voot, 1992; Chao & Riegeluth,1986; Corkill, et al. 1988; Dean, et al. 1990; Holms, 1987; Kenny, 1992; McLean, et al. 1983; Newby & Stepich, 1991; Rigney & Lutz, 1976; Winn & Sutherland, 1989).

Whereas the written cognitive strategy activators are effective under the following conditions:

1- High ability students (Holms, 1987).
2- With familiar learning content (Lambiotte & Dansereau, 1992; Lambiotte, 1993) .
3- High levels of learning (Beenties & Van Voot, 1992 (See Figure 3).

----- Insert Figure 3 about here -----

Discussion

Before discussing the findings of this research, it is worthwhile to bear in mind three important points: 1) the current research was based primarly on a sample but not on all studies that have been conducted on cognitive strategy activators, 2) the findings represent the general trend of previous studies' results which were found in most of the reviewed studies but not in every study, and 3) the findings were organized with respect to three major instructional variables: a- learner characteristics, b- content characteristics, and, c- levels of learning. This organization does not mean that there were no other variables that might interact with cognitive strategy activators. These variables are used just because they were most frequently examined by previous researchers.

Thus, researchers are recommended to take into consideration some other instructional variables in future research such as, learner's level of anxiety (high, medium, or low), learner's level of motivation (high, medium, or low), type of personality (introvert, or extrovert), type of instructional content (facts, principles, concepts, or procedures), type of delivery system (text book, computer, interactive video disc, TV) etc...

1- Ebmedded vs. Generative Cognitive Strategy Activators' System:

The review of previous studies on embedded vs. generative cognitive strategy activators revealed six important results with relation to: 1) learner characteristics, 2) content characteristics, and 3) levels of learning.

1) With respect to the learner characteristics, the results of this research have indicated that the Embedded System (ECS) was effective with low and medium ability students; Field-dependent students, and un-trained students; whereas the Generative System (GCS) was effective with high ability students, Field-independent students, and trained students.

One explanation of these findings could be that, students under ECS are required to manipulate the cognitive activators that have been prepared by teachers. Hence, students in this system are dependent on teachers and expect to receive such activators from them, especially when they don't own the required ability to do this task by themselves (e.g., Darwazeh, 1982; Carrier, et al. 1983, 1984; Drane, et al. 1989). On the other hand, once they receive these activators from a teacher they don't need to be trained in how to generate these activators; because, the teacher is expected to give them ideal ones due to their competence and mature experience in teaching.

But the opposite was true with students under (GCS) in which students are required to generate the cognitive activators by themselves. Thus, students in this system are independent of the teachers and are expected to to do this job by themselves. And because it is not an easy job to do, students need to have a high learning ability or to be trained to do this job. In other words, it is not easy for everybody to generate cognitive activators unless they are capable enough to do it, and have an independent cognitive style. This explanation was supported by Wittrock (Wittrock, 1974) when he proposed and found in his research that highly skilled learners are more likely to possess and spontaneously use generative learning strategies; whereas less skilled learners are more likely to use generative straegies only when directly guided to do so during learning.

2) With respect to the content characteristics, the results revealed that ECS was effective with orgnaized and familiar content; whereas the GCS was effective with random and unfamiliar content. Perhaps, the explanation of these results has to do with learner characteristics. We mentioned above that the high ability students are more able to function under GCS; whereas the low and medium ability are more able to function under ECS. The high ability students are also more able to deal with unorganized and unfamiliar content because of the high learning ability they own. And the organizational skill is one of those special abilities that the distinguished students do have, so they can apply it in organizing random and unfamiliar content; whereas the low and medium ability students are most of the time lacking in such skills, thus, they can not deal with random and novice content as well as the high ability students can do (Carter & Wittrock, 1975, Doctorow, Wittrock, & Marks, 1978; DiVesta & Peverly, 1984; Lambiotte & Dansereau, 1992; Sharger & Mayer, 1989).

3) Considering the levels of learning, the results also revealed that ECS was more effective in promoting low and medium levels of learning; whereas GCS was more effective in promoting all levels of learning: low, medium, and high. The major explanation for these results could be that the students under ECS receive the prepared cognitve activators from the teacher and are required to manipulate them only, thus, their role during learning is supposed to be passive; whereas students under GCS are required to generate and manipulate cognitive acitvators, thus, their role is expected to be active. Therefore, it is obvious that students' involvement in generation activity makes them process the content information on a semantic and deep level of learning; whereas students who are not involved in such activities and just receive prepared cognitive activators instead, are not expected to process information deeply, and, to retrieve it on high levels of learning.

This rationale was supported by several researcher studies suchs as, Dinnel & Glover, 1985; Peper & Mayer, 1986; Shrager and Mayer, 1989; Weinstein & Mayer, 1985. They agreed that as long as students are getting actively involved in learning activities, they will proccess information on a deep leve. of learning.

2- Pre vs. Post Cognitive Strategy Activators's Position:

The review of previous studies on pre vs. post cognitive strategy activators have also revealed important results with its relation to: 1) learner characteristics, 2) content characteristics, and 3) levels of learning:

1) With respect to the learner characteristics, the results of this research indicated that pre cognitive activators were more effective with low ability students; whereas post cognitive activators were more effective with medium and high ability students.

One explanation for this finding is that the selective attention function of pre cognitive activators is more important for low ability students than for medium or high ability students; whereas the memory refreshing function of post cognitive activators is more important for high ability students than for low ability students (e.g., Frase, 1967; 1968; Darwazeh, 1982; Hudgins, et al, 1979; Memory, 1983). It could be that, without selective attention, low ability students cannot remember important information presented in the passage. High and medium ability students, on the other hand, can remember most of the important information without the aid of selective attention aids, as they are good readers and have a better background in learning content. Therefore, the high and medium ability students profit more from a memory refresher, which the post cognitive activators provide.

2) with respect to the content characteristics, the findings of this research revealed that pre cognitive activators were more effective with a content sequenced form specific to general information; whereas the post cognitive activators were more effective with a content sequenced from general to specific information.

One explanation of these results could be that when instruction begins at the most detailed level, learners need to start with a synthesizer that is represented in the cognitive activator to provide context for each detailed concept. On the other hand, when the instruction is arranged in a general-to-detailed sequence, it would appear that the most general concepts themselves provide the context for the subsequent concepts, such that students do not benefit from a pre CSA as an initial overview of the set of concepts (e.g., Frey and Reigeluth, 1981; Sanders, 1973). Conversely, in the general to detailed sequence, students appear to need a synthesizer that is representd in the cognitive activator at the end of the instruction to review the relationships among the concepts.

3) With respect to levels of learning the findings also revealed that pre cognitive activators were more effective in promoting low levels of learning such as memory, intentional, or direct levels; whereas post cognitive activators were more effective in promoting high, incidental, or indirect levels of learning. One explanation of this finding, as was supported by Darwazeh & Reigeluth (1982); Andre, et al. (1981) in their experiment No.1); Anderson & Biddle (1975); Rothkopf & Bisbicos (1967); Sanders (1973) is that pre cognitive activators serve as a method of of arousing " selective attention". Hence, while reading the passage, the learner will focus attention on those thoughts and ideas which are related directly to the pre-cognitive activators and will neglect the ideas and thoughts which are not related to the pre CA. However because post CA comes after the passage, they cannot serve as a selective attention function; rather they can only serve to refresh the learner's memory within and beyond the frame of the passage, that is they reinforce intentional and incidental levels of learing (e.g., Andre & Womack, 1978; Darwazeh & Reigeluth, 1982). Well, further future studies are recommended on this issue.

3- Visual vs. Written Cognitive Strategy Activators:

The review of previous studies on visual vs. written cognitive strategy activators have revealedthe following findings:

1) With respect to learner characteristics, the previous studies revealed that visual (concrete) CSA'S were more effective with low ability students; whereas the written (abstract) CSA's were more effective with high ability students (e.g., Holmes, 1987; New & Stepich, 1991; Winn & Sutherland, 1989; Cha & Dwyer, 1991). The most reasonable explanation for these findings could be that, students using the visual CSA's, depend on more than one sense to manipulate them. They could use pictures, graphic organizers, maps or other concrete CSA beside reading the passage. Thus, using more than one sense while manipulating the CA will lead to a better understanding, hence to better learning. In addition, using visual or concrete CSA will

simplify the complicated ideas that are presented in the passage. Therefore, this will help low ability students in particular, who lack of the ability to deal with complex and abstract CSA'S like the written ones, more than high ability students who have the ability to deal with complex and abstract.

On the other hand, visual CSA's usually summarize the content and its relationships and present them in figures, diagrams, maps, trees, flow charts, etc.. This would help low ability students, who find it difficult to skim the content and see its relationships, to pay attention to the essentioal ideas, hence to understand the learning content. The opposite is true in the case of using written CA which use the narrated language for this purpose. Therefore, only the high ability students, who can deal with the abstract language, can befifit from this kind of activators.

2) With respect to the content characteristics, the general trend of previous studies' results revealed that the visual CSA's are more effective with unfamiliar content; whereas the written CSA's are more effective with the familiar ones (e.g., Winn & Sutherland, 1989; Lambiotte & Dansereau, 1992, Lambiotte, 1993). According to our above explanation, two characteristics of visual CSA are, the concreteness and clearness. Such characteristics are expected to make the unfamiliar content familiar, hence, more manageble and understandable. In contrast, two characteristics of a written CSA are abstraction and complex. Such characteristics are not expected to make the content familiar, manageble, or understandable, because, these CSA's need some clarification themselves. So, Students in this case would not get the optimal benefit from such activators unless they were intelligent enough to deal with the abstract and symbolic CSA's. Thus, further experiments are recommended on this matter.

3) Finally, with respect to the levels of learning, the research revealed that the visual CSA's are likely to be more effective in promoting low or sometimes medium levels of learning; whereas the written CSA's are likely to be more effective in promoting high levels of learning (e.g., Corkill, et al. 1988; New & Stepich, 1991). The results make sense in terms of the level of processing that the CSA's needed. The visual CSA's most of the time are simple, concrete, and clear, so, they are easier to be understood without the need of deep thinking. On the other hand, the written CSA's most of the time are complex, abstract, and not clear, so, they need from the students a great deal of attention and deep processing of information in order to manipulate and understand them . The deep processing mostly leads to a high level of learning such as application and problem solving, (or incidental levels); whereas the shallow processing of information mostly lead to a shallow level of learning such as remember (or intentional levels). So, this could be a reason that the visual CSA's promote low or medium level of learning; whereas the written CSA's lead to a high level of learning. Further experiments are recommended on this matter too.

Research Implemention

The research findings havean important implemention for designing instruction based on cognitive strategy activators.

The implemention of this research is represented in proposing two prescriptive models for designing instruction. These two models depend basically on Dick and Carey's model for designing instruction (Dick & Carey, 1990). The first model is for embedded cognitive strategy activators, and the second model is for generative cognitive strategy activators. These models are recommended to be used by teachers when they plan for every day teaching, and by instructional designers and developers when they design schools' curriculum, computers' programmes, or business projects. These models will be discussed from four angles: 1) Rationale of creating such models, 2) their outcomes, 3) method, and 4) conditions.

1- Rationale:

The Science of Instructional Design became prosperous in the last two decades in different countries of the world. Accordingly, instructional designers have done a great job in designing instruction based on the principles of instructional design science (e.g.; Briggs, 1977; Briggs & Wager, 1981; Darwazeh, 1986; Dick & Carey, 1990; Gagne, Briggs, & Wager, 1992; Mirrell, & Tenyson,1977; Reigeluth,(Ed.) 1983; Snelbeker,1974; Wager, et al. 1990). But still, the cognitive strategy activators are not considered in their models.

Recently, there was an attempt by West and his colleagues to specify a template for designing instruction based on cognitive science principles (West, Farmer, & Wolf, 1992, pp. 209-263) but still they did not specify a clear procedure on how to design instruction with a consideration of cognitive strategies.

Therefore, the major purpose of the current research is to propose two prescriptive models for designing instruction: one model is for Embedded CSA's, and the another model is for Generative CSA's. I believe that without considering the embedded and generative cognitive strategy activators while designing instruction, the learning and instructional process will be incomplete specially in this decade which is accompanied by cognitive revolution in the field of psychology. Stimulating students' cognitive strategies has become a very important issue for enhancing and accelerating their learning.

2- Outcomes:

Using embedded or generative cognitive strategy activators under certain conditions will help learners, teachers, devolopers, and instructional designers to do the following:

a) For Learners:

1- Stimulate their cognitive strategies and use them properly during learning.
2- Focus attention on the content of instructional materials, hence increase their level of motivation to learning.
3- Input, process, and output information effectively.
4- Create linkages between the existing knowledge and the new one, and between the ideas in the text itself, hence making the content more manageble and understandable.
5- Simplify complicated information to be learned, and make it more managable, and understandable.
6-Process information on deep (or high) level of learning, hence to store it in long term memory.
7- Retrieve information for later use specially for problem solving either for solving academic or persoal problems.

b) For Teac[illegible], Developers, and Instructional Designers:

1- Design instruction comprehensively and integrated.
2- Compensate the defect in teaching method, if any, specially for novice teachers.
3- Compensate the defects in the organization of the learning content (i.e., incoherent, unfamiliar, or random content) and make it coherent, familiar, and organized as much as possible.
4- make the learning content more interesting.
5- Promote learning on high levels rather on low levels.
6- Enhance the quality of instructional process generally.

3- method (how to use):

1- Establish overall goals (ECS & GCS models).

2-Conduct content analysis and determine its characteristics. Is it organized or unorganized; familiar or unfamiliar; sequenced from specific- to-general or from general-to-specific information; containes mainly concepts, principles, procedures, or facts; long content or short one, or what I determine (ECS & GCS models).

3- Conduct learner analysis and determine if they are above average, average, or below average; field-dependent or field-independent; high motivated or low motivated; trained or untrained learners, or what I (ECS & GCS models).

4- Identify the level of performance that you want students to demonstrate after instruction. Is it a knowledge (low) level, or comprehension (medium) level, or application, analysis, synthesis, problem solving, evaluation (high) level of learning, or what I determine (ECS & GCS models).

5- Develop test items for measuring each level of performance that you have determined (ECS & GCS models).

6- Develop or select instructional materials and mass media that are suitable for teaching the determined learning content (ECS & GCS models).

7- Develop instructional strategies for teaching each component of the content that you have determined (ECS & GCS models).

8- Develop cognitive strategy activators to be used (ECS model).

9- Develop directions or a training program for generating cognitive strategy activators (GCS model).

10 - Determine the kind of cognitive strategy activators to be used. Is it adjunct questions, advance organizers, note-taking, pictures, outlines, stories, underlining, etc... or what ! (ECS & GCS models).

11- Determine the position of the cognitive strategy activators to be used. Is it pre, during, or after the passage ! (ECS & GCS models).

12- Determine the mode of cognitive strategy activators to be used. Is it concrete or abstract, audio-visual or written ! (ECS & GCS models).

13- Design and conduct formative evaluation (ECS & GCS models).

14- Revise instruction according to the results of formative evaluation (ECS & GCS models).

15- Design and conduct summative evaluation (ECS & GCS models).

------Insert Figure 4 about here------

4- Conditions (When to use):

1- Use (ECSM) if you deal with low or medium ability students; otherwise, use the (GCSM) when you deal with high ability students.

2- Use (ECSM) if you have students charactarized by field-dependent cognitive style; otherwise, use (GCSM) when you have students charactarized by field-independent cognitive style.

3- Train Students if you use (GCSM) only, unless students under (ECSM) faild to manipulate the given cognitve activators.

4- Use (ECSM) if you deal with organized content of learning; otherwise, use (GSM) when your deal with unorganized or random content of learning.

5- Use (ECSM) if you deal with familiar content of learning; otherwise, use (GCSM) when you deal with the unfamiliar.

6- Use (ECSM) If you want learning to occur on low or medium levels; otherwise use (GCSM) when you want learning to occur on all levels of learning (Go back to Figure 1).

7- Under (ECSM), Use pre-cognitive strategy activators if you deal with low ability students; whereas use post-cognitive activators when you deal with either medium, or high ability students. But under (GCSM), use cognitive strategy activators during or after the passage, with any level of students ability specially with high abilities, and for any level of learning specially for high levels.

8- Under (ECSM), use pre-cognitive strategy activators if you have a content sequenced from specific to general information; whereas, use post-cognitive strategy activators if you have a content squenced from general to specific information. But under (GCSM)use the cognitive strategy activators during or after the content with any type of its sequence.

9- Under (ECSM), use pre-cognitive strategy activators if you want learning to occur on low levels such as remember, intentional, or direct learning; whereas use post-cognitive activators if you want learning to occur on all levels of learning such as comprehension, application, analysis, synthesis, evaluation, problem solving. But under (GCSM) use during or post-cognitive strategy activators for promoting any level of learning specially for high levels (Go back to Figure 2).

10- Use visual (concrete) cognitive strategy activators if you have low ability students, whereas use written (abstract) cognitive strategy activators if you have high ability students (ECS & GCS models).

11- Use visual (concrete) cognitive strategy activators if you have unfamiliar content, whereas use written (abstract) cognitive strategy activators if you have familiar content (ECS & GCS models).

12- Use visual (concrete) cognitive strategy activators if you want learning to occur on low or medium levels, whereas use written (abstract) cognitive strategy activators if you want learning to occur on high levels (ECS & GCS models), (Go back to Figure 3).

Recommendations

Considering the importance of cognitive strategy activators in promoting and enhancing students' learning in particular, and teachers' teaching in general; the potential for continuing and extending research on the effects of generative activities is very crucial. Given past research results, several suggested studies are recommended on cognitive strategy activators to compensate the shortage in the previous studies. Future studies are recommended to manipulate the folloing issues:

1- Comparing ECS's with GCS's by using other kinds of cognitive activators that were rarely used in the past, such as: abstracts, objectivs, stories, analogies, synthesizers, and mnemonic devices (Carney, et al., 1988; Pressley, et. al., 1976).

2- Using posttest measuring high levels of learning such as analysis, synthesis, evaluation, and discovery levels beside the remember and comprehension levels (Bloom, 1956).

3- Using different lengths of learning content : short, medium, and long content (Reigeluth, 1981).

4- Using different modes of cognitive strategy activators such as abstract vs. concrete; audio vs. visual vs. written.

5- Using different learners characteristics such as high anxiety, low anxiety, high motivated, low motivated. Plus, using subjects in different stages of education such as kindergarten, elementary, middle, secondary, and graduate stages.

The aim of experimenting on such issues is to help researchers, hence, instructional designers to specify more conditions for using the cognitive strategy activators. Therefore, they can modify or add to the above suggested models whenever necessary.

Summary:

The research tried to accomplish three ends:
1) give definitions and clarifications on cognitive strategy activators in terms of their system, positions, and modes.

2) Summarize a sample of the previous experimental and theoretical studies which were conducted between 1960's - 1990's on cognitive strategy activators in terms of their systems, positions, and modes, and with their relation to three instructional variables: a- learner characteristics, b- content characteristics, and, c- levels of learning.

3) Propose two instructional design models based on cognitive strategy activators: one for embedded cognitive activators in which teachers, developers, or instructional designers are expected to take the major role in generating the cognitive activators, and the other model for generative cognitive activators in which learners are expected to take the major role in generating such activators.

These two proposed models are expected to lay a foundation of a theory on how to desgin instruction with a consideration of cognitive strategy activators. At the same time, they are considered as an invitation for researchers to conduct more studies on this subject, with the aim of increasing the validity of those models which was extracted from previous studies, hence, to modify and add to them whenever necessary.

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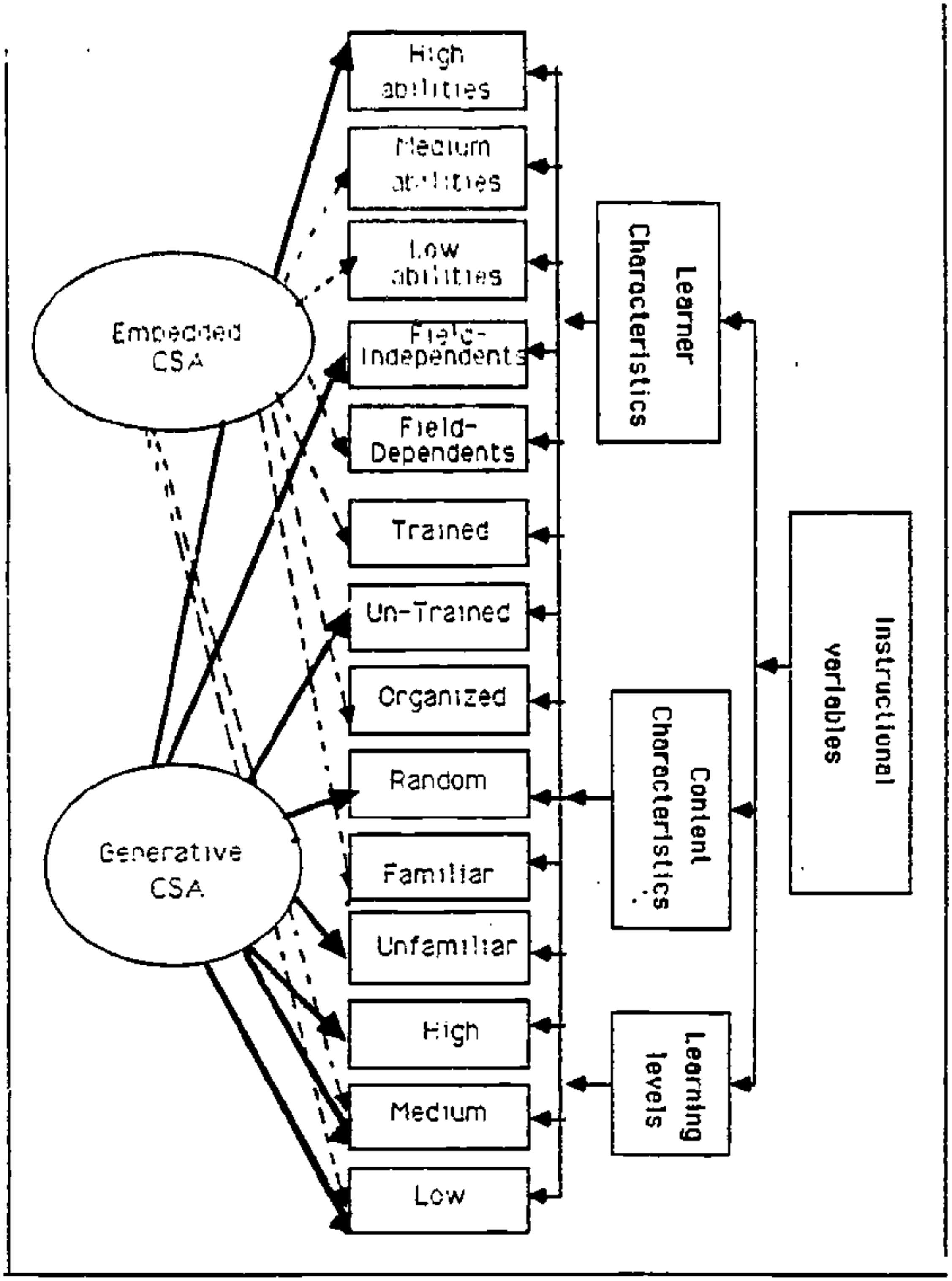

Figure 1 Conditions for using Embedded versus Generative Cognitive Strategy Activators (ECSA vs. GCSA).

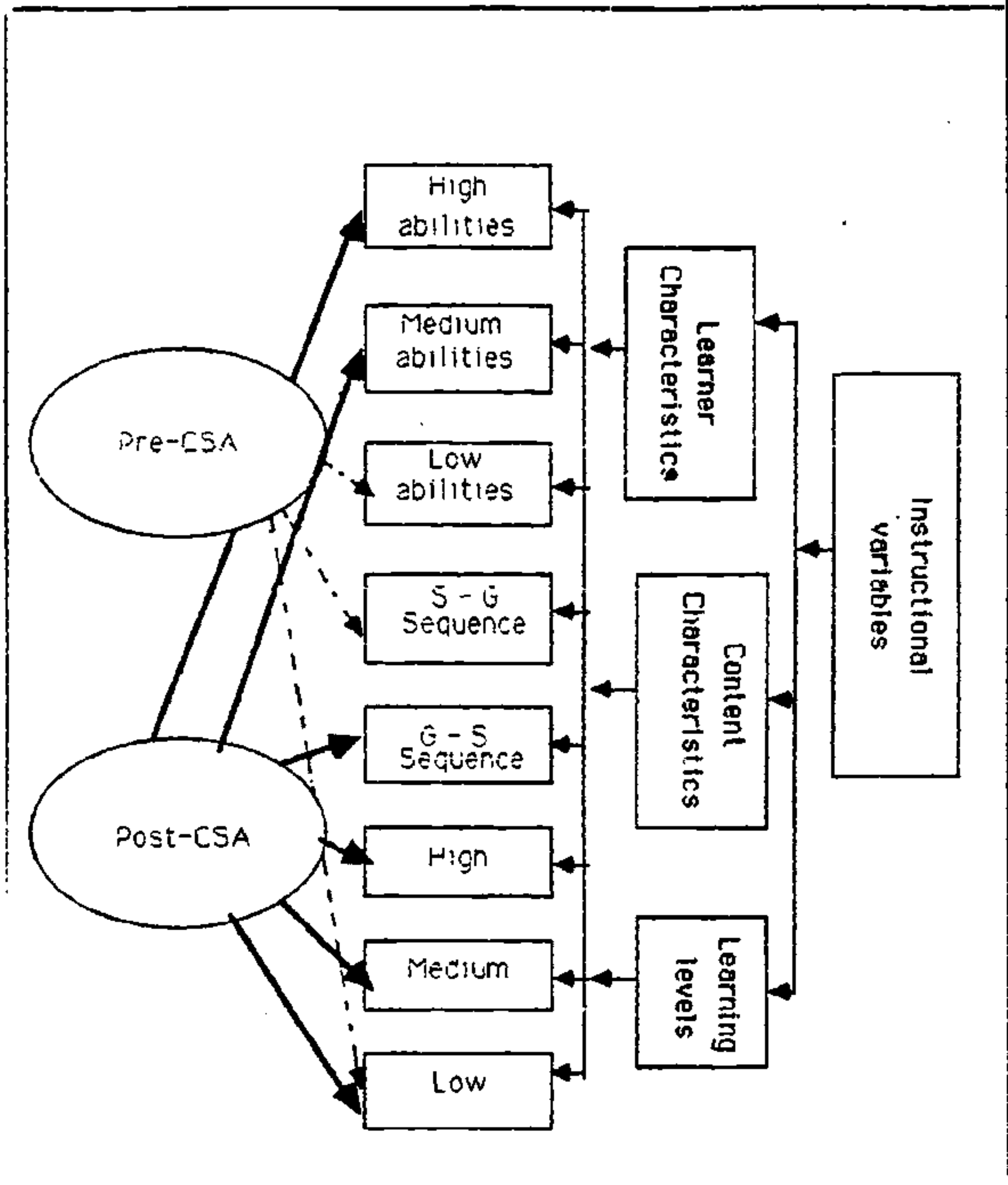

Figure 2. Conditions for using Pre- versus Post-Cognitive Strategy Activators (Pre-vs. Post-CSA).

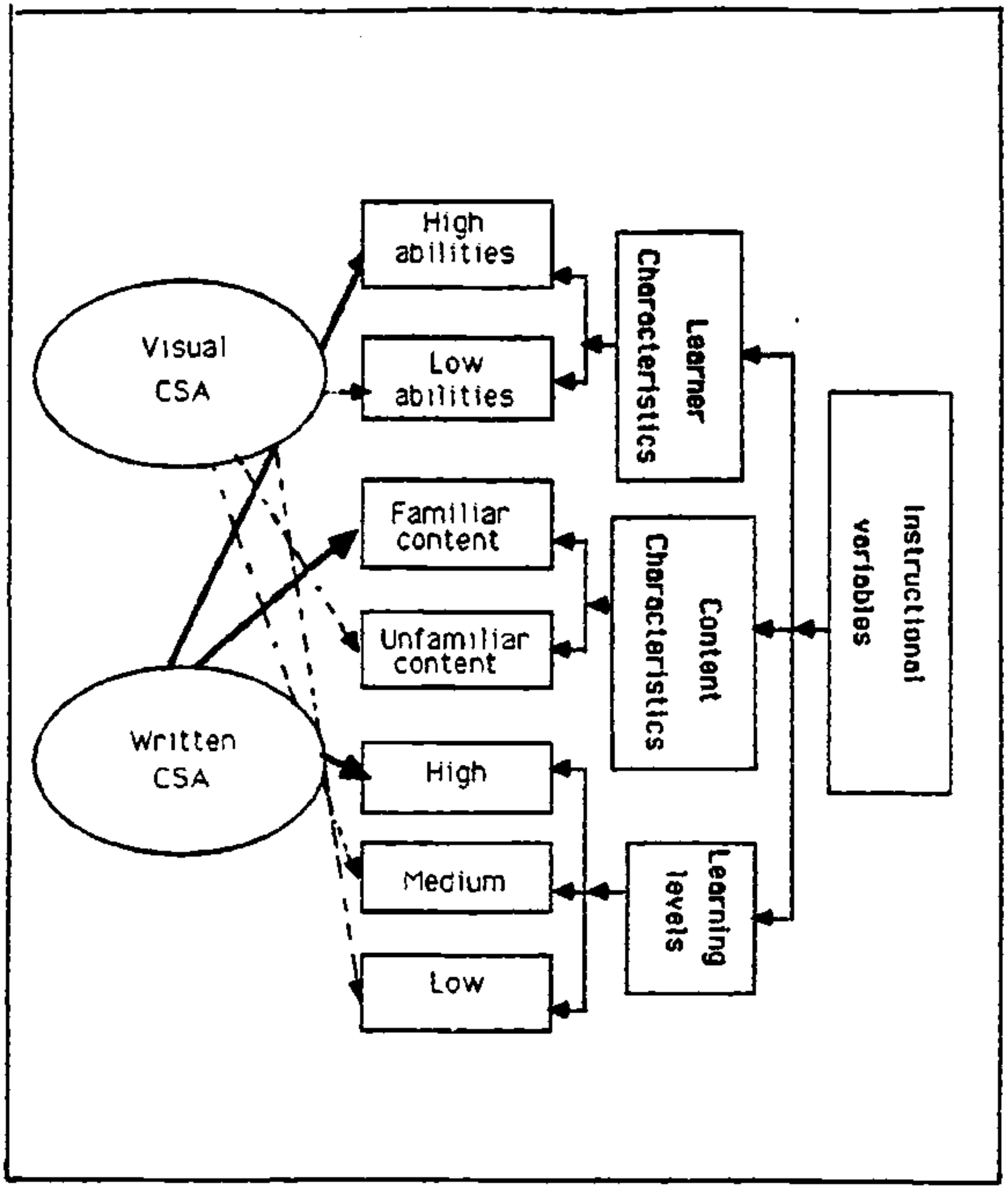

Figure 3. Conditions for using Visual versus Written Cognitive Strategy Activators

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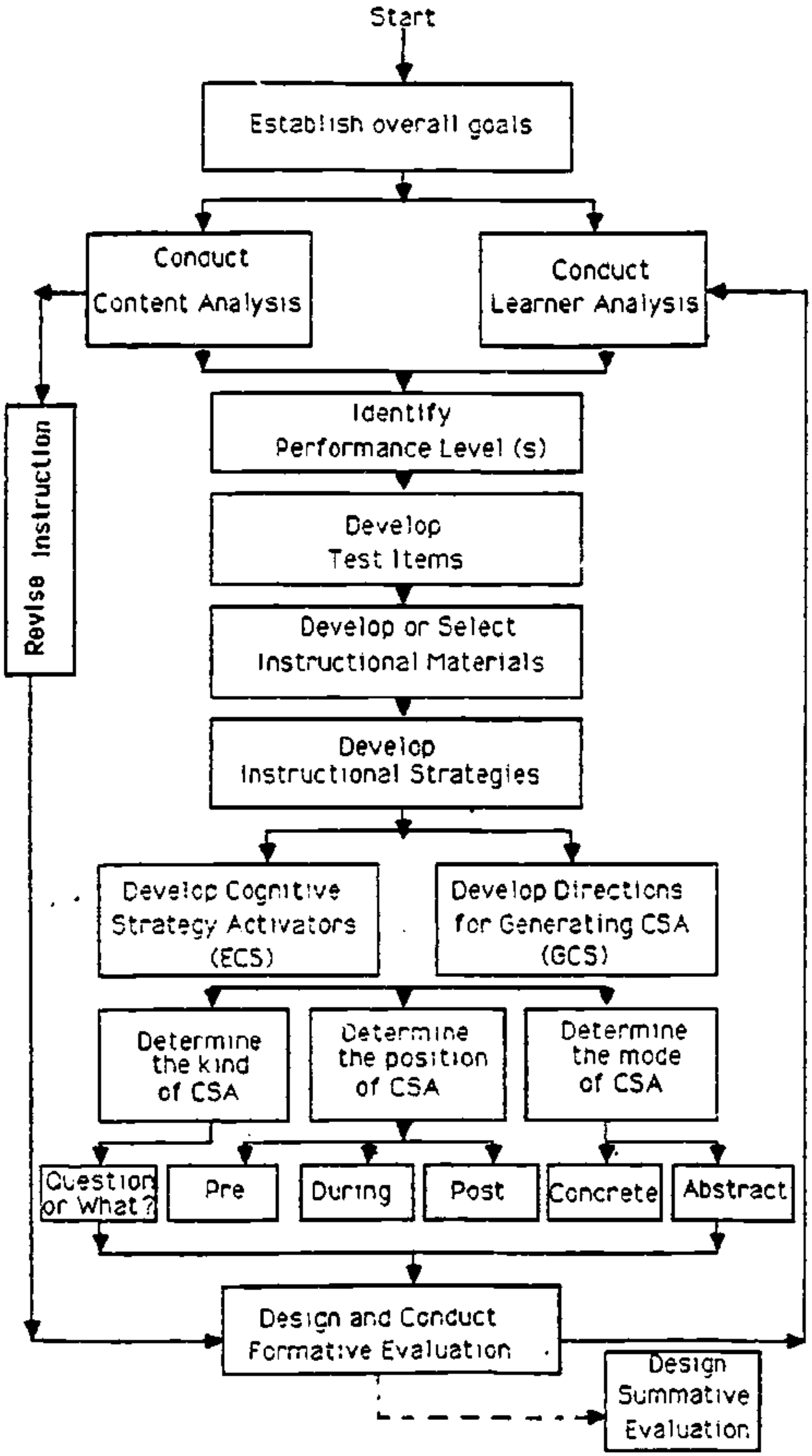

Figure 4 The instructional design model with a consideration of cognitive strategy activators

Title:

An Analysis of a Computer Assisted Learning System: Student Perception and Reactions

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An Analysis of A Computer Assisted Learning System: Student Perception and Reactions

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Abstract: Within Mathematics of Finance classes at the Smeal College of Business Administration at Penn State University, lectures are developed using Asymetric's Toolbook and are presented via a computer system. This approach was implemented because it has the potential to effectively convey concepts that are ordinarily difficult to communicate to large classes of students. For example, the class can input arbitrary interest rates and instantly see their effect on other variables.

In the fall semester of 1992, an analysis was conducted on a class of 58 junior level Actuarial Science students. The methods used to make this analysis were to video record all class lectures with two video cameras. One camera focused on the students and collected their physical reactions such as facial expressions and body movements and the second camera recorded images projected by the computer system. Students also received a pre and post attitude survey to collect their perception of the computer-assisted lectures.

The Smeal College of Business Administration at the Penn State University continues to investigate the potential of computer-assisted learning systems. Within Mathematics of Finance classes, lectures are developed using Asymetric's Toolbook and are presented via a computer system. This approach was implemented because it has the potential to effectively convey concepts that are ordinarily difficult to communicate to large classes of students. For example, arbitrary interest rates can be fed to the system and students can instantly see a visual representation of their effect on other variables. The instructor can ask questions and input student responses and electronically graph the result during lectures to help monitor the classes' attentiveness or understanding of the material. This approach adds additional dynamics to lectures and assignments.

While it seemed, from an instructor perspective, that the computer-assisted learning approach could positively impact classes, it was unclear as to how students would react to it. A pilot study was therefore conducted to collect student perceptions and reactions to this instructional approach. The objectives were to make an initial assessment of the computer-assisted lecture delivery format; to collect student reactions to this delivery format; and to investigate the potential of video recording as a method of data collection because, among other things, videotaping has been used extensively for subject observation with substantial benefits reported (Baum & Gray, 1992).

Methods

In the fall semester of 1992, an analysis was conducted on a class of 58 junior level Actuarial Science students. In previous years, the general characteristics of the classroom were as follows: each student had a copy of the professor's typed notes upon which they wrote comments; the professor knew each student by name; an attempt was made to call upon each student at least once each class to respond to question related material; and an important part of each lecture was explaining concepts to the "man on the street." The change this semester was that lectures were presented via a computer systems using Toolbook.

There were two methods of analysis used. One method was to video record all class lectures. For video recording, the researchers used two cameras. One camera focused on students to collect their physical reactions such as facial expressions and body movements and a second camera recorded the visual images projected by the computer system. The researchers later combined the video signal so that physical reactions could be seen simultaneously with what was projected electronically by the computer. Thirty-two 75 minute class lectures were recorded of which 7 are examined in this paper. For analysis, non-verbal communications as well as classroom interactions were examined relative to the delivery format.

The second method used to assess the impact of this technology was an attitude survey. In week one of class, students were given an introduction to computer-assisted lectures and informed that throughout the course, lectures of this type would be given. At the end of the first week, students received a pre-attitude survey .

A post-attitude survey, identical in nature to the pre-attitude survey, was given in the last week of class. The researchers compared surveys to observe if any differences occurred in attitude toward the computer-assisted lectures from the beginning of the semester to the end.

Each survey presented statements to which respondents rated their reactions on a 9 point scale from 0 to 8. The scale ranged from Strongly Agree (0 points), to Indifferent (4 points), to Strongly Disagree (8 points). Of the 58 students who completed a pre-attitude survey, only 31 completed a post-attitude survey. The analysis of survey data is, therefore, based on 31 respondents.

Results & Discussion

Videotaping method

Video recording class lectures appears to have potential merit in monitoring student reactions to new technological approaches in the classroom. The video medium provided a permanent record of students and how they responded to the computer-assisted lectures. Numerous observations could be made specifically about the technology, as well as the class in general, and these observations could be reviewed repeatedly and verified by others.

Video recording lends itself to the collection of large amounts of various kinds of data, which requires more time, effort, and resources to analyze. The advantages of this technique relative to cost need to be more thoroughly investigated. At present, however, the video recording approach as presented in this study appears to be an effective method for identifying student reactions to computer-assisted lectures.

Videotaping results: classroom interaction

For this analysis, tapes from five class sessions were reviewed. The researchers look at the following classroom interactions:

- areas to which the majority students directed their attention (e.g., professor's typed notes, the professor or the projected image) in response to the computerized lectures;
- areas to which the majority students directed their attention in responses to type of visual images projected (e.g., graphs).

Computerized lectures can, in many cases, take significantly longer to develop than traditional lectures. Because of this time and labor intensiveness, it is important to ensure that the visual information projected effectively cues students and is useful to them. By making observations, the researcher hoped to improve the presentation material by identifying screens designs which caught student attention and designs to which students responded favorably.

To determine whether or not screen designs effectively cued student attention, the researchers counted each time the majority of students look up or looked down in response to what was projected by the computer. Four categories were created:

1. No visual and looking up
   The number of times the majority of students were looking up when no visual was projected by the computer.

2. No visual and looking down
   The number of times the majority of students were looking down when no visual was projected by the computer.

3. Visual on and looking up
   The number of times the majority of students were looking up when a visual was projected by the computer.

4. Visual on and looking down
   The number of times the majority of students were looking down when a visual was projected by the computer.

If the purpose of presenting visual information via a computer system is to promote, in some way, student understanding, then it becomes important to ensure that the visual effectively conveys its meaning and that students attend to it. The primary reason, therefore, for identifying these categories was to determine, in a general sense, if students viewed the visual information when it was presented. The highest incidences occurred in the visual on and looking down category (see Table 1).

Table 1
Response to Visuals: Attention Areas

	Class 1	Class 2	Class 3	Class 4	Class 5	Total
No visual & looking up	15	0	12	1	3	31
No visual & looking down	10	0	7	13	0	30
Visual on & looking up	9	15	2	19	13	58
Visual on & looking down	16	14	8	22	18	78

This means the there were 78 incidences when the majority of students were looking down for the period of time when the visual was projected. It should be pointed out that students had the professor's typed notes with which to follow the lecture. Thus, it is to be expected that they would page through these notes while the concept was discussed. Oftentimes the professor talked through visuals using the computer mouse to point out key areas and formulas. Frequently during this time, a large portion of the class referred to the professor's notes and paged back and forth through them. It appeared that, among other things, the notes enabled students to bring together additional information that may or may not have been presented on screen. The reliance on the notes seems to provide an additional means by which students individually verified the presented information and or came to understand it.

Given the value of the projecting visual information for the entire class to view and the way in which students, during class lectures, utilized the professor's typed notes, it is difficult to assess the effectiveness of screen designs. A future inquiry might include a control group which is presented the visual information unaccompanied by the professor's notes to more accurately identify student reactions.

Videotaping results: reactions to visual types

The researchers wanted to identify the types of visuals (text, animated graphs or tables) which most effectively cued student attention. It appeared that students looked down or took notes when visuals containing text and formulas were presented. On most occasions, however, when the professor presented graphs containing animations, students looked up. Two reasons are suggested this observation. First, the professor's typed notes contained formulas and replicated what was present on screen and thus there may have been no need for students to look up. They could easily follow the professor by looking at his typed notes. Second, unlike text and formulas, animated tables and graphs can not be duplicated on paper. Animation may have received more attention because of its distinctiveness. Animation as an attention gaining device can be effective since attention is influenced by unique stimuli. Possibly, animating tables and graphs was unique enough to gain students' attention.

General observations:

Video recording made additional observations about the class possible and some of these observations are presented below.

- For five of the class sessions, the number of student initiated interactions with the professor were recorded. Each time a student commented or asked a question, it was considered an interaction. If a student, for example, asked a question and then followed up immediately with a second question, then it was counted as one interaction. There were 83 occurrences when students initiated interaction with the professor, 32 of which were initiated by males and 51 by females. Such information may prove useful to the professor since classroom interaction among all students was highly encouraged.

- Cueing students with key words is attention getting. Students, as observed in this study, spent much time following along with paper handouts and often ignored what was projected on screen. For example, when the professor said, "I have a picture here." students looked up, and on subsequent occasions the word "picture" appeared to get their attention.

- Much can be gained from observing students and watching their body language and reactions. In some cases an observer can readily tell when students do not understand or are confused (Alessi & Trollip, 1985). Throughout the course the professor constantly challenged students by posing questions. Students often displayed behaviors like smiling or looking downward when they did not know the answer. It was also clear by viewing the video tapes when more than one student was having difficultly with a concept or question. In such cases students looked to one another, shook their head or made a facial expression.

Attitude Survey Results

On a survey, subjects ranked the number of computer courses they had completed on a 10-point scale ranging from 0 to 9 or more completed courses. Completed computer courses was used as a measure of computer knowledge (Rattanapian, 1992). The researchers obtained this measure to determine if knowledge about computers influenced perceptions of the lectures. On average, students completed 2 computer courses. Figure 1 shows the percentages of respondents by number of courses completed.

Courses Completed

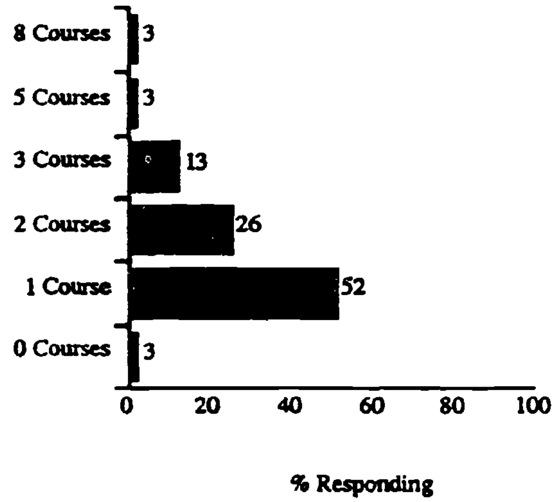

Figure 1. *Computer Courses Completed*

Given the proliferation of technology in today's classrooms and the use of computers to present information electronically, the researchers sought to identify the extent to which students in this class had been exposed to computerized lectures. On the pre-survey, students ranked their experience and on average reported having no experiences with the lecture format. (see figure 2).

Experience Level

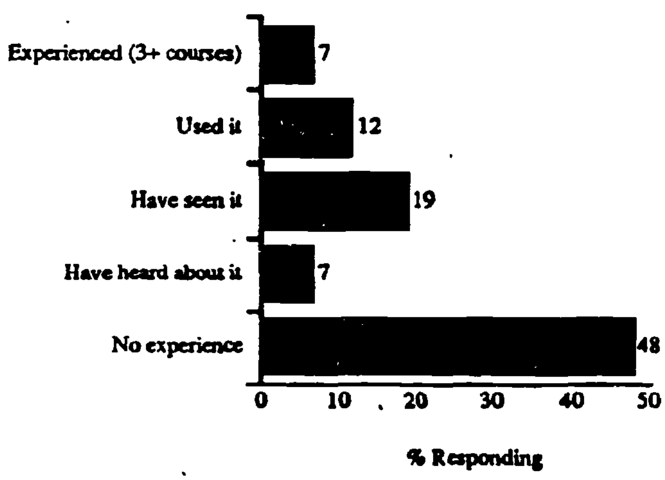

Figure 2. *Experience with Computer-Assisted Lectures*

Despite the lack of exposure, students anticipated that the computer would not make lectures more complex (see figure 3). On the survey, for example, students were asked if they thought the computerized lectures would be easy to follow. Responses to this item were positive and this perception remained constant from the pre to the post survey.

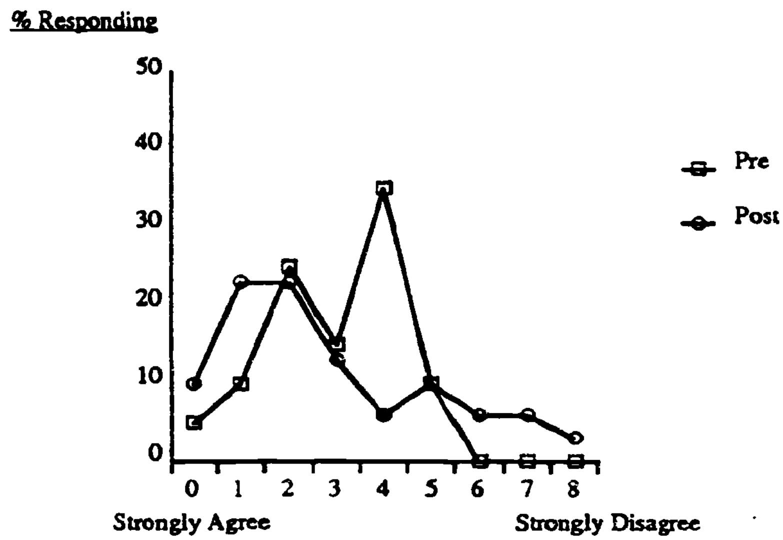

Figure 3. *Lectures were easy to follow pre and post surveys*

Students anticipated that the lectures would be informative (see figure 4). On the survey, students were presented the following item, "Computer-assisted lectures will be informative." Responses tended to be on the positive side and this perception remained constant throughout the semester.

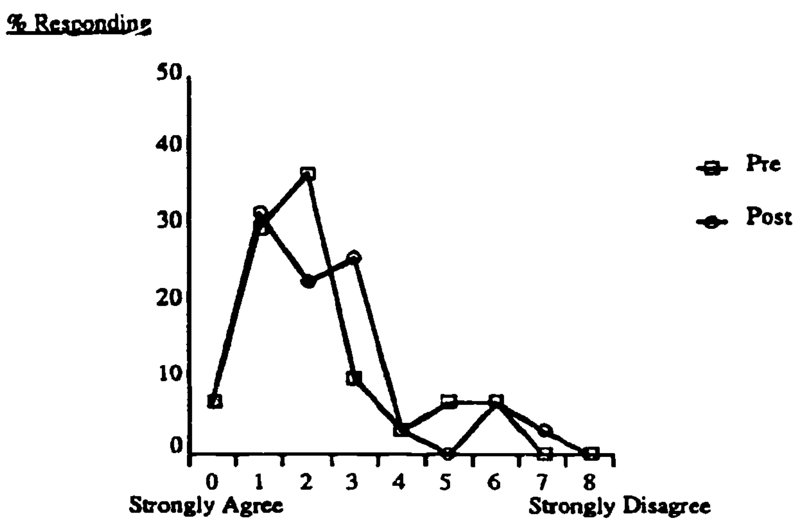

Figure 4. *Lectures were informative pre and post surveys*

Computer familiarity and attitude

Classroom computers are neutral in design but lack neutrality often times in the way they are used (Jones, 1987) and perceived. Males, for example, have been found to readily express interest in computers while females are less likely to do so (Miura, 1987). Students in this study had varying levels of computer expertise ranging from novice to experienced users. The researchers were interested in determining if computer familiarity effected (positively or negatively) students' attitude toward lectures. As a measure of familiarity, number of computer courses completed was used based on the assumption that some familiarity with computers is required with course completed. Familiarity did not appear to negatively bias students' opinion of lectures and in fact, students appeared to look forward to the teaching format.

At the beginning of the semester, in the pre-attitude survey, students were asked if they thought the lectures would dramatically impact the way in which the course was taught. Responses, examined in terms of computer familiarity, show that for some respondents the perceived degree of impact of the computerized lectures decreased as the number of computer courses completed increased (see figure 5). Thus, those having completed more computer courses felt that the computerized lectures would have less of an impact than those with fewer courses. This may suggest that those with more courses completed understand the technology and its limitations to a greater extent than those with fewer courses. It should be pointed out, however, that only 7 students completed more than 3 courses and the majority of respondents completed fewer than 2 courses. From such a small sample, it is difficult to assess whether or not this trend would persist for larger populations.

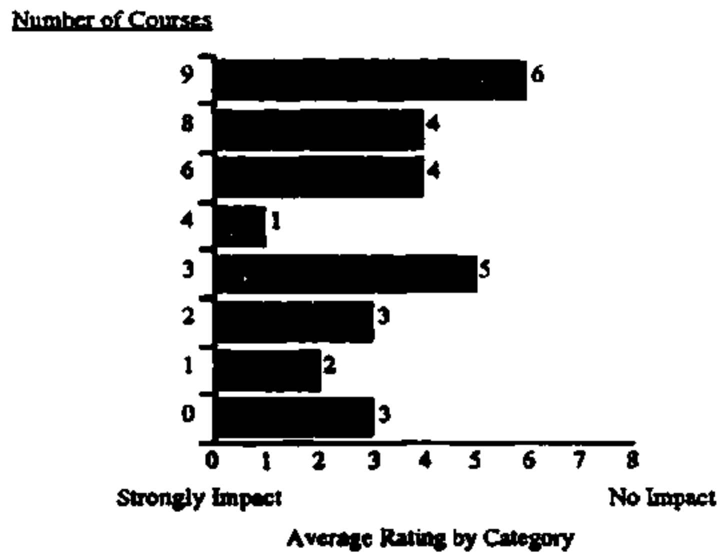

Figure 5. *Perceived Impact by Number of Computer Courses*

On the pre-attitude survey, students indicated whether or not they would feel comfortable being taught with computerized lectures. For this analysis, there were 15 out of the 32 respondents who had completed fewer than 3 computer courses and they indicated that they would feel comfortable being taught with computerized lectures (see figure 6). Of these 15 respondents, fewer computer courses completed coincided with favorable ratings. There appeared to be a tendency for those who had completed fewer courses to indicate that they would feel comfortable being taught with computerized lectures. Again, because of the lack of distribution of students across the different levels of courses completed, it should not be concluded that those with more familiarity would feel uncomfortable being taught with computerized lectures. On the post-survey, attitudes toward being comfortable with computerized lectures seemed to even out.

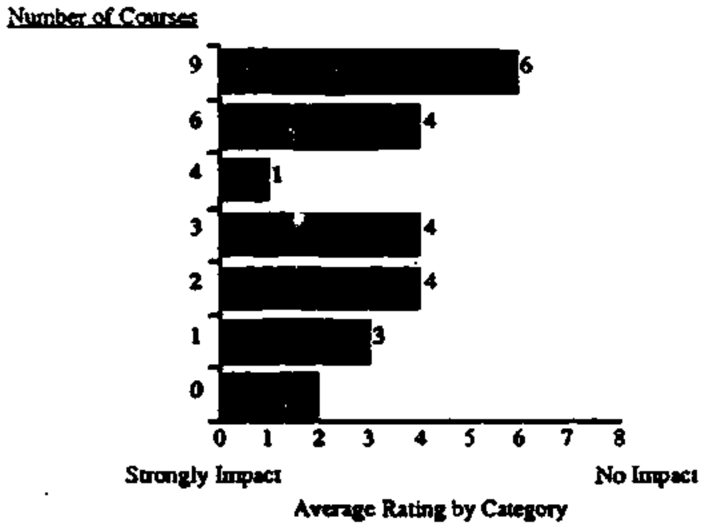

Figure 6. *Comfort by Computer Courses completed: pre survey*

Animations and attitude

Many of the lectures included animations of tables and graphs to visually represent concepts and ideas. The professor could, for example, when discussing interest rates, ask students to suggest an appropriate rate of interest. The given rate could be input into the computer and by animating the graph or table effects on other variables could be instantly represented. Students perceived the animation of concepts positively both prior to their exposure to animation and after long-term exposure to it. From the data collected students anticipated at the beginning of the semester that animations of graphs would be attention getting and useful (see figure 7). This perception remained constant, for the most part, from the beginning of the semester to the end.

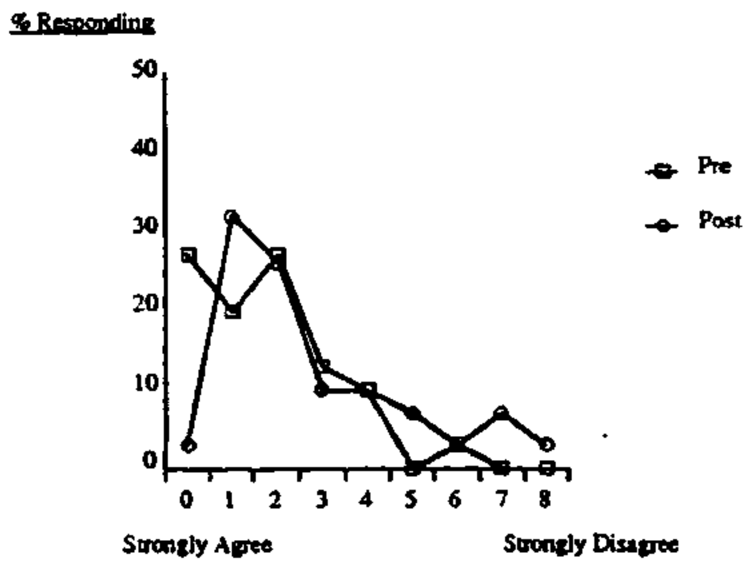

Figure 7. *Animating Graphs: pre and post survey*

951

Summary

This pilot study attempted to make an initial assessment of student reactions to computer-assisted lectures and thus no efforts was made to control for extraneous factors which may have influenced student attitudes during the course of the semester. Given the constraints of this study, the researchers hesitate to make any generalizable conclusions, however, some interesting observations were made. First, video recording class lectures with two video cameras is an effective technique to assess the implementation of a new classroom technology. Video preserves rich details about observations which can be studied repeatedly and validated by other researchers (Van Dalen, 1979). One drawback to this technique is that video recording lends itself to the collection of large amounts of data and consequently requires substantial resources in time, money and energy to make thorough analyses. Second, upon review of the video recordings it appeared that students tended not to look at visuals which included text or formulas and appeared more attentive to animated tables and graphs. This was expected because students had the professor's typed notes with which to follow the lectures. Third, the subject population had very little computer knowledge or exposure to computer-assisted lectures. Results, however, from the pre-survey show that students anticipated that the lectures would be easy to follow and informative and that they would feel comfortable being taught with this delivery format. The researchers were concerned that students, without much computer familiarity, might be skeptical about the delivery format which may impact learning. Fourth, students appeared to perceive animation of concepts and ideas as useful and attention gaining. Moreover, its use in this study whereby the professor maintained an interactive dialogue with students and fed their responses into the computer and animated results, from the researchers' perspective, added additional dynamics to class lectures and assignments. This technique also helped to monitor student attentiveness in a large lecture room.

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Title:

Implementation of an Interactive Videodisc Program: An Ethnographic Study

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Implementation of an Interactive Videodisc Program:
An Ethnographic Study

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ABSTRACT

This ethnographic study examines the process of implementing an interactive videodisc program in a senior high school. The research questions were: What happened during the implementation process and what factors facilitated or hindered the implementation of the innovation? Descriptive data were collected through participant observation, interviews, and artifact collections. Study results revealed that implementing an educational innovation is a complex, multidimensional process involving the organization, the people, and the innovation. Effective implementation depends on the combination of all the factors described in the study, including initiation; planning, preparation, and support; communication and collaboration; district and school policies; teachers' realities; students' characteristics; change strategies; and characteristics of the innovation.

Introduction

As technology development continues, educational institutions are planning and expanding technology-related learning experiences. However, the implementation of a technology-related educational innovation is a highly complex process involving relationships between end-users and change agents; people and technology. The implementation often involves changes in curriculum, changes in instructional approaches, changes in people's attitudes, behaviors, knowledge, skills, and changes in interpersonal interactions among people. Much of the research on educational innovations is characterized by a heavy reliance on recall from memory, a short time frame, and after-process data gathering (Rogers, 1983). Such research tends to neglect the in-process complexities and difficulties of implementation which have a vital influence on the eventual adoption of an educational innovation. Rogers further suggested that innovation-related research methodologies should include longitudinal investigations, broader contexts, multiple perspectives, and in-process studies. Hord, Rutherford, Huling-Austin, and Hall (1987) also noted that efforts to understand the change process should concurrently focus on the individuals, the innovation, and the context of the innovation. The research reported herein followed the above guidelines when examining the implementation of an educational technology innovation in a high school.

Purpose and Questions of the Study

The purpose of this study was to investigate and analyze the process of implementing an interactive videodisc program in a high school. The design of the study was an ethnographic case study which involved intensive data collection on many instances of the phenomenon over an extended time period. The study attempted to reflect the various dimensions of the implementation process from the point of view of the people involved, primarily the teachers, the media specialist, and the administrators. The research questions of the study were:
1. What happened during the implementation process?
2. What were the factors that facilitated or hindered the implementation of the innovation?

Methodology

Rationale for Ethnographic Case Study Approach

The basic assumption underlying the research design was that implementation of an educational innovation is a change process occurring over time and involving the interaction of the people, the innovation, and the context. All these three elements were considered simultaneously in this study by using an ethnographic approach, thereby creating a complete and credible study of the implementation.

Setting

A mid-west comprehensive high school, referred to by the pseudonym "North High School (NHS)," was selected as the setting for this study. Selection of this school was made because the school was chosen by the

Library of Congress as the test site for an interactive videodisc program -- American Memory.

Innovation

The educational innovation that was examined in this study was the American Memory program. The program, collections of historical primary sources, included photographs, manuscripts, motion pictures, books, and sound recordings appropriate for use in American History classes. The hardware of the program included a Macintosh microcomputer, a CD-ROM player, a videodisc player, and a television monitor.

Participants

The selecting and sampling process in this study included strategies for expanding the scope of the study, refining the questions or constructs under investigation, and generating new lines of inquiry. In general, the study employed two means of participant selections: criterion-based or "purposive sampling" (Patton, 1980) and "snowballing" (Delamont, 1992). The participants of the study included: program users (8 teachers), program coordinator (1 media specialist), program initiators (2 district administrators -- media and social studies coordinators), school administrators and staff, and students.

Data Collection Methods

The ethnographic approach used multiple data collection strategies to provide the flexibility needed to study diverse aspects of setting, innovation, and participants. Participant observation, formal interviews, informal conversations, and artifact collection were the primary data collection methods of this study. The combination of multiple data collection strategies provided more complete and complex data than do unimodal research designs, therefore enhancing the credibility of study.

Analysis and Interpretation Strategies

A "concurrent approach" (Marshall & Rossman, 1989) was employed in which data analysis is simultaneous with data collection. On the basis of the strategies suggested by Goetz and LeCompte (1984), the data analysis included theorizing, sequential selection, and general analytic procedures. The researcher looked for "repeatable regularities" of the phenomena and events (Miles & Huberman, 1984). Themes and subthemes representing the recurring patterns were developed to indicate the ebb and flow of the implementation process. Together the themes and subthemes answered the research questions; they indicated the interrelatedness of the factors involved with the setting, the innovation, and the people during the implementation process.

Findings

After examining the implementation process, the data were analyzed, categorized, and conceptualized into the major themes, which together tell a complete story of the implementation phenomenon and reveal dynamic interrelation of the setting, the innovation, and the people which influenced the implementation processes. The themes and subthemes take their form from recurring patterns which have similar characteristics. The five themes are: agendas and actions; teachers' realities; the haves and the have-nots; the role of the internal program coordinator; and the reactions to the innovation.

Agendas and Actions

In general, the *American Memory* program was initiated by the district administrators without bottom-up participation of the teachers and the media specialist at the school level. In fact, the initiation was mainly opportunism -- the program was there, and the grant was not difficult to write for. Minimal instructional needs or curricular goals were identifies.

The initiation was not followed by careful planning and preparation, by clarified staffing and responsibilities, by effective communication, by proactive change strategies, or by the provision of sufficient resources.

It was also worth noting that the district administrator, the media specialist, and the teachers were making efforts to enhance the technology inventory of the school. However, no relationships were identified or made between the technology equipment and the school's instructional needs or curricular goals.

Teachers' Realities

The teachers' working conditions were time-bounded and management-conscious. The teachers had to attend to various responsibilities such as classroom management, material coverage, administrative duties, professional development demands, and school and district policies. Surrounded by multiple realities, teachers were faced with the difficulty of "squeezing" the *American Memory* program into their practice or discussing the program with their colleagues.

Additionally, competing with other instructional demands required by the school district, the *American Memory* program was not considered as a top priority by the teachers. While exercising their limited autonomy, the teachers were likely to rule out using the *American Memory* program in their classroom instruction.

The Haves and the Have-Nots

Like a cafeteria providing different foods for different customers, the NHS offered different courses for the different students. Also, like a cafeteria designing foods for different classifications of customers, the school designed courses as an intellectual diet for different students' categories. Not every student could take any course he or she wanted. In order to take certain courses, students had to meet certain requirement.

The tracking and ability grouping in NHS had a great impact on the students in terms of the distribution of learning opportunities, day-to-day school experiences, classroom climates, utilization of educational resources, and access to the *American Memory* program. In addition, the teachers' expectations and instructional strategies also differed for the various ability.

Role of Internal Program Coordinator

Using the school media specialist as an internal program coordinator resulted in mixed outcomes. The familiarity of the school environment and the technological skills the media specialist already had were very important to utilizing the program. However, the multiple working loads of the media specialist seemed to have negative impact on the effectiveness of the program implementation. The roles of the school media specialist can be divided into formal and informal categories. The formal and informal roles constructed media specialist's work span.

In addition, the distribution of authority in the school seemed not to equip the media specialist with enough power to help her in implementing the program.

Reactions to the Innovation

Throughout the implementation, the American Memory program received limited use because it was not effectively integrated into the instruction and because the teachers and students had limited knowledge about the technology and the program. Besides, the value of "primary sources" was seldom mentioned. The curricular goal and instructional objective of integrating the American Memory program into the senior high school social studies curriculum were not identified or clarified.

In addition, it was unclear if the use of primary sources was a goal for social studies instruction or just a novelty used for entertainment, attention-getting, or enhancing assignments with visuals. It was also questionable whether using primary source material in senior high school social studies curriculum will even establish it significance. In stead of exploring and enjoying the interactive learning experience as proposed by the Library of Congress, district administrators, and media specialist, the teachers and students sometimes felt frustrated while using the program.

Implications

Implementation of an educational innovation is a complex, multidimensional process. The study was not able to identify any discrete factor as dominating the implementation process. Rather, all the themes and subthemes presented in the study should be taken together to represent the critical factors in the implementation process. Seven implications are drawn for understanding the process of implementing the interactive videodisc program:

Implication: The top-down initiation of an innovation with little bottom-up participation may impede the implementation of the innovation.

The findings of the study indicated that the school district administrators initiated the innovation with very little involvement of teachers or the media specialist. The teachers and the media specialist perceived the program as just one of the various demands put upon them. This top-down initiation with little bottom-up participation seemed to result in the lack of teachers' commitment to or interest in the implementation. Such findings re-emphasized a finding in the literature: The less teachers are involved in the decision making processes, the lower their acceptance and support for the innovation and the lower their morale regarding adoption of the innovation (Combs, 1991; Louis & Miles, 1990).

However, Salisbury (1992) indicated that in order to have large-scale change it is very important to have proper sponsorship from the top so the innovation will be sustained. Salisbury argued that the bottom-up model can only facilitate small-scale change, because an innovation usually requires support beyond the resources of an individual school. People at the top are the ones who can provide pressure as well as support, such as equipment, funding, personnel, and rewards. In this study, if people at the top had provided implementation pressure and support, the program might have been more fully implemented.

Marsh (1988) suggested that the blending of top-down initiative and bottom-up participation is often a characteristic of successful implementation. The combination of pressure and support from educational leaders along with high levels of participation from school personnel is probably the more effective approach.

Implication: <u>The implementation planning, teacher preparation, and on-going monitoring may affect the implementation process.</u>

The study showed that there was a lack of planning for implementing the program to fit into the educational system. The curricular goals and instructional objectives were not identified. Ambiguous strategies and unspecified work division preceded anxiety, uncertainty, and confusion for the people involved. As many research findings indicated, an innovative program imported from outside an organization not only needs to be modified to improve the "fit" between the innovation and the conditions in the system; but the structure of the organization may also have to be changed to accommodate the innovation; otherwise the ability of people to deal with the innovation will be impeded (Fullan, 1991; Guskey, 1988; Louis & Miles, 1990; Rogers, 1983). In this case, if the program was taken as a priority of the school district and teachers were provided with time and incentives, the program might have had a better chance to be more fully implemented.

The findings also indicated that the district administrators' preconception of innovation adoption was somewhat simplistic. Their reliance on a single inservice program to prepare teachers was neither realistic nor appropriate, because each teacher had a different reaction toward the program. In addition, teachers said they needed to know more about the program in order to be able to use it effectively. The need to respond to teachers' individual concerns and the need for additional teacher training are obvious. The findings were consistent with the argument of Hord, Rutherford, Huling-Austin, and Hall (1987) that one of the most common and serious mistakes made by administrators and leaders in the change process is to presume that once a program had been introduced and initial training has been completed, the users will put the program into practice. A serious mistake is to assume that all users of the program will react in a similar way.

Teachers in the study indicated that the pre-implementation training was insufficient. One-shot workshop prior to and even during implementation is found to be not very helpful. As Wedman (1986) suggested, an inservice program introducing an entire package of computer technologies can only serve to raise teachers' awareness at the beginning stage of the implementation. Individuals' concerns are often focused on different parts of the technology. During implementation, teachers need to be offered additional training on skills and knowledge which deal with the computer, Hypercard, reference search techniques, and the videodisc player. Additionally, and perhaps more importantly, teachers need to be provided with time to learn and plan curricular integration of the program.

Although the innovation under study was initiated by upper level educators, the process of implementation was not monitored. In fact, people involved paid only minimal attention to their obligations. The attitude of "let's play with it and see what happens" seemed to be prevalent in the organization. The belief that "nothing will be perfect for the first year," even though the program was proposed by the administrators to foster an atmosphere of risk-taking, seemed to serve as an excuse for people to pull back rather than move forward. Fullan (1991) noted that monitoring the innovation process serves two functions. First, by making information on the program available, it provides access to good ideas. Many good practices go unreported because teachers, schools, and districts are isolated from each other. Second, monitoring exposes new ideas to scrutiny, helping to weed out mistakes and further develop promising practices. Neither of these advantages were realized at NHS.

Implication: <u>Implementation without frequent communication among the people involved may impede the process of innovation implementation</u>.

The study revealed that the communication network did not run very effectively. Specifically, there was little communication and discussion among the initiators, program coordinator, and users. Two reasons may apply: there was no information system; and people were too busy with other duties.

The lack of an established information system at NHS was evident in two ways. First, the newsletters were not circulated among the administrators and the teachers. Second, data was not gathered on how the program was being used in the classrooms and school. As a result, the district administrators were unaware of the progress of the program. Ornstein & Hunkins (1988) cautioned that communication channels during the implementation process must be kept open, and the communication network must be comprehensive, so that the people involved can be allowed to input, discuss, and interact with each other.

The findings also revealed that teachers did not have time to learn from other colleagues. Partly because of the physical isolation and partly because of the norms of not observing or discussing each other's work, teachers did not develop a common "technical culture" (Fullan, 1991, p. 119). Therefore, teachers did not have clear and exact information about the program; the knowledge of the program was not diffused among the teachers. The finding was consistent with the research evidence that teachers interact with each other infrequently (Goodlad, 1984; Rosenholtz, 1989). Sarason (1990) commented that the isolation of teachers in the school organization negatively impacts on the innovation implementation.

Implication: Implementation with little understanding of teachers' realities may impede the use of an innovation.

The study showed that teachers' realities were defined by diverse influences. Teaching at NHS was always bound and influenced by the policy and opinions from the state, district, community, and parents. Teachers' realities were also shaped by school policy, schedules, activities, curriculum coverage responsibilities, students' characteristics, and teachers' personal knowledge and skills.

The teachers in this study faced the program with various reactions. The reactions were influenced by both the organizational and personal dimensions of teaching. Organizational dimensions included an emphasis on academic achievement, a focus on subject, and a perception among teachers that they had little influence on policy. Personal dimensions included level of experience with technology and length of service with the school district.

The school culture, with its strong emphasis on students' academic achievement, did not give teachers much cause for implementing a program which was not perceived as relevant to academic achievement. The teachers mentioned the competing demands of several teaching improvement programs promoted by the district which often cause confusion and anxiety for the teachers. Rosenholtz (1989) cautioned that an innovation given less emphasis by school and district administrators will have less of a chance to be accepted by the teachers. Since American Memory program was not proposed as the top priority of the school district, it was less likely to be implemented by teachers.

The findings of the study indicated that teachers who frequently used computers and media services showed stronger intentions to use the program. For those who were not comfortable with the new technology, the resistance to the program tended to be much greater. Such tendency is consistent with the finding indicated in the literature that teachers who experience satisfaction in using a technology are more accepting of the computer related innovation. And teachers who express high levels of enthusiasm toward computers are more likely to be heavy computer users (Schofield & Verban, 1988).

Implication: The grouping of students by ability may affect teachers' expectations and students' access to educational technology.

The study findings indicated that teachers' expectations toward students affected their selection of teaching strategies and resources for the students. Teachers' expectations toward different ability groups of students seemed to result in differential treatments of students. Although this study did not attempt to answer questions dealing with the relationship between teachers' expectations and students' learning, the findings of the study seemed to be consistent with past research on teachers' expectations.

Research evidence is available to demonstrate that some teachers provide different ability students with sharply different learning opportunities, with students of high potential tending to receive more stimulating environments (Good, 1987; Oakes, 1985, 1992; Oakes & Lipton, 1990). This rich-get-richer scenario occurred in NHS classrooms. The interactive videodisc program was perceived as complicated and novel by the teachers. Therefore, the teachers made the decision not to have "less competent" low-tracked students the opportunity to use the program. Such a tendency is consistent with the evidence of class-, race-, and ability-based differences in computer use (Apple, 1992; Sutton, 1991), raising issues of equality and equity of access to educational resources by different ability student groups.

Implication: The change agent responsibilities and strategies may affect the implementation of an educational innovation.

Using a media specialist as an internal change agent in the school setting seemed to result in mixed effects. One of the advantages was that the media specialist was knowledgeable about the interactive videodisc technology and had credibility in terms of providing technical assistance to the teachers. In addition, such an in-house expert was more familiar with the organization and teachers. However, questions arose regarding the overloaded responsibilities of the media specialist and the cordial relationship she tried to maintain with the teachers. With too many roles -- formal and informal -- to fulfill and too little time to undertake them, the media specialist could not fully attend to the implementation of the program. In addition, the media specialist, in fact, had no power over the teachers. As a result, there was hardly any pressure which is necessary for successful implementation.

The media specialist in this study also indicated that she lacked subject matter expertise and expected the teachers to plan the integration of the program into the existing curriculum. This finding was consistent with the argument raised by Becking (1986) and Femian, Benedict, and Johnson (1988) that practical courses on working with teachers and on services and curriculum development are essential for the school media specialist. Without teachers' commitment and subject matter expertise, the technical expertise of the media specialist alone did not warrant the program's utilization. One possible way to avoid reliance on the single change agent might be to use the "multiplier mode" proposed by Miles, Saxl, and Lieberman (1988). The strategy combines the expertise of subject matter teachers and the expertise of the technical specialist.

This study illustrated that several change strategies the school media specialist used might have affected the implementation process. First, the media specialist tended to interact more with people who had more computer knowledge. Also, her use of technical terminology appeared to distance her from the teachers. Her passive approach to providing information on the program may also have slowed down the speed of diffusion. Strudler (1991) cautioned that an effective change agent must possess strong interpersonal and organizational skills to carry out necessary training and support functions. These skills include initiative-taking, securing resources, program continuation, and facilitating group-functioning and decision. Strudler also argued that successful change tend to play down their computer expertise and resist being called "the expert." Rather, they prefer to be seen as just another teacher who knows something about using computers in school. By de-emphasizing their expertise, change agents could minimize the discrepancies that exist between them and teachers.

Implication: An innovation that is perceived to be complicated and less educationally significant may have less of a chance of being implemented.

The study showed that the interactive videodisc program involved the combination of different technologies such as a computer, videodisc player, CD-ROM, and television; and the program was regarded as time-consuming, complicated, and novel by the teachers. When the value of "primary sources" was not a consideration, teachers and students chose to use other competing resources such as videotapes, microfilms, newspapers, and magazines which were perceived as easier to use. Such findings were consistent with Rogers' (1983) caution that an innovation will have a higher chance of being adopted if it is perceived to have low complexity, high relative value, high trialability, high observability, and high applicability.

The study indicated that the information presented through the combination of technologies was confusing to users. Hypercard is considered a powerful tool with non-linear thinking characteristics so users can choose their own learning strategy according to individual needs. While the idea of giving learners control of their own learning may have a strong intuitive appeal, the study findings did not show that users always choose or appreciate what is designed for them. Some users were impatient about the wait-time and a few were confused by the various icons presented on a single-screen display. Some teachers were reluctant to organize the instruction by themselves. Some expected the information to be organized in a package. The strong interests of students in watching the "execution of the prisoner who assassinated President McKinley" in the program was regarded as entertaining rather than educational.

These reactions are consistent with literature regarding the barriers to using the interactive video. As Jonassen (1988) and Jost (1990) pointed out, several problems occur in using interactive video technology: difficulties in navigation as the user gets lost in the unstructured knowledge base; difficulties in integrating information into personal knowledge structures and in synthesizing and tuning that knowledge; and cognitive overload. Attention should be given to the design and development of interactive videodisc programs, the iconic metaphors of the computer screen display, and the instructional strategies for interactive videodisc programs.

Researcher's Reflection

The researcher was a foreigner in the United States and an outsider to its schools. As such, the researcher was impressed that teachers and students in the American educational system were able to have access to an instructional program like American Memory. However, the researcher was also impressed that the implementation has so little direction and that the program was not really utilized by the teachers and students.

Gathering information on the financial and human resource investment by the Library of Congress in developing this program was outside the scope of this study. Nor did the researcher know how the decision was made by the Library of Congress to develop the American Memory program. But if the program is not being used by teachers and students, if the program has not established its instructional significance, then questions must be asked about why the Library of Congress developed it and who has really benefited from this interactive videodisc program? Perhaps the NHS school district, NHS itself, and the district administrators who applied for the grant received the most benefit -- promoting their public and personal images. Or, perhaps the Library of Congress which developed the program shared this benefit. If that is the case, if school administrators, federal officials, and their organizations, but not the students, realized the greatest benefits, then one must question the value of promoting technology-related innovations in education.

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Title:

The Integration of Learning Strategies in Interactive Multimedia Instruction

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Introduction

A perplexing assortment of uses of the term "multimedia" abounds in the literature, variously describing computer-driven devices, computer programs, and combinations of the two, all of which are capable of producing mixtures of sound, graphics, animation and video. Schroeder (1991) describes "interactive" multimedia broadly as a hybrid technology merging various types of media with the computer. McCarthy (1989, p. 26) provides more detail, defining it as "the integration of text, audio, graphics, still image and moving pictures into a single, computer - controlled, multimedia product." Gayeski (1993, p.4) defines multimedia in terms of systems, as "a class of computer-driven, interactive communications systems which create, store, transmit, and retrieve textual, graphic, and auditory networks of information", while Schwier and Misanchuk (1993, p. 6), to place the emphasis on the computer program rather than hardware, describe interactive multimedia *instruction* as "an instructional program which includes a variety of integrated sources in the instruction with a computer at the heart of the system." Whatever the specific definition, such systems provide the possibility of nearly unlimited combinations of digitized audio, graphics and text, analog and digitized video, accessed through the computer itself and/or a variety of peripheral devices such as videodisc players, compact disc players and music synthesizer. They have the potential to utilize new developments in data-storage (laserdisc, compact disc, digitized video and audio), ever-increasing computer speeds and capabilities, and sophisticated software tools to allow a learner to move through a rich, multimedia base in a way that fits his/her own learning needs and preferences (Schroeder, 1991).

Interactive multimedia instruction can be linear and/or structured or more non-linear, resembling a database incorporating multiple formats. The organization of the information in a tightly structured program, those designed for a specific instructional purpose or objective, is generally very clear. Programs such as Eduquest's Stories and More, a literature- based curriculum system, offer information in multiple formats (digitized audio, graphics, text), allowing the learner choices, but still guide the user in a structured fashion. However, many of the newest programs, such as IBM's Illuminated Manuscripts and Intellimation's Letter from Birmingham Jail are more open-ended, with the structure of the information less obvious to the user. These resemble multimedia databases where the user selects the path, information, and format to view.

Interactive Multimedia and Instruction

Romiszowski (1990) defines instruction as a goal-oriented teaching process that is based on pre- planning and formative evaluation. He views hypermedia [an alternate term for non-linear interactive multimedia instruction] as independent of specific goals and instructional objectives, as possibly a component of an instructional system, but functioning separately as an informational system. Duchastel (1990) claims hypermedia is better suited to informal learning than formal instruction; a learning rather than a teaching tool. Thus, " [A]ny structure imposed upon the situation in order to enhance the learning experience to be derived from it is really extrinsic to hypermedia itself" (Duchastel, 1990, p. 139). Structure in hypermedia may actually inhibit user interest and, hence, exploration. Associational learning is an appropriate use of hypermedia.

This is consistent with a constructivist view of learning which holds that the learner individually constructs knowledge through interpreting perceptual experiences of the external world (Jonassen, 1991). Learners develop unique associations between prior knowledge stored in long term memory structures and new information. This encoding may involve the integration of information into existing schemata (assimilation) or the construction of new schemata (accommodation). Constructivists encourage inductive, or discovery, learning in which learners engage a domain and "construct their own concepts and rules based on their interpretation of the instances encountered" (Rieber, 1992, p.96). Learning occurs through interactions with one's environment or culture and the potential for learning increases as the instructional situation becomes richer and more engaging for the learner. From a constructivist point of view, it is important that learning environments provide learners with experience in and appreciation for multiple perspectives, encourage multiple modes of representation, and embed learning in realistic and relevant contexts which support intrinsically motivating and self-regulated learning (Rieber, 1992, McMahon, Carr & Fishman, 1993).

Interactive multimedia instruction can provide the rich learning environment central to a constructivist view of learning by furnishing databases of information in multiple formats and perspectives and which nurture incidental learning. However, such environments necessarily provide a limited amount of structure and require learners to create their own. How can designers help learners to construct meaning in such environments? Learners may benefit from strategies that help them encode the information they encounter in interactive multimedia instruction, strategies such as paraphrasing, generating questions, outlining, cognitive mapping, creating images and summarizing. These activities could be supplied by the instructional system or generated by the learner.

Learning Strategies to Facilitate Encoding

Learning strategies have tended to be explained in terms of information-processing theory rather than constructivism. Bruning (1983, p. 93) defines learning strategies as "any internally or externally mediated cognitive process that will facilitate transfer of information to be learned from short-term into long-term memory". Information-processing theory holds that short term memory has a limited processing capacity such that learners are forced to select from all possible information presented for processing. Short term memory holds information for only seconds before it is lost or encoded for storage in long term memory. Learning strategies are generally called into use at this point to facilitate the transfer of information (Bruning, 1983).

Weinstein and Mayer (1986) also link learning strategies to encoding. Based on Cook and Mayer's (1983) analysis of the encoding process, they describe encoding as comprised of four components: a) *selection* - the learner actively pays attention to some of the information impinging on sense receptors and transfers it to working memory; b) *acquisition* - the learner actively transfers information between working and long-term memory for further study; c) *construction* - the learner actively builds internal connections between ideas in the information that reaches working memory; and d) *integration* - the learner actively searches long-term memory for prior knowledge and transfers it to working memory to construct external connections with the new information.

Learning strategies are used to rehearse, organize, and elaborate information to make it more meaningful. Strategies include underlining and repetition for rehearsal; outlining, categorization, and mapping for organization; and mental imagining, forming analogies, inserted questions, paraphrasing and analyzing key points for elaboration. Rehearsal strategies help focus attention on important information and encode it in short term memory (selection and acquisition), while organization strategies help in selecting appropriate information and constructing connections among the ideas (construction). Elaboration strategies help transform information by making the material more meaningful and building connections among new ideas and prior knowledge.

This paper will overview the research on perhaps the most widely used learning strategy, notetaking, and on two related techniques, outlining and concept mapping. It will provide an analysis of their effectiveness to aid the learner in encoding new information, examine current uses of these strategies in interactive multimedia instruction, and offer suggestions for the incorporation of these learning strategies into future designs.

Notetaking and Related Learning Strategies

Historically, much of the research has focused on notetaking from oral or videotaped lectures (Hartley & Davies, 1978, Carrier & Titus, 1979, Rickards, 1979, Kiewra, 1985, 1987). Only recently have studies begun to focus on notetaking from text (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989; Wade & Trathen, 1989). Two hypotheses have been advanced to explain the potential effectiveness of notetaking to facilitate learning: 1. notetaking assists encoding or 2. notetaking provides a product which can be reviewed later (Divesta & Gray, 1972, cited in Rickards, 1979).

The encoding hypothesis or process function of notetaking

This hypothesis holds that notetaking is beneficial, independent of review, because it increases attention during the lecture and facilitates encoding of lecture ideas into long term memory (Kiewra, 1985, 1987, Hartley & Davies, 1978). Peper & Mayer (1986) advance three sub-hypotheses to explain why the encoding hypothesis may or may not be true. The first two are based on how much is learned while the third focuses on the degree to which the learner is able to actively relate material to existing knowledge. The first, the Attention Hypothesis, states that notetaking facilitates learning by forcing the learner to pay more attention to presented material or to process presented material more deeply. Notetakers would perform better than non- notetakers on dependent measures. The second, the Distraction Hypothesis, holds that notetaking impedes learning by forcing the learner to concentrate on the motor act of writing instead of more fully listening to lecture. Notetakers would perform worse than non- notetakers on dependent measures. The third, the Generative Hypothesis (Wittrock, 1974), is based on idea that notetaking helps the learner to generate meaning by relating presented information to prior knowledge and thus building a more integrated learning outcome. Notetakers are expected to perform better than non- notetakers on far transfer tasks but worse on near transfer tasks.

The external storage or product function of notetaking

This hypothesis holds that notetaking is beneficial because the notes comprise a tangible product which can be retrieved and used once the instructional event has passed. Rickards (1979) suggests two possible functions for the external storage idea:

1.) a Rehearsal Function: enhanced recall is only due to remembering material from the notes just reviewed (the notes provide the learner with more information).
2.) a Reconstruction Function: recall of notes allows learners to reconstruct parts of the passage on which no notes previously taken (the notes help the learner to recall other information).

The effectiveness of notetaking

The encoding hypothesis. Research evidence for this function is mixed. Combined findings (Kiewra, 1987) of review papers by Hartley & Davies (1978) and Kiewra (1985) reported 35 studies on notetaking from lectures supporting the encoding function, 23 indicating no significant differences between those who do and those who do not record notes and 3 indicating the activity of notetaking to be dysfunctional relative to listening only. For notetaking from text material, there is some evidence that notetaking served a minimal encoding function and may even have interfered with processing (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989). Also, a study by Wade and Trathen (1989) indicated that noting information (including notetaking) has little effect, independent of the importance of the ideas noted, on the recall of that information.

The external storage hypothesis. Initial research findings appear to strongly support this function. Combined findings (Kiewra, 1987) of review papers by Hartley & Davies (1978) and Kiewra (1985) reported 24 studies on notetaking from lectures supporting the product function (those who reviewed their notes achieved more), 8 studies indicating no significant differences between reviewers and non- reviewers and no study indicating reviewing notes to be dysfunctional.

The rehearsal function of the external storage hypothesis. More recent evidence seems to support this explanation (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989; Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991). These investigators indicate that, for these earlier studies, what has traditionally referred to as "external storage" has really been a combination of encoding and external storage because the latter group consisted of students reviewing their own notes. Learners had, in effect, two chances to process the information (a repetition effect). When "external storage" is reformulated as those who review notes but who have not previously viewed the lecture, the results appear less conclusive. In these two studies, the reformulated product function was shown to be less effective for factual recall and recognition than an encoding plus storage treatment condition, although not for higher order (synthesis) performance. Encoding only was consistently the least effective treatment and no more effective than listening to a lecture without notetaking. Thus, notetakers who review outperform notetakers who do not review.

Further, the encoding process per se (without review) did not appear to be aided by recording notes on linear or matrix frameworks (Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991). This is consistent with results from a study of fill- in versus completed graphic organizers (Kenny, 1992) used with interactive video where the notetaking treatment appeared to interfere with, rather than facilitate, learning from the program. In fact, when learning from text was tested, students who read twice from the material but did not take notes outperformed those using any form of notetaking (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989). Further, Anderson's (1980) reanalysis of a study by Arnold (1942) found that simply rereading a passage was more influential on recall than more obtrusive techniques such as outlining which he hypothesized might actually be detrimental. Other studies comparing notetaking to repetitive reading (Hoon, 1974; Dynes, 1932; Stordahl and Christensen, 1956) found notetaking no different from reading alone. Notetaking, whether from lecture or text, may be a sufficiently demanding process that relatively little encoding actually occurs during the act of notetaking (Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991; Kenny, 1992). Also, evidence further contradicting the efficacy of the product function is that students' notetaking is generally incomplete (Kiewra, 1987, Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991). The review of instructors's notes provides best results (e.g. Kiewra, 1985, Kiewra & Frank, 1988; Risch & Kiewra, 1990) although student notes improve with repetition (Kiewra, Mayer, Christensen, Kim & Risch, 1991).

Outlining

Outlining is defined as "a high level skill which involves identifying relationships between concepts and arranging those concepts in an order which demonstrates the superordinate and subordinate nature of the concepts involved" (Anderson-Madaus, 1990, p. 3). Outlining: a) causes focusing on important points, b) helps students gain familiarity with text structure, c) aids retention, d) generates useful alternative texts to supplement materials read, and e) causes active participation in learning (Bianco and McCormick, 1989).

The effectiveness of outlining. Several studies have shown that outlining results in improved recall of facts (Barton, 1930, Annis and Davis, 1975; Glynn and DiVesta, 1977; Shimmerlik and Nolan, 1976). The use of hierarchical summarization strategy, a form of outlining, improved comprehension and recall in the middle school students (Taylor and Beach, 1984), while ninth-graders who completed an outline grid when reading did better on multiple choice recall tests (Slater, Graves, and Piche, 1985). Further, research asking students to generate outlines provides some support for their facilitation of recall. Outlining, if done properly (e.g. focusing on main ideas, organizing from abstract to concrete in the hierarchy, working from a classification of concepts) and not viewed as being too intrusive in the study process, can aid in both organizing new information and integrating new knowledge into one's personal knowledge structure (Hoffler, 1983; Anderson, 1980). For example, Tuckerman (1993) studied coded elaborative outlines, a method which involves outlining chapters, coding the main points using a six-code scheme, and adding elaborations of main points, such as examples and explanations. College students who were required to create coded elaborative outlines of chapters performed significantly better than students who did so voluntarily, who created standard outlines, or who did not outline (Tuckerman, 1993). Students given the option of outlining generally chose not to do so, but those not required to write these outlines performed better the more they outlined.

Outlining has also been compared to other learning strategies. Palmatier (1971) found that college students using outlining had the highest level of essential content in their notes compared to those using a three-column method, the Bartush Active Methods or no method, while Snyder (1984) found a significantly higher recall performance for the outlining method in a study comparing the use of SQ3R, outlining, and underlining to study college textbooks. Iovino (1989) found that outlining significantly helped college students to achieve higher immediate recall than did networking, but networking significantly improved their ability to retain information over time. Students were given five hours of training in the technique they used. In a study of the use of outlining and clustering in prewriting (Kellogg, 1990), outlining was most beneficial when only the topic was provided and students had to generate and organize ideas, but did not help if the topic, ideas, and organization were given.

Other studies report no advantage of outlining over other strategies (Arnold, 1942; Stordahl and Christensen, 1956; Todd and Kessler, 1971; Willmore, 1966 cited in Iovino, 1989) or a marginal advantage for outlining in writing papers (Branthwaite, Trueman, and Hartley, 1980; Emig, 1971). Emig (1975) found no correlation between creation of an outline and organization of a written theme.

Training Needed in Outlining. Anderson (1980) notes that outlining, like strategies such as imaging and paraphrasing, requires a major intrusion in the reading processes and also necessitates a significant amount of training to use properly. In research on student-generated study aids, he found, that without explicit instruction in the use of the aid, students do as well simply rereading the assignment. Outlining is often one of the only strategies taught in the middle grades and is the strategy preferred by students (Bean, Singer, Sorter & Frazee, 1983). Training to outline is done in most schools, but often not in a way that students understand it conceptually. Matott (1987) claims that few students have been taught that outlining requires the identification of major points, then all sub-major points and so on. Hoffler (1983) stresses the need to present an outline as moving from abstract to concrete as one goes down the hierarchy. To do this he suggests students must work backwards, classifying from concrete items to more abstract concepts.

Spatial notetaking strategies

An outgrowth of schema theory (Kiewra, 1988) is the study of learning strategies involving the reorganization of linear information into a spatial representation that specifies relationships among concepts. The process of creating a spatial arrangement requires a relatively deep level of processing aimed at determining internal connections among ideas. Kiewra & his associates (Kiewra, DuBois, Christensen, Kim & Lindberg, 1989; Risch & Kiewra, 1990; Kiewra, DuBois, Christian, Mcshane, Meyerhoffer & Roskelly, 1991) have developed and tested a modified form of spatial notetaking strategy which supplied learners with a matrix already containing horizontal and vertical headings from the presentation. Results from four experiments varied. The investigators found no significant advantages for matrix notetaking in three studies. A significant difference in favor of the technique compared to conventional notetaking - when students were allowed to review their notes - was found in the fourth study.

Concept Mapping

Perhaps the most widely known and researched spatial learning strategy is concept mapping (Novak, Gowin & Johansen, 1983; Novak & Gowin, 1984, Heinze-Fry & Novak, 1990; Novak, 1990). Concept mapping was developed as a spatial knowledge representation technique based on Ausubel's Theory of Meaningful Learning, a theory which holds that knowledge in memory is hierarchical, with more general, more inclusive concepts subsuming progressively less inclusive, more specific ones (Novak & Gowin, 1984). Concept maps, then, are drawn hierarchically, with more inclusive concepts at the top of the map and progressively more specific ones arranged below. Concepts are placed in ovals and linked by labelled lines to form semantic units termed propositions.

Concept maps are viewed, first and foremost, as a tool for negotiating meanings. Maps are constructed in collaboratively by the instructor and the learner(s). However, it can also be used as a pre-instructional tool in the form of an advance or graphic organizer and as a notetaking technique for extracting key concepts from printed or oral material (Novak & Gowin, 1984).

The effectiveness of concept mapping. A recent meta-analysis of nineteen studies (Horton, McConney, Gallo, Senn & Hamelin, 1993) provides an overview of the general effectiveness of the technique. Studies had to occur in an actual classroom and use concept mapping as an instructional tool compared to an alternate technique as a control. Nearly all studies examined involved science content, material which could be argued lends itself to a hierarchical depiction. in 15 of the 19 studies, the students prepared the maps. Effect sizes (E.S.) for achievement ranged from -0.31 to + 2.02 with a mean E.S. of 0.46. For measures of student attitude towards the particular subject matter, E.S.'s ranged from 0.05 to 4.88 with a mean E.S. of 1.57. The investigators concluded that concept mapping has generally medium positive effects on achievement and large positive effects on attitude.

Research results also indicate that the primary benefit of concept mapping accrues to the person who constructs the map (Novak, 1990; Horton et al, 1993), that teacher-prepared maps may be helpful to students, but only after they have had practice preparing their own maps and that, at first (for 2-4 weeks), there is generally an average *decline* in performance for strategies that require meaningful learning although they finish up significantly higher (Novak, 1990). The implication is that time is needed for students to learn and learn to appreciate meaningful learning strategies such as concept mapping.

Integrating Learning Strategies in Interactive Multimedia Instruction

Interactive multimedia instruction has many capabilities to facilitate encoding. It can provide a variety of practice strategies with feedback depending on learner choices, provide learner guidance in terms of recommended paths, incorporate multimodal techniques, and provide active manipulation of lesson content for interaction and resolution of conflicting information. Current interactive multimedia instruction often takes the form of a multiple format database. In many systems, learners are guided to manipulate the lesson content through notetaking. The learner is able to open a notetaking screen by clicking a button, type in notes about the current topic being explored, or copy sections from different screens into the notebook, and either print or save these notes to disk. Guidance on taking notes is rarely given. This presents a problem since learners frequently do not incorporate structure in their notetaking or fail to elaborate on the new information. Since research has indicated that students are generally incomplete note-takers (Kiewra, 1987, 1988), this may represent a serious design flaw. A number of notetaking techniques have been proposed which could be incorporated into interactive multimedia to enhance learner encoding in a more structured fashion. These include linear approaches like outlining (Kiewra, DuBois, Christian & McShane, 1988) and spatial learning strategies such as concept maps (Novak and Gowin, 1984).

Programs with notebooks or notepads are often fairly rudimentary. If they are used by students they risk replicating the same shortcomings of notetaking, outlining and mapping on paper. The computer offers capabilities that might be used to incorporate the best aspects of each of these learning strategies while avoiding some of their pitfalls. It also offers the ability to offer a degree of guidance to the user if necessary or if desired by the instructor. Capabilities that might be exploited in incorporating learning strategies into a notebook include:

- cutting, pasting and manipulating text and media (graphics, sound, video - e.g. pasting in Quicktime/ Video for Windows movie into a word processing document). This could be done in outline or spatial map format using text and/or icons.
- using screen titles and/or topics to organize information and the ability to connect and manipulate these, pull them together into a concept map or hypermap. This could be done in outline or spatial map format using text and/or icons.
- creating a multimedia document from information gathered.

Kozma (1987) has also proposed the electronic notebook idea. Computers can aid the learning process by a) supplementing working memory, b) making relevant prior information available quickly, c) prompting the learner to connect, integrate, and structure new information with old in an easily changeable manner, and d) providing both verbal and visual representations. Learning Tool by Intellimation for the Macintosh computer is an example of a program that presents the learner with blank workspaces and tools to develop key points, connect them in networks, and provide textual and graphic information about each. The program cues, evokes, models, and supplements the learner's thought processes. in effect, it provides a tool for concept mapping and related spatial notetaking techniques.

Outlining in a computerized environment can add several new features. Students can incorporate text as well as various other media types in a outline, by either cutting and pasting or linking to external resources. When using a interactive multimedia program, all the information can be included, no matter what the format. Applications such as Mediatext, WordPerfect and Microsoft Word already offer these features.

Many word processors also offer the ability to expand and compress outlines. If this feature were incorporated into a program's notebook, students could view their information at different levels of the hierarchy, e.g. degree of abstraction or detail. If the designer or instructor desires, he/she could provide an intact outline in which to take notes and include media, acting as guide through the system and showing one view of the overarching structure in a linear, hierarchical fashion. Students might chose to view or not to view this as desired. Different outlines might be available to show different perspectives on the interactive multimedia system's information.

Types of notebooks

The design of notebooks for interactive multimedia systems can incorporate some or all of the features discussed previously. Their degree of sophistication can be thought of as a hierarchy with each level having its advantages and disadvantages. A possible hierarchy is described below. The forms of learning strategy involved, according to Weinstein's and Mayer's (1986) categories, are listed in parenthesis after each point.

1. Copy and paste text & graphics a whole screen or section at a time in the order found.

   Advantages:

   a. At the very least would create active involvement by the learner in the selection of relevant information, that is elicit generative learning (rehearsal, organization, elaboration).
   b. Multiple formats could be included in the notes (rehearsal, organization, elaboration).
   c. The accuracy of information could be guaranteed because it would be recorded exactly (rehearsal).

   Disadvantages:

   a. No depth of processing is required of the learner, making it much like underlining/highlighting.
   b. The learner is not encouraged to relate the new information to prior knowledge and to elaborate it in a personally meaningful way.
   c. Encourages external storage of information, but not necessarily encoding.
   d. The learner cannot show relationships among ideas. The information may have to be stored in the order selected and copied rather than reorganized in a personally meaningful way.
   e. May be difficult to get an overview of the organization of the information.

2. Copy and paste text and graphics selected in the order found.

Advantages:

a. Multiple formats could be included in the notes (rehearsal, organization, elaboration).
b. The accuracy of information could be guaranteed because it would be recorded exactly (rehearsal).
c. The learner could select only the information needed as it is found (rehearsal, organization).
d. The learner is more actively involved in selecting information to include, that is, generative learning (rehearsal, organization).

Disadvantages:

a. The learner is not encouraged to relate the new information to prior knowledge and to elaborate it in a personally meaningful way.
b. Encourages external storage of information, but not necessarily encoding.
c. The learner cannot show relationships among ideas. The information may have to be stored in the order selected and copied rather than reorganized in a personally meaningful way.
d. May be difficult to get an overview of the organization of the information.

3. Use headings in interactive multimedia to create hierarchy of an outline (i.e., the levels of hierarchy are embedded in headings themselves).

Advantages:

a. This would accurately show the hierarchy intended by the developer (organization).
b. If the learner can select which headings to include, he / she has the ability to create a unique structure of this information to a certain extent, that is, elicit generative learning (organization, elaboration).
c. The accuracy of the information could be guaranteed because it would be recorded intact from the program (rehearsal).

Disadvantages:

a. The hierarchy portrayed may not match the learner's prior knowledge or information need.
b. The learner cannot create his / her own relationships or reorganize the information in a personally meaningful way.
c. The learner is not encouraged to relate the new information to prior knowledge.
d. Encourages external storage of information, but not necessarily encoding.
e. If the learner cannot select the headings to include, superfluous information could be included.

4. Arrange and rearrange text and graphics copied from the program without adding additional information.

Advantages:

a. The learner can create his / her own categorizations/connections among ideas (organization, elaboration).
b. The learner can display his / her own conception of the relationships among the ideas, becoming actively involved in the integration of new information (organization, elaboration).
c. Multiple formats could be included in the notes (rehearsal, organization, elaboration).
d. The accuracy of information could be guaranteed because it would be recorded intact from the program (rehearsal).

Disadvantages:

a. There is no inherent way to show relationships; the learner must use text to relate the ideas.
b. May be difficult to get an overview of the organization of the information.

5. Add own text/graphics to information selected.

Advantages:

a. The learner can create his/her own categorizations/connections among ideas (organization, elaboration).
b. The learner can display his/her own conception of relationships among the ideas, becoming actively involved in the integration of new information (organization, elaboration).
c. Multiple formats could be included in the notes (rehearsal, organization, elaboration).
d. The learner can make the new information personally relevant through elaboration with prior knowledge (elaboration).
e. The learner can connect new information to prior knowledge (elaboration).
f. The learner could type in prior knowledge before going through the program, offering a framework to attach new information to (organization).
g. The learner or instructor could provide an initial framework or questions to act as an organizer for the new information (organization).
h. The learner can put information into his/her own words, facilitating encoding and retrieval cues (organization, elaboration).
i. The learner can add connection words or symbols to show relationships among the concepts (organization, elaboration).

Disadvantages:

a. There is no inherent way to show relationships; the learner must use text to relate the ideas.

958

b. May be difficult to get an overview of the organization of the information.
c. Information added may be inaccurately copied or connected.

6. Create an outline from information in the program and text/graphics added.

Advantages:

a. The learner can create his / her own hierarchical arrangement of the information (organization, elaboration).
b. The learner is actively involved in selecting information to be included, elaborating with prior knowledge, and integrating new and prior knowledge (organization, elaboration).
c. Multiple formats could be included in the notes (rehearsal).
d. The learner could type in prior knowledge before going through the program, offering a framework to attach new information to (organization).
e. The learner or instructor could provide an initial framework or questions to act as an organizer for the new information (organization).
f. The learner can put information into his/her own words, facilitating encoding and retrieval cues (organization, elaboration).
g. It may be easy to move this to actual student production.

Disadvantages:

a. Learners not trained in outlining may try to create outline in a linear fashion and not really develop hierarchy.
b. The outline format may in itself be cumbersome.
c. It may be hard to for the learner to see levels of hierarchy unless outline can be collapsed.
d. Not all information lends itself to a hierarchy.
e. It may be difficult to incorporate other media resources into the outline.
f. Information added may be inaccurate.

7. Creating a spatial map from information in the program.

Advantages:

a. The learner can create and see the hierarchy or connections visually (organization, elaboration).
b. The information included does not have to be hierarchical in arrangement (organization).
c. The learner may be able to hide layers of hierarchy as necessary (organization).
d. The learner may be able to create linkages among concepts and describe the nature of the relationships shown by the links (organization, elaboration).
e. The accuracy of the information could be guaranteed if it was recorded intact from the program (rehearsal).

Disadvantages:

a. Learners not accustomed to this techniques will require instruction in its use.
b. Not all students may be graphically oriented.
c. Additional information cannot be added to make it personally meaningful.

8. Spatial mapping with learner adding own text elaborations.

a. The learner can create and see the hierarchy or connections visually (organization, elaboration).
b. The information included does not have to be hierarchical in arrangement (organization).
c. The learner may be able to hide layers of hierarchy as necessary (organization).
d. The learner may be able to create linkages among concepts and describe the nature of the relationships shown by the links (organization, elaboration).
e. The learner can display his / her own conception of the relationships among new and old ideas, becoming actively involved in the integration of new information with prior knowledge (organization, elaboration).
f. The learner could type in prior knowledge before going through the program, offering a framework to attach new information to (organization).
h. The learner can put information into his/her own words, facilitating encoding and retrieval cues (organization, elaboration).

Disadvantages:

a. Learners not accustomed to this techniques will require instruction in its use.
b. Not all students may be graphically oriented.
c. Information added may not be accurately copied or connected.

9. Spatial mapping with adding own text / graphics elaborations and media resources from the program.

Advantages:

a. The learner can create and see the hierarchy or connections visually (organization, elaboration).
b. The information included does not have to be hierarchical in arrangement (organization).
c. The learner may be able to hide layers of hierarchy as necessary (organization).
d. The learner may be able to create linkages among concepts and describe the nature of the relationships shown by the links (organization, elaboration).
e. The learner can elaborate the spatial map with prior knowledge (organization, elaboration).
f. Multiple formats could be included in the notes (rehearsal, organization, elaboration)).
g. The learner could type in prior knowledge before going through the program, offering a framework to attach new information to (organization).

h. The learner or instructor could provide an initial framework or questions to act as an organizer for the new information (organization).
i. The learner can put information into his/her own words, facilitating encoding and retrieval cues (organization, elaboration).
j. The learner can add connection words or symbols to show relationships among concepts (organization, elaboration).

Disadvantages:

a. Learners not accustomed to this technique will require instruction in its use.
b. Not all students may be graphically oriented.
c. Information added may not be accurately copied or connected.

10. Creating a multimedia document / presentation.

Advantages:

a. The learner can create his/her own categorizations/connections among ideas (organization, elaboration).
b. The learner can display his/her own conception of relationships among the ideas, becoming actively involved in the integration of new information (organization, elaboration).
c. Multiple formats could be included in the notes (rehearsal, organization, elaboration).
d. The learner can make the new information personally relevant through elaboration with prior knowledge (elaboration).
e. The learner can connect new information to prior knowledge (elaboration).
f. The learner could type in prior knowledge before going through the program, offering a framework to attach new information to (organization).
g. The learner or instructor could provide an initial framework or questions to act as an organizer for the new information (organization).
h. The learner can put information into his/her own words, facilitating encoding and retrieval cues (organization, elaboration).
i. The learner can add connection words or symbols to show relationships among the concepts (organization, elaboration).

Disadvantages:

a. Learners not accustomed to this technique will require instruction in its use.
b. There is no inherent way to show relationships; the learner must use text to relate the ideas.
c. May be difficult to get an overview of the organization of the information.
d. Information added may be inaccurately copied or connected.

Design Considerations

When determining the type of notebook to include with a program, the designer much take into account the capabilities of the computer, the needs of the learners, and the research on notetaking strategies. Just copying and pasting in notebook is not likely to be any more effective than underlining or highlighting in a text. Research has shown no significant effect on recall from these techniques. Research on outlining and concept mapping offers suggestions for the designer.

Notetaking in an interactive multimedia system is not the same as notetaking in a lecture, because pacing not an issue in the computer program. Learners have time to copy text and elaborate, similar to underlining with margin notes or two-column notetaking, and then elaborate with their own text and graphics. They can organize or categorize information as they go along or after gathering all the information, due to the ease of cutting and pasting. They might also create a graphical representation of the information as they go along or after collecting all the information. Potential ease of expanding and collapsing outlines may make it easier for learners to perceive the structure of the information at various levels. Tuckerman's research on coded elaborative outlining provides a basis for this use of a notebook (Tuckerman, 1993).

Learners also need to have reason to use a notebook. Notetaking and other learning strategy research has shown that students prefer to merely read and reread information as their strategy of choice. Strategies such as concept mapping and outlining may not be in their repertoire of strategies. If they are aware of the strategy, they will tend to use those they feel most comfortable with, even if it may not be the best for the situation. A notebook may be provided, but not used. A notebook that provides some of the more sophisticated features may need introduction to the students or they may use it in a simple cut and paste mode. Such introduction may be available and/or guidance in the use of the notebook provided and then extinguished as the learner becomes more comfortable with its use.

Notetaking research has shown that learner who elaborate on the information interact more with the new information and tie it to existing knowledge. They need to organize and elaborate on information to help in encoding and creation of retrieval cues, tie to prior knowledge, and make the new information personally relevant. Guidance to elaborate may be required in a notebook where this feature is available. The combination of the encoding and external storage function of notebooks is most valuable. Learners have the ability to review organized and elaborated information in a notebook. This allows them to process the information again and assists by cuing retrieval. Generative processing research supports the use of a notebook to copy text, graphics, etc. and then add one's own elaborations. Learners can then arrange information into their own framework, be it outline or spatial map. This allows for both repetition of the information and additional processing.

The use of a notebook can be carried even further to creation of multimedia presentation. This allows the notebook to be used as an organizer for drafting such a presentation. The ideal notebook would make the transition to a finished multimedia product seamless.

Another use of the notebook would be for teacher provided questions, outlines, frameworks, or keywords. Any of these strategies can act as an advance organizer for the learner, especially those with low prior knowledge. They can provide a framework for gathering information and stimulate recall of prior knowledge. Learners could also be asked to generate their own outline or framework of prior knowledge at start to stimulate recall and provide hooks for integrating the new information. Learners could also generate their own questions to be answered at the start and fill in the blanks as they go through the program.

No matter what type of notebook is incorporated, there is a need to teach use of the learning strategy. Students using even simple notetaking have difficulty selecting the major concepts and including the appropriate level of detail. Many simply copy verbatim and never elaborate with their own prior knowledge, a strategy proven ineffective. Outlining and concept mapping are even more challenging. Unless the strategies are understood and carried out correctly, they will be ineffective, considered burdensome, and probably not used.

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Title:

What is Nursing Informatics?

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What is Nursing Informatics?

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Abstract: Information technology has developed to the point of providing a means to effectively manage nursing and related health care data for nursing administrators, educators, practitioners, and researchers. Therefore, the newly recognized area of nursing informatics is important to the nursing profession as a whole. Nursing schools and health settings, in which nurses must prepare for or function in their nursing roles, must fully utilize the nursing informatics capabilities currently available. Technologically enhancing nursing will ultimately improve client care.

Background

The amount of information available in health care continues to grow by leaps and bounds. This vast quantity of information makes it difficult to manage. To further complicate the issue, the dissemination of this information is not timely and this is related to the time gap between submission and publication of journal articles. According to Werley and Grier (1981), "the information with which nursing is concerned is broader than that in other health care fields. If nursing is to continue to provide patient care, can it afford not to emphasize the computerization of information?" (p. 319). Nursing is a broad, practice-based profession and needs a variety of information to be readily available. Therefore, nursing informatics evolved--nursing's integration of information and computer science--to enhance client care and the nursing profession.

However, the mountain of health care information available and the need for timely information to enhance client care is not unique to nursing. The medical field has recognized the need to harness the information explosion and facilitate the dissemination of relevant information. The National Library of Medicine (1986), in its Report of Panel 4, has asserted that "by 1996, one fifth of American medical schools will offer training in medical informatics and all American health science schools will offer training in medical informatics as part of their curricula" (p. 67). As a means to this desired goal, nursing must work collaboratively, so that nursing informatics can augment the health data field in such a way that nurses' skills and knowledge enable them to efficiently and effectively manage the ever increasing amount of health care data available today.

Introduction

Currently, nurses are not adequately prepared to integrate computer and information science technology (Romano, 1988). The result of this technological retardation affects every aspect of nursing. Therefore, nurses must be able to understand the potential uses of computers in both information management and research to fully benefit them in their work settings. Nursing must be able to move forward and embrace the potentials that computers and information systems offer.

Nursing Informatics

Nursing informatics means so much more than simply utilizing computers. It is the integration of computer and information science into the nursing practice settings to ultimately enhance client care and the nursing profession as a whole. Nurses must be able to manage, manipulate, and disseminate data, information, and knowledge. Data refer to raw facts that have no meaning in and of themselves, but information is processed data that is given meaning. It is important to note that each user has a knowledge base from which they draw in order to assimilate information. Knowledge is considered to be a body of related information. However, not all information is informative to everyone. The related scraps of information are integrated and synthesized to form a knowledge base for the individual. Therefore, nursing informatics, as adapted from McGonigle and Eggers' (1991) definition, is the synthesis of nursing science, information management science, and computer science to enhance the input, retrieval, manipulation, and/or distribution of nursing data, information, and knowledge for the four areas of nursing to enhance client care while advancing the profession of nursing.

Nurses must integrate nursing informatics into their professional lives. When nurses in all four areas of the nursing profession have a firm nursing informatics knowledge base, they will no longer have to rely solely on commercially available nursing systems but may be able to escalate to the level of designing and developing their own nursing systems to meet specific needs.

Nursing Administration

The nursing administrator is responsible for coordinating, supervising, and facilitating subordinates to work toward the goals and objectives of the institution in which they practice. They also integrate research findings, conduct research studies, and assist with research efforts under their governance. They are also educators at times, as well.

Administrators are able to access more than 150 functions, depending on the system used in their practice facility and these functions range from budget preparation to personnel surveys and beyond. Additionally, they have access to quality assurance worksheets and collation.

Nurses in these positions have a variety of uses for their electronic communications that range from administrator to administrator, administrator to nursing employee, administrator to patient, administrator to physician, and administrator to other health care employees. Furthermore, they are able to network within their facility, across the state, country or the world, and they can access electronic bulletin boards and/or even create their own. Administrators can electronically manage their personnel files, budgets, payroll, census, staff planning, staff allocation, and summary reports. With the move toward the concept of case management, they can develop the critical pathways and electronically manage this data and information. As if this integration is not enough, word processing, spread sheets, and database management programs can further facilitate their roles.

Nursing administrators must support the integration of nursing informatics into their settings to enhance the nursing profession. They could also benefit from the integration of nursing informatics into their specialty area of nursing. Nursing administrators are able to electronically manage their data, including personnel and client data, and the electronic networking capabilities that link them with other administrators and promote collaboration. Since administrators are responsible for all four areas of nursing, they must assume responsibility for the integration of nursing informatics into each area. It will be their commitment to the increased integration and exploration of technological advances that will enhance nurses' job performance and the advancement of the nursing profession.

Nursing Education

Nurse educators impart knowledge and skills. These nurses also incorporate research findings and conduct and assist with research studies. There has also been an increase in the number of nursing educators that are currently practicing as well.

Within recent years, the health care field has experienced a growth in the number of facilities utilizing personal computers to meet their inservice, staff education, and patient teaching needs. These facilities have also integrated client discharge educational plans. As a result, the nurse educator can use computer assisted video instruction (CAVI), computer assisted instruction (CAI), compact disc interactive (CDI), computer mediated instruction (CMI), expert systems, and knowledge synthesizers. Thus, the nurse educator preparing nursing students must be informatics competent to fully prepare their students for the real world of the registered nurse through the use of multimedia and computerized testing. Additionally, the nurse educator needs to both demonstrate and utilize a variety of information systems that the students might encounter during their clinical rotations and on the job after graduation. More importantly, nurse educators must require nursing students to be informatics competent and capable of maneuvering within an electronic environment in order to conduct electronic literature searches and navigate within electronic bulletin boards and electronic mail systems.

Nursing education must assess the nursing informatics' needs of the nursing profession and make necessary curricular changes to better prepare their students because the entry level professional can no longer be technologically retarded. This beginning practitioner needs to be informatics competent. Nursing schools are not adequately preparing their students for computer use, and nurses, who are currently working and want to learn about nursing informatics, are not afforded continuing education course work in this area. Therefore, nursing educators must begin to incorporate and utilize nursing informatics throughout their nursing curriculums.

Nursing Practice

Nursing practice refers to nurses who provide direct care to the client, coordinate and supervise subordinates who are also providing direct client care, and oversee the education of peers, subordinates, and clients. This nursing area focuses on health promotion, maintenance, early detection, and intervention. Furthermore, practicing nurses integrate current research findings and assist with clinical research efforts.

The nurses who are practicing at the client's side are using computers and information science to manage their client's electronic data. They also need timely accurate information to enhance their nursing skills and client care. The use of electronic bulletin boards, databases, and networking with other professionals will greatly enhance their ability to access needed information. Utilizing nursing informatics, practicing nurses would be able to retrieve up to date information electronically rather than waiting for the journal article to be published because by publication date, the information may be outdated. Thus, practicing nurses can greatly improve their client care by having access to electronic information and networking. The networking capabilities have linked nurses across the country and beyond. This high-tech communication capability facilitates collaboration and clinical research, an area of priority since nursing is a practice-based profession.

In their direct care role, the use of automated nursing notes has already increased. These notes contain nursing orders that require medical orders, as well as independent nursing functions including the nursing process documented on the care plan. As the nursing profession moves toward case management, critical pathways will be electronically documented, monitored, and researched. There are many functions that have become electronic including the nursing process, transfer notes, and discharge plans and summaries.

Nursing Research

The nurse researcher is looking for solutions. This nurse can also be an educator or currently practicing. A nurse researcher uses information retrieval methods that are vastly improved. Electronic media are timely and provide the researcher with immediate data, information and knowledge. Enhanced data processing methods, database management systems, statistical analyses, graphic displays, and text editing capabilities facilitate the research effort even more. An example of this can be seen with word processing packages that place text into manuscript style with specific style formats available.

As on-line information sources continue to develop and become refined, data, information, and knowledge can be available within minutes of its submission. Nursing researchers will be able to quickly disseminate their findings using electronic formats and will also be able to electronically locate current and accurate information as more bulletin boards, newsletters, and journals move toward becoming available on INTERNET.

Electronic networking capabilities assist nursing researchers by linking them in communication with other researchers who share commonalties. This enhances collaboration and joint research ventures. Coupling the networking capabilities with the ability to access, retrieve, input, and manipulate data greatly promotes nursing research efforts. The immediate dissemination of research findings will enhance the nursing profession as a whole.

Summary

Each of the four areas of nursing can benefit from using nursing informatics and the functions are shared across the four areas. That is, nurses who are providing direct care use functions once thought to be only for research, administration, and/or education. In some instances, nurses are now evolving from users to developers of systems designed specifically to meet nursing needs. They are no longer looking to others to design systems to solve their problems. Instead, they are developing the systems.

Nursing informatics must come of age; it is important to meet the challenges currently facing the nursing profession while preparing for nursing's future. As the nursing profession embarks on incorporating the state-of-the-art electronic capabilities into nursing informatics, it must also project and embrace the future direction of the technological explosion. Nurses must be informatics competent to continue to grow professionally while fostering the growth of the nursing profession.

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Title:

The Effects of Multimedia Presentation Formats on the Spatial Recall of a Narrative

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This study investigated four types of media formats: talking head, voice-under-text, voice-under-video and multiformat (a combination of talking head, voice-under-video and text). Sixty-four suburban middle school students were shown four different narrative stories; each story was presented to the students in a different media format. The four stories were exactly the same except for the format of presentation. The students were tested to determine what they remembered about each story through verbal recall and a spatial task. The verbal recall results in this study indicated that memory of a narrative differed significantly, depending on whether it was shown in a talking head, voice-under-text, voice-under-video or multiformat presentation. More particularly, the formats of presentation which appeared to most enhance memory of a narrative were the primarily visual formats (multiformat and voice-under-video). Students were less apt to remember stories presented in the primarily audio formats (voice-under-text and talking head). In contrast, initial analysis of students' spatial recall was inconclusive. However, we argue that this was due more to the inadequacy of the spatial scoring schemes to reflect the real differences in the drawings. This paper reports the verbal recall findings of the study and suggests how the spatial task findings can be reviewed and evaluated to further an understanding of the relationship of format of presentation to understanding.

INTRODUCTION

A multimedia presentation combines the inherent media attributes of different electronic technologies to produce a message which uses the auditory/verbal and visual/pictorial channels of information processing. Just as the choice of a medium is important to how a message is received and understood, so too is the choice of the format of presentation within that medium because of the possible effects it may have on the perception and ultimate understanding of the message. Research on the interplay between the auditory/verbal and visual/pictorial channels of information processing suggests that understanding of electronic media presentations is determined not only by the clarity of the message being presented, but also by the associations made between the two cognitive channels during processing.

There have been many investigations comparing children's understanding of visual and verbal information presented in television programs. Some have concentrated on defining the distinctions between iconic and symbolic modes of representation (Bruner, 1966; Glass, Holyoak & Santa, 1979). Other research has concentrated on the behavioral issues associated with visual-auditory presentations, such as vocal characteristics (Shosteck, 1973; Burgoon, 1978; Beighley, 1952; Hadwiger, 1970; Smith & McEwen, 1973) or eye contact with the camera lens (Tankard, 1970).

The inherent characteristics of a newscast itself also have been found to influence a viewer's perception. For example, viewers are more apt to believe (Baggaley, 1980), agree with (Allen, 1973), or recall unfamiliar information (Davey & Kapinus, 1985) presented first in a newscast. The pace or action of a televised presentation also appears to influence understanding: children are less apt to understand and recall televised information that is presented through dialogue than content presented with moderate to high rates of character action (Calvert et al., 1982; Hayes & Birnbaum, 1980; Watkins, Calvert, Huston-Stein & Wright, 1980). On the other hand, increasing the video pacing of a film does not appear to affect recall (Schlater, 1970). It has also been shown that there is a relationship between the visual and verbal memory of televised messages and the emotional valence of that message (Fiske, 1982; Bradley, Greenwald, Petry & Lang, 1992; Bower, 1981). The left hemisphere of the brain is associated with positive messages and the right side of the brain is thought to process negative messages best (Lang & Friestad. 1993; Davidson. 1985). Furthermore. since it is generally believed that the left hemisphere of the brain is the verbal processor and the right hemisphere is the visual–spatial processor (Kinsbourne, 1982), there have been suggestions that there is a relationship between the valence of the message and it's format of presentation with regard to the memory (Reeves, Lang, Thorson and Rothschild, 1988).

A tremendous amount of television research has focused on what Salomon (1974) refers to as the "inherent symbolic media attributes". In general these media attributes can be defined independently of the narrative content (Coynil. 1974). For example. cuts have been shown to increase interest in a film (Kraft, 1986) and serve as visual punctuation (Carroll & Bever, 1976) as well as a method of setting the pace of the film (Giannetti, 1982).

Viewer comprehension of an electronic media presentation is influenced by many factors and interactions including how the information is organized and linked to knowledge structures in long term memory. In general, these frames (Minsky. 1975); scripts (Shank and Abelson. 1977); or schemata (Anderson, Spiro and Anderson, 1978), as they are variously referred to in the literature. are used to facilitate a subject's ability to make inferences about a concept. Some researchers believe that to understand the influence electronic media has on learning it is important to understand the skills needed to process the form of a message as well as its content (Clark, 1975; McLuhan, 1964. Olson & Bruner, 1974). These skills include visual and verbal analysis. perspective taking and spatial manipulations. The media attributes which affect knowledge acquisition are not limited to the physical representation of the message. When an individual is presented with information about an event. a different set of rules will be applied if that event is read in a newspaper rather than presented on radio (Williams. Paul & Ogilvie. 1957; Wilson. 1974). or if the message is seen on television in a talking head format, rather than in a video format (Katz. Adoni, et.al.. 1977; Edwardson. Kent & McConnell. 1985). Furthermore. research suggests that there are hemispheric differences in information recalled from global versus local processing (Hansen. 1981) or positive versus negative emotions (Davidson, 1985).

The effect of media attributes on the message is perhaps most pronounced in multimedia productions because several electronic media forms are combined to create one presentation. The attributes of one medium interact with those of another and it is these interactions that ultimately form the attributes of multimedia. Therefore, it is necessary to analyze the parts of a multimedia presentation. such as format of presentation. to define the whole.

The formats of presentation examined in this experiment included those most often used in multimedia productions: talking head, voice–under–text, voice–under–video and a multiformat combination of all three. These formats are familiar to students as they are frequently used individually or in tandem in all electronic media presentations. The question asked in this experiment was a simple one: would children remember more about a narrative if it was presented in one format rather than another. Specifically, when subjects were given simultaneous, or near simultaneous signals from multiple sources.

how were those stimuli encoded by the subject to be either stored and utilized in long term memory, or discarded as irrelevant?

Method

Subjects

Sixty-four students from Westchester County, New York participated in the experiment. The 32 boys and 32 girls participating in this experiment ranged in age from 12 years 7 months to 15 years 1 month and were racially and ethnically mixed to include 51 White, 5 African-American, 4 Latino and 4 Asian children. English was the first language for all the students. The students were evenly distributed to view the four sequences of the experiment: eight boys and eight girls saw each story once and each media format condition once.

Materials

Formats of Presentation

Each story was produced in four formats of presentation: talking head, voice-under-text, voice-under-video and multiformat, which is a combination of the three. The talking head was taped in a studio with a noninterfering blue backdrop. A female announcer read from cue cards placed near the camera lens to replicate the style of most video announcers. She did not appear to be reading the story from a text and she looked straight into the lens to increase believability and influence recall (Tankard, 1970). The pace of the presentation was between 160 and 180 words per minute, within the ideal range for memory (Schlater (1970). The soundtrack from this initial taping was used for the other three presentation formats. Thus, the audio, including vocal inflections and timing, was consistent across all four experimental conditions.

The voice-under-text used in the experiment was designed to suggest an interactive computer screen. The text was shown in serif font with white letters on a blue background. Each "page" was numbered at the bottom of the screen and there were ten lines of text on each "page". This was in keeping with the recent literature on screen design (Faiola and DeBloois, 1988).

The voice-under-video format was produced by first laying down the soundtrack on a 3/4" tape. Video which was redundant with the audio of the story was then copied onto the soundtrack. For example, if the text described a man at work on a sewing machine, a video showing a man working at a sewing machine was shown.

The final format used in the experiment was produced by combining talking head with the voice-under-video and then enhancing the film with key points of the story by using captions over the video. These captions were chosen from the main headings of a conceptual map developed from the text.

Each of the testing materials designed and used for this study were unique: each of the formats of presentation had their own individual characteristics, and each of the narratives were organized in a different structure or with a different purpose. The formats of presentation were categorized as being either primarily audio or primarily visual. The talking head and voice-under-text were primarily audio because the main focus of the viewer of a presentation in either of these formats was on the audio portion of the narration. In other words, the visual representation of the story through text on the screen provided additional information, but was not the primary focus of the viewer's attention. Similarly, the eye contact of the narrator may have provided an additional incentive for the viewer to listen to the story, but no additional information about the narration was projected.

The primarily visual formats identified in this study were the voice-under-video and multiformat presentations. In each of these formats, the primary focus of the viewer was the image on the screen. Admittedly, the audio portion of the film provided a structure to the images being projected on the screen, but it was the visual image which seemed to enhance cue recognition for information processing and retrieval. In the voice-under-video presentation there was no break in the visual images being projected over the audio narration. This was not the case in the multiformat presentation because the video portion was interspersed with clips of the talking head and captions of text. Theoretically, the two formats should compliment each other by directing and maintaining the attention of the viewer.

The Stories

In general, understanding and remembering the events of a dramatic story utilize the same processes people empower to understand and recall other events and presentations (Bower and Black, 1980). Since narrative, dramatic stories have proven to be valuable in testing children's understanding of media presentations (Meringoff, et.al., 1983), four original narratives were written for this experiment. The stories were intentionally diverse to eliminate any confusion when subjects were asked to recall the presentation. The four narratives were: "A Child is Taken", "The Strength of Memories", "Return to the Sea" and "The Sound of Hatred".

"A Child is Taken", was about a young child being kidnapped from her home in the middle of the night. Time and space were key factors in understanding the inferences presented in this narrative which sequentially presented the events surrounding the kidnapping and vividly described the scene of the crime. A second story, entitled "The Strength of Memories", was about a prisoner in Auschwitz during WWII. It was presented as a series of abstract recollections by a man confined to a German prison cell. There was nothing sequential or predictable about the story as it described the man's girlfriend, his family, and his past career as a champion boxer. This was the most abstract of the stories and the one which required the most concentration on the part of the viewer. A third narrative, entitled "Return to the Sea", was about a beached baby whale. Though time and space were important to this story, the primary structure of the narrative was a problem to be resolved. This was the most positive of the four narratives. A fourth story, entitled "The Sound of Hatred", was about Apartheid. It was written to be an emotion-evoking depiction of a powerful event: the attack of a South African village by white military. In this narrative, an ominous tone was set at the beginning of the story when the narrator asked: "What was that sound?". The subject did not know what to expect. but the scenario implied something negative. The "why" of the event was never given, however inferences were clearly presented about the occurrence to suggest racial prejudice and injustice. It should be noted that three of the stories ("A Child is Taken", "Return to the Sea" and "The Sound of Hatred") were more schematically predictable than the other story ("The Strength of Memories"). Also, "A Child is Taken" and "The Sound of Hatred" ended on a very negative emotional tone, whereas "The Strength of Memories" and "Return to the Sea" ended with positive connotations and inferences about what had happened and was expected to happen next.

Procedure

Since each story was produced in four media format conditions, there were sixteen segments to be manipulated for the experiment. Four sequences were made and each story in each format was used once. The order of the format was manipulated in the four sequences of the experiment so that each format was in every position once. No format was in the same position more than once: however, a story may have been in a position more than once. The four presentation sequences used in the experiment are listed in Table 1.

Table 1 — Order of Video Presentation for Each Sequence

Ord	Sequence I		Sequence II	
1	Multiformat	A Child is Taken	Talking Head	Sound of Hatred
2	V-U Text	Sound of Hatred	Multiformat	Return to the Sea
3	V-U Video	Return to the Sea	V-U Text	Strength of Memories
4	Talking Head	Strength of Memories	V-U Video	A Child is Taken
Ord	**Sequence III**		**Sequence IV**	
1	V-U Video	Sound of Hatred	V-U Text	Return to the Sea
2	Talking Head	Return to the Sea	V-U Video	Strength of Memories
3	Multiformat	Strength of Memories	Talking Head	A Child is Taken
4	V-U Text	A Child is Taken	Multiformat	Sound of Hatred

The experiment was designed to show each student a different story under four different media format of presentation conditions. As a result, each format/story combination was seen by 16 students. The students viewed a video tape of the four stories, completed the personal media information sheet, ranked the titles of the stories and performed four tasks for each story — verbal recall, spatial task, forced-choice recognition and continuation. The students were shown the tape and interviewed individually. The total time to view the tape was 18 minutes. The total time for the experiment was 1 hour and 15 minutes. The dependent variables used in this study were: the proportion of propositions recalled verbally; the proportion of forced choice recognition questions answered correctly; the proportion of propositions recalled in the spatial task; and the type of elaborations made in the continuation of the story. As stated previously, this paper focuses on the findings of the verbal recall and spatial task activity.

In the verbal recall analysis the interviewer asked each subject the following question and audio taped the response for later transcription and analysis: "The title of the first story you saw was: (Title of Presentation) Suppose I didn't see or hear this presentation. Tell me everything you can remember about this story." There were four different tasks to determine spatial recall. The task for "A Child is Taken" asked the students to imagine they were investigating the Armstrong kidnapping and needed a map of the scene of the crime which would show the route taken by the kidnappers as well as clues which may have been left. In the task for "The Strength of Memories" students were asked to imagine they wrote history books about boxers and wanted to include a map of the town where Salamo was raised. The spatial task for "The Sound of Hatred" asked subjects to imagine they were newspaper reporters and were covering the raid to the Crosstown Settlement. They needed to draw a map of the settlement for the article. In "Return to the Sea" students were asked to imagine they were movie directors and needed to draw a story board of the scene when the baby whale was saved by the villagers.

Coding Procedures

Each story was broken down by propositions (Kintsch & VanDyke, 1975) for analysis and coding. Subject recall of the narrative was coded for each proposition to reflect if the proposition was recalled and whether that recall was an exact or synonymous replication of what was stated in the text or whether it was recalled erroneously by the subject. A coding sheet was also designed to record subject recall of the spatial aspects of the presentation. This coding sheet served as a way to evaluate a drawing made by the subject in accordance with specific propositions from the presentation. For example in "The Sound of Hatred" certain items were mentioned in the narrative such as shelters, a road, a bus stop and a raw sewage ditch. The spatial task drawings by the students were evaluated to show whether the students drew the items, textually represented the items on the spatial map or neglected to represent the items in any manner for the task.

Results

Overview

The influence that format of presentation had on a subject's verbal recall of a narrative was the strongest finding in this study. Not only did the overall verbal recall of the narrative differ significantly among groups of students who saw the talking head, voice-under-text, voice-under-video or multiformat presentation condition, but also, when the variance due to the influence of the other independent variables (story, age and gender) was removed in an analysis of covariance, the variance among the different format of presentation groups continued to be significant. Furthermore, whether the narratives were analyzed separately or together, the formats that generally showed the highest mean proportion of propositions recalled, were the primarily visual formats (multiformat and voice-under-video). Specifically, the proportion of propositions verbally recalled by the students differed significantly among the four formats of presentation: students remembered the most about stories shown in the more visual formats (multiformat and voice-under-video): and students remembered the least from the primarily audio formats (voice-under-text and talking head). The greatest proportion of propositions recalled was from narratives shown in a multiformat presentation and the least proportion of propositions was recalled from stories seen in the talking head format. The spatial task findings were basically inconclusive and will be discussed later.

Verbal Recall Results

The proportion of propositions recalled verbally were computed for each student according to the coding procedure described previously. Analysis of this data showed significant main effects for three (format, story and age) of the four independent variables used in the study. Specifically, the proportion of propositions verbally recalled by the students differed significantly among the presentation formats: talking head, voice-under-text, voice-under-video and multiformat ($F_{(3,252)}=11.29, p<.001$). Furthermore, when the nuisance effects of the other independent variables (story, age and gender) were removed in an analysis of covariance, the proportion of propositions verbally recalled still differed significantly among the talking head, voice-under-text, voice-under-video and multiformat presentation formats ($F_{(3,249)}=11.32, p<.001$). The highest mean proportion of propositions recalled was by students who saw multiformat presentations (.29) and to a lesser extent, voice-under-video presentations (.27). Students who saw the stories in the voice-under-text (.23) or talking head (.20) formats recalled fewer propositions from the narratives.

Table 2 shows the individual and overall mean and standard deviation of the proportion of propositions recalled from presentations shown as a talking head, voice-under-text, voice-under-video and multiformat.

Table 2 — Proportion of Propositions Recalled Verbally by Format of Presentation

	Talking Head	V-u-Text	V-u-Video	Multiformat	Entire Population
Mean	.1991	.2320	.2728	.2923	.2491
Std. Dev.	.0764	.1032	.1076	.1070	.1052

The second independent variable showing a strong main effect significance was story. The proportion of propositions verbally recalled by the students differed significantly among "A Child is Taken", "Return to the Sea", "The Sound of Hatred" and "The Strength of Memories" ($F_{(3,252)}=5.80, p=.001$). In general, it was found that students recalled the most from the two positive narratives, "Return to the Sea" (.28) and "The Strength of Memories" (.27). The most predictable story, "A Child is Taken" (.23), ranked third in the proportion of propositions verbally recalled by students in the study, and "The Sound of Hatred" (.22) was recalled the least among the students. This last story most resembles a news documentary.

Spatial Task Results

The proportion of propositionally relevant items drawn on the "spatial map" were analyzed for each student. Table 3 shows the mean and standard deviation of that recall by format of presentation.

Table 3 -- Proportion of Spatial Items Recalled by Format of Presentation

	Talking Head	V-u-Text	V-u-Video	Multiformat	Overall
Mean	.4008	.4206	.4134	.4272	.416
Std. Dev.	.1584	.1676	.1729	.1790	

Analysis of variance of the proportion of items recalled by students during the spatial task did not show independent variable effects for format, age or gender. However, the proportion of spatially recalled items did show a main effect story significance among "A Child is Taken", "Return to the Sea", "The Sound of Hatred" and "The Strength of Memories" ($F(3,224)=21.50$, $p<.001$). Students recalled the most from "Return to the Sea" (.52) and progressively less from "The Strength of Memories" (.44), "A Child is Taken" (.39) and finally "The Sound of Hatred" (.32). This was consistent with the verbal recall findings in the study. The two-way interaction of format and story was also significant ($F(9,209)=2.06$, $p<.05$), but none of the other interactions were significant.

Since story was the only independent variable that showed a main influence on recall for spatial task, the stories were investigated further to see if there was an individual story-format relationship. Table 4 shows the mean proportion of spatial items recalled when the stories were analyzed separately. Only "The Sound of Hatred" differed significantly in the proportion of items recalled by students who saw the voice-under-text (.40), talking head (.35), voice-under-video (.26) or multiformat (.26) presentations ($F(3,60) = 3.75$, $p<.05$).

Table 4 -- Mean Proportion of Spatial Items Recalled by Format and Story

	Talking Head	V-u-Text	V-u-Video	Multiformat	Total Population
CHILD	.35	.34	.39	.46	.39
RETURN	.50	.51	.52	.55	.52
SOUND	.35	.40	.26	.26	.32
STRENGTH	.40	.44	.48	.44	.44

Conclusions

The findings reported here suggest that format of presentation does influence the memory for a narrative. Significant differences in the proportion of propositions verbally recalled were found among stories presented as talking head, voice-under-text, voice-under-video and multiformat presentations. Students who viewed the primarily visual formats (multiformat and voice-under-video) showed the highest recall and students who viewed the primarily audio formats (voice-under-text and talking head) recalled fewer propositions. Also, more was recalled from the more positive narratives than the stories with a relatively negative slant.

Since the verbal recall findings were so strong, it showed that there were memory differences associated with presentation formats, but the coding procedures used to evaluate the spatial tasks of the students were so rough they were unable to adequately reflect the differences in the drawings. The coder was instructed to look for certain items on the spatial task sheet and mark only whether they were represented in some manner by the student. As a result, this static evaluation lost the creativity of the drawings as well as their uniqueness. For example, as can be seen in the attached drawings, subjects 4 and 46 saw the same version of the experiment. However, each subject had a different interpretation of the tasks. Some drawings are very "busy" and the student completely covered the space provided for the spatial task with incidental scenery, people or other information about the story. Another drawing by that same student is a very verbal, textual representation the task for the story. This contrast in drawings by the same student was neither recognized nor evaluated with the current coding scheme. More sensitive coding procedures could be developed to identify unique drawing patterns within each format of presentation for comparison and analysis.

Furthermore, the fact that the task for each story was different confounded the problem of accurately interpreting a student's spatial memory for a story. For example, the most structured task was for "Return to the Sea" and included a story board for students to use to draw certain scenes from the narrative. Students were able to draw the most propositionally relevant items for this story. On the other hand, the tasks associated with the other three stories gave students about the same amount of structure to stimulate their response in the spatial drawing. It is interesting that the proportion of spatial items recalled from these stories were about the same.

Finally, a coding scheme could be developed to see if there was a positive-verbal and negative-visual relationship among the presentation formats, the stories, and the drawings. For example, did students who saw the primarily visual presentation formats (voice-under-video and multiformat) display more recall in the spatial task for the more negative stories ("The Sound of Hatred" and "A Child is Taken") than the positive stories? Similarly, did students who viewed the primarily audio presentation formats (talking head and voice-under-text) display less recall of the negative stories than the more positive stories ("Return to the Sea" and "Strength of Memories")? The coding procedure to determine this relationship would need to reflect a sensitivity to the media formats, the emotional valence of the stories, the spatial task of the drawing and individual differences in a subject's drawing ability. That information could also then be compared to the students verbal recall and forced recognition performance of this study.

Much more analysis is needed to further advance the implications of the findings in this particular portion of the study. However, if one conclusion can be drawn from the data provided in this study, it is that each format of media presentation has unique attributes which interact with, and enhance the memory for, a variety of information.

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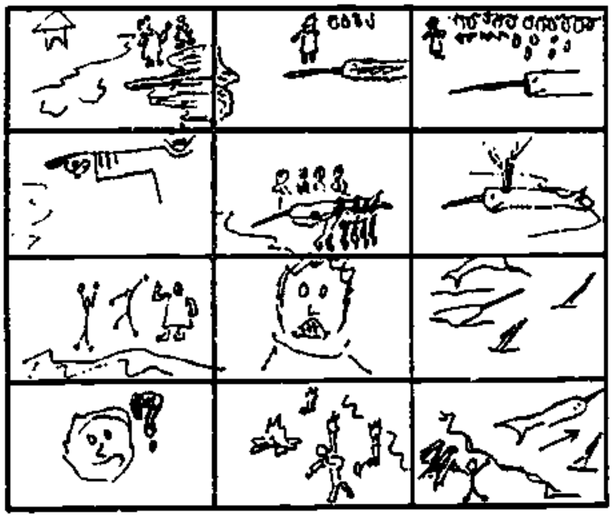

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Format=M Story=Return

Subj.=4 Vers.=2
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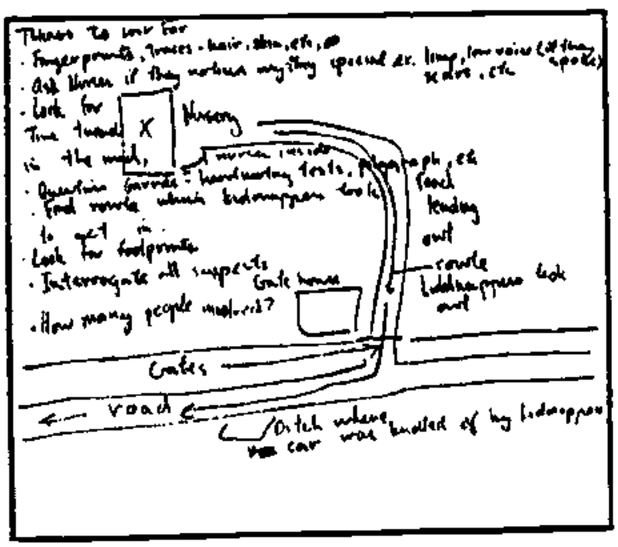

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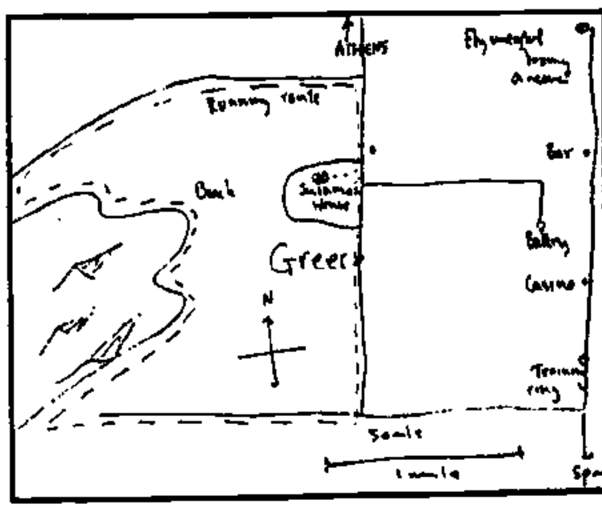

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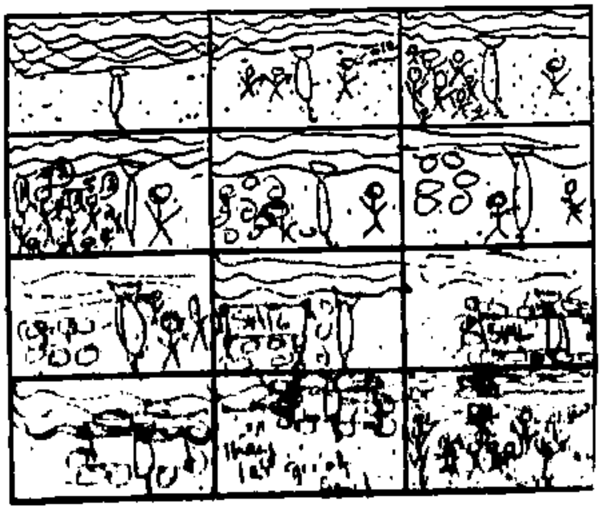

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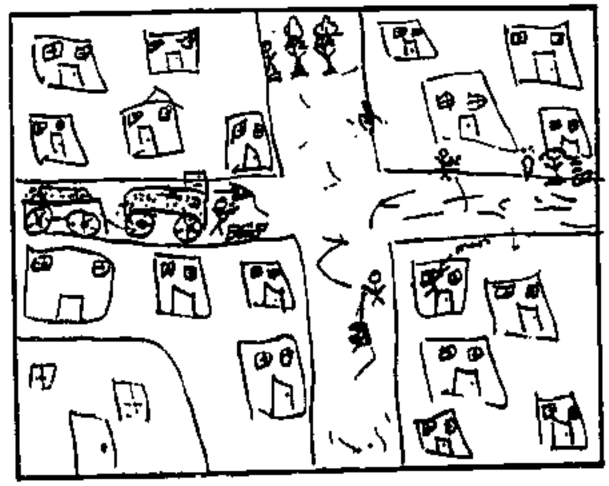

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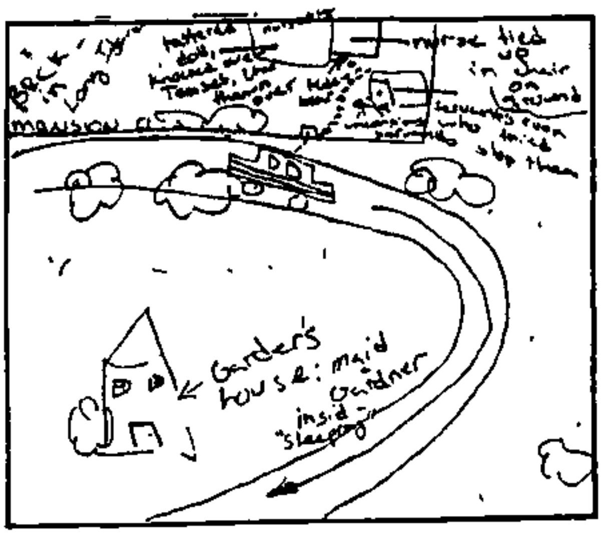

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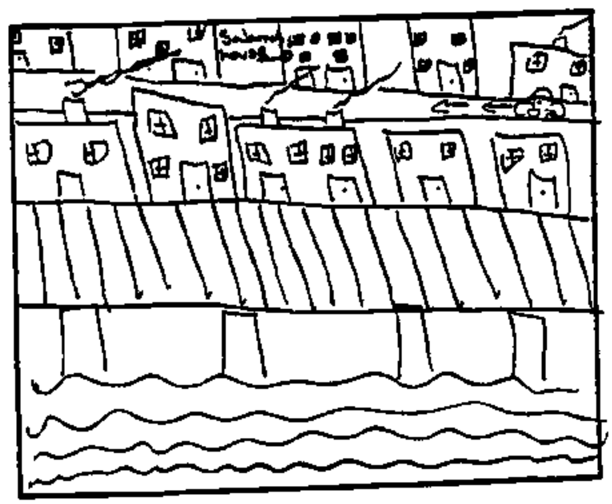

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Title:

Macro I.S.D.: Using an Instructional Design Paradigm to Plan Non-Traditional Degree Programs

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Macro I.S.D.: Using an Instructional Design Paradigm to Plan Non-Traditional Degree Programs

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Introduction

Walter Dick has reminded us that with the advent of new ideas, such as constructivism and total quality management in education, we are faced with the need to reassess the viability of our existing paradigms and models, such as instructional systems design (Dick, 1993). Models, such as the systems approach, remain viable as they are able to be used to solve our problems. Although ISD has traditionally been used as a micro-level model to design instructional interventions, there has been, in recent years, an encouraging trend of using the systems approach for more macro-level applications, such as performance technology (Mager, 1987; Mager & Pipe, 1984; Rossett, 1990) and educational systems design (Banathy & Jenks, 1990; Kahn & Reigeluth, 1993; Salisbury, 1990).

The purpose of this paper is fourfold:

- To provide an overview of nontraditional degree programs.
- To demonstrate that the difference between traditional instruction and ISD is analogous to the difference between traditional and nontraditional degree programs.
- To present an example of how a popular instructional systems design model can be adapted for use at a macro level to design nontraditional degree programs for adult students.
- To demonstrate that the systems approach is a viable model that can offer solutions to various types of educational problems.

The problem

Adult re-entry students, those 25 years of age or older who have returned to pursue college studies, are the fastest growing segment of our student population. Of all currently enrolled college students, two out of five belong to this group (Klein, 1990). Until recently, our present college system has had difficulty meeting the needs of these learners, who often feel out of place or "behind" younger peers who entered college straight from high school (Klein, 1990; Pierson and Springer, 1988). Re-entry students are generally highly motivated (Pierson and Springer, 1988) and achieve at a level equal to or higher than younger students (Klein, 1990). It appears that adult re-entry students bring certain critical skills and experience that enables them to more fully avail themselves of educational opportunities.

Unfortunately, many professionals and other working adults have encountered a great deal of difficulty in their efforts to further their education. Many factors contribute to this difficulty, including a lack of available courses that meet after work, location of classes, insufficient independent study or correspondence courses, difficulty in transferring units from several institutions, residency requirements, and lack of programs that meet individual learner needs. Many of these adult learners are facing a dilemma. They find themselves in need of a college degree to advance in their careers or desire personal enrichment, but cannot leave work to do so.

Although professionals often have skills and expertise which far surpass lesser experienced full time college students, they may lack sufficient "units" for an undergraduate degree. Many express a feeling of frustration (ie. "With my current schedule, I'll never have time to finish my degree.")

Special programs for adult learners

In response to these needs, many colleges and universities are now providing special programs that allow working adults to complete their degrees by attending classes at nights or on weekends, sometimes at their actual work site. Many of these institutions offer accelerated courses that can be completed in less than a typical semester. More institutions of higher learning are offering independent study and correspondence courses and accepting higher amounts of these courses as transfer units. The amount of courses taught via distance learning, television, videotapes, cassettes and other forms of alternative delivery increase dramatically with each new year.

Several colleges have established learning centers in cities and military bases across the nation. Students may pursue degrees at these centers and complete their residency requirements without having to take courses at the home campus.

Nontraditioninal degree programs

More innovative and controversial than the external academic centers are the "alternative" or "nontraditional" external programs. These programs have characteristics that differ radically from traditional degree programs (Bear, 1988, 1990; Thorson, 1992).

- They often require little or no residency at the degree granting institution
- Nontraditional programs are built upon the concept that college-level knowledge can be learned both inside and outside the classroom. These programs tend to be much more liberal about how degree requirements may be fulfilled than traditional programs.
- Knowledge gained outside the classroom can be assessed by College Level Examination Programs (CLEP), Graduate Record Examinations (GRE), DANTES examinations (military), and portfolio assessments. These assessments allow learners with college level knowledge to receive credit for their skills and expertise and reduce the length of time to finish their degrees.
- Alternative learning experiences, such as books written, research reports, computer programs, and other independent projects can be used to fulfill the requirements for a degree.
- Nontraditional programs generally assume that the learner has amassed a high degree of knowledge and experience prior to commencing his or her degree program.
- Many programs allow individualized majors to be designed by the learner, in conjunction with a faculty mentor or committee.

Differences between traditional and nontraditional degree programs are illustrated in Table 1. A few of the tenets of alternative programs, such as the awarding of college credit for experiential learning, have met with criticism (Bailey, 1979). Some educators have expressed concern about the quality of nontraditional programs (Bowen, Edlestein, and Medaker, 1979), while others think that any program that deviates from the well-established norm must be a diploma mill.

Quality of nontraditional degree programs

Advocates of alternative degree programs point to the fact that their institutions are accredited by the same regional associations that accredit the traditional schools (Andrews, 1978) and that the American Council on Education has clear guidelines for the evaluation of such programs (ACE Task Force, 1990). Another testament is the fact that one of the most popular guides of alternative programs lists well over 100 accredited colleges and universities that offer off-campus college degrees, including some very well-known and prestigious private and state universities (Thorson, 1992). It is claimed that these programs are geared toward individual learner needs, rather than institutional needs, and that greater involvement and active learning is required from each student.

Studies conducted in Michigan and Texas suggest that degrees achieved through alternative programs are successful in meeting the needs of adult learners who enroll in these programs. In the Michigan study, 130 traditional and 182 nontraditional alumni showed no significant differences in their perception of their degree's importance in improving pay and promotion, effectiveness in obtaining jobs, ability to improve job skills and work performance, and enhancement of career development (Firenze, 1984).

Nontraditional students rated significantly higher in satisfaction of having the degree, enjoyment of the learning experience, and desire to obtain prerequisites for graduate education than their traditional counterparts. Nontraditional students also placed a higher value on learning the subject area for pure interest purposes (Firenze, 1984).

In the Texas study, 863 graduates of a nontraditional program showed a high degree of satisfaction in career usefulness of the degree, improved self image, level of difficulty compared to traditional programs, and salary increase. It was suggested that the quality of both traditional and nontraditional degree programs should be assessed by the satisfaction of its graduates, rather than by less relevant criteria, such as student selectivity, admissions and programmatic homogeneity (Pierson and Springer, 1988).

Macro I.S.D.

Systematic instructional design as a metaphor

Proponents of instruction systems design (Dick and Carey, 1990; Gagné, Briggs and Wager, 1988; Knirk and Gustafson, 1986) have held to a more learner-centered conception of the instructional process (Reiser, 1987). When instruction is developed according to a systems view, it is viewed in terms of learner performance, rather than teacher or institutional performance (Mager, 1987). This learner-centered orientation of instructional designers is also the orientation championed by proponents of alternative degree programs.

The literature on alternative degree programs versus traditional degree programs is scanty. However, the differences between systematic instructional development and traditional institution-centered instruction are well documented. A recent ERIC search produced no models for alternative degree programs. Several different models for instructional development, on the other hand are present in the literature.

Traditional institutional model of instruction

The flow diagram in Figure 1 illustrates how instruction has been handled traditionally under the institutional model. This is the model most commonly encountered in our present educational system.

First, the curriculum or content of an instructional program is formulated. In the traditional model, this is accomplished at the administrative level. School boards or administrators determine what is necessary to meet learner needs.

Once the content has been established, it is then divided into manageable units or lessons, either by the institution in its choice of texts, or by the teacher. The content is then taught to the learners. The major objective of instruction in the traditional system is the teaching of the unit or lesson content to the learners. This is most often accomplished through lecture.

After the content has been disseminated, the teacher administers an examination based on the content. Following the tallying of the test scores, a norm referenced (bell curve) scale is most often utilized to compare a given learner's score with the others in the class. Passing the course is achieved when a certain number of units or lessons are completed at a specified level (ie. "C" grade or above).

In the traditional institutional model of instruction, learners play a relatively passive role. They have little input in deciding what they need to learn and how they are to learn it. The rigid nature of the institutional model makes it difficult, if not impossible, to tailor the program to individual differences and needs of learners.

Traditional institutional model for degree programs

The flow diagram in Figure 2 illustrates the process in formulating and awarding a traditional college degree. The similarities to the traditional instructional model are apparent:

- The institution's administration decides upon the general education and specific major curriculum.
- The instructional content is divided into specific courses offered by the institution.
- Course material is taught to the learner.
- Acceptable passing level is determined for the courses. (ie. "C" grade or above)
- A degree is awarded when a certain number of prescribed courses are completed with a "C" grade or above.

As with the traditional model of instruction, the traditional degree program is designed and administered from an institutional point of view. Learners are processed through the system, but have little voice in the development of the system.

Systematic instructional design

The instructional designer who utilizes a systems approach must address three important issues:

- **What should the learner know and be able to do at the completion of the instruction?** Answers to this question allow the developer to formulate the instructional objectives and develop the evaluation instruments for the objectives.

- **Which of these objectives does the learner already know?** Answering this question helps the developer to eliminate redundancy in the instruction and lets the teacher know what not to teach.

- **What is the most effective and efficient way to help the learner meet the objectives?** The answers to this question determine the content of the instruction and allows the learner to receive instruction with maximum efficiency and minimum waste.

Systematic alternative degree design

The developer of an alternative external degree program utilizes the same learner centered thinking:

- **What should the learner know and be able to do to qualify for a bachelor of arts degree?** A body of competencies, rather than a specific sequence of courses, become the educational objectives.

- **Which of these objectives does the learner already know?** An evaluation of prior learning decides how many of these objectives have already been met by the learner.

- **What is the most effective and efficient way to help the learner meet the objectives?** Appropriate instructional strategies may be utilized to give the learner the remaining competencies for the degree.

Toward a model for development of alternative degree programs

Figure 3 is an illustration of one of the most widely utilized systems model in instructional design (Dick and Carey, 1990; Gagné, Briggs and Wager, 1988). This model can easily be adapted for the designer of an alternative degree program. Figure 4 illustrates this adaptation.

Both instructional and alternative program designers must identify the goals of their programs (ie. what is to be accomplished?). Needs and task analyses, commonly utilized by instructional designers, can be used also by the degree program designer to determine what the competency requirements of the degree should be. The instructional designer and the degree program designer need to identify prior knowledge in order to avoid teaching what the learner already knows, thus increasing efficiency and decreasing redundancy. Subtracting the learner's prior knowledge from the competency requirements leaves the objectives, which form the basis for the program.

Systematic instructional design requires criterion referenced (mastery level), rather than norm referenced measures. Criterion referenced measures are based on the program's objectives. Learners in an alternative degree program should advance only when they have mastered all of a given course's objectives, not when they have received a 70 percent score on a rote memory test. The designers must then decide upon the strategies (attending classes, distance learning, independent study, research projects, etc.) that will best help the learner achieve the program's objectives.

Once the program requirements and structure have been designed, appropriate experiences must be developed or selected for use by the learner. The effect of the program is then evaluated and, if needed, revised.

Discussion

Robert Mager, Charles Reigeluth, Allison Rossett, David Salisbury and others are encouraging the rest of us ISD'ers to look beyond designing instruction and use our expertise to solve corporate and institutional problems (Dick, 1993). One such problem that can benefit from a systems approach is the design of learner-sensitive programs for adult students.

The application of a systems approach to degree program planning will require a paradigm shift (Kuhn,), just as ISD requires a change from the traditional model of instruction. Well-establish concepts, such as the Carnegie Unit, will need to be reassessed along with our other models, to see if they are still viable.

The population of adult re-entry students will likely increase, rather than decrease, in the coming years. As college degrees become required credentials for more professions, the issue of educational access for adult learners will continue to rise in importance. Higher education programs will need to accommodate those who study while they maintain full time jobs. Nontraditional alternative degree programs may provide a viable option for these learners. According to graduates of alternative programs, their degrees have met their needs and have been as useful as degrees earned through traditional institutional programs. Models and procedures utilized to design learner based, mastery level instruction are the same models which can be utilized by those designing learner based degree programs.

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Table 1: Some Differences Between Traditional and Nontraditional Degree Programs (After Thorson, 1992)

Traditional	Nontraditional
Provides regimented dependence on traditional systems.	Provides self-direction and autonomy.
Classroom is main source for exchange of knowledge.	Independent self-discovery is main source of knowledge.
Curricula oriented to school's tradition and societal needs.	Curricula oriented to learner's personal and professional needs.
Faculty member transmits block of knowledge to learners.	Faculty member acts as mentor and facilitator of learning experiences.
Degree requirements based on bureaucratic standards.	Degree requirements based on learner's needs, goals and on practical standards.
Degree awarded when all prescribed classes have been completed.	Degree awarded by credits based on previous college-level knowledge and academic standards agreed to by faculty and learner.

Figure 1:
Institutional Model
of Instruction

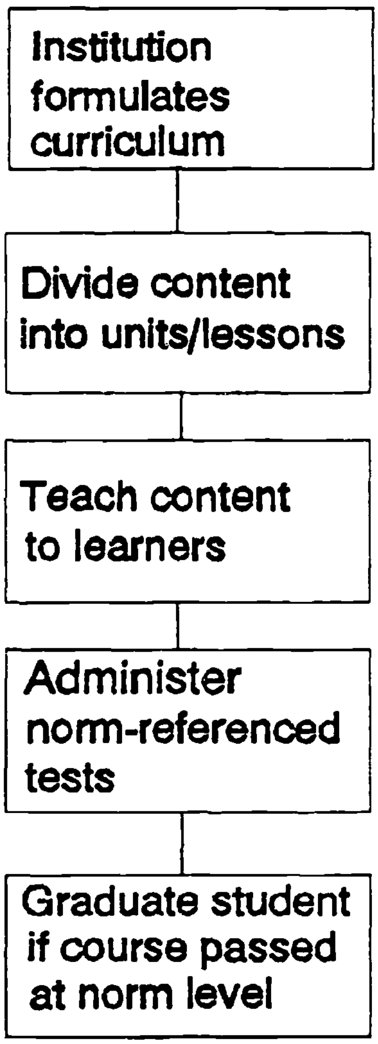


Figure 2:
Institutional Model
for Degree Programs

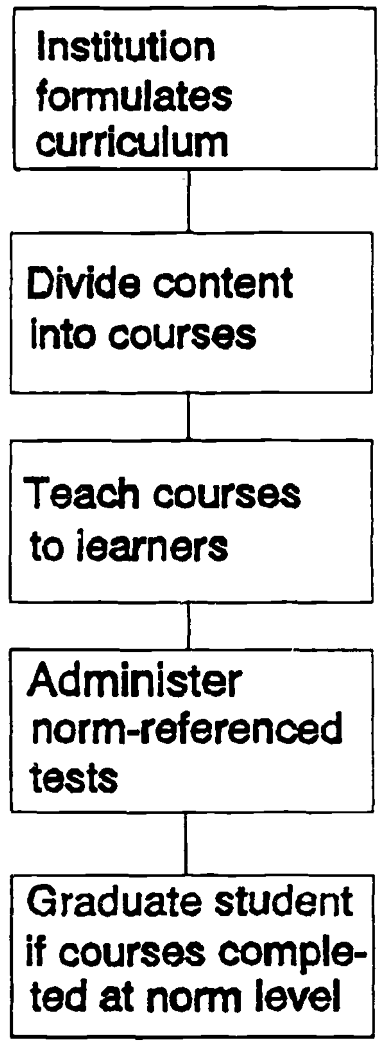


Figure 3:
Systematic Process of
Instructional Design
(After dick & Carey, 1990)

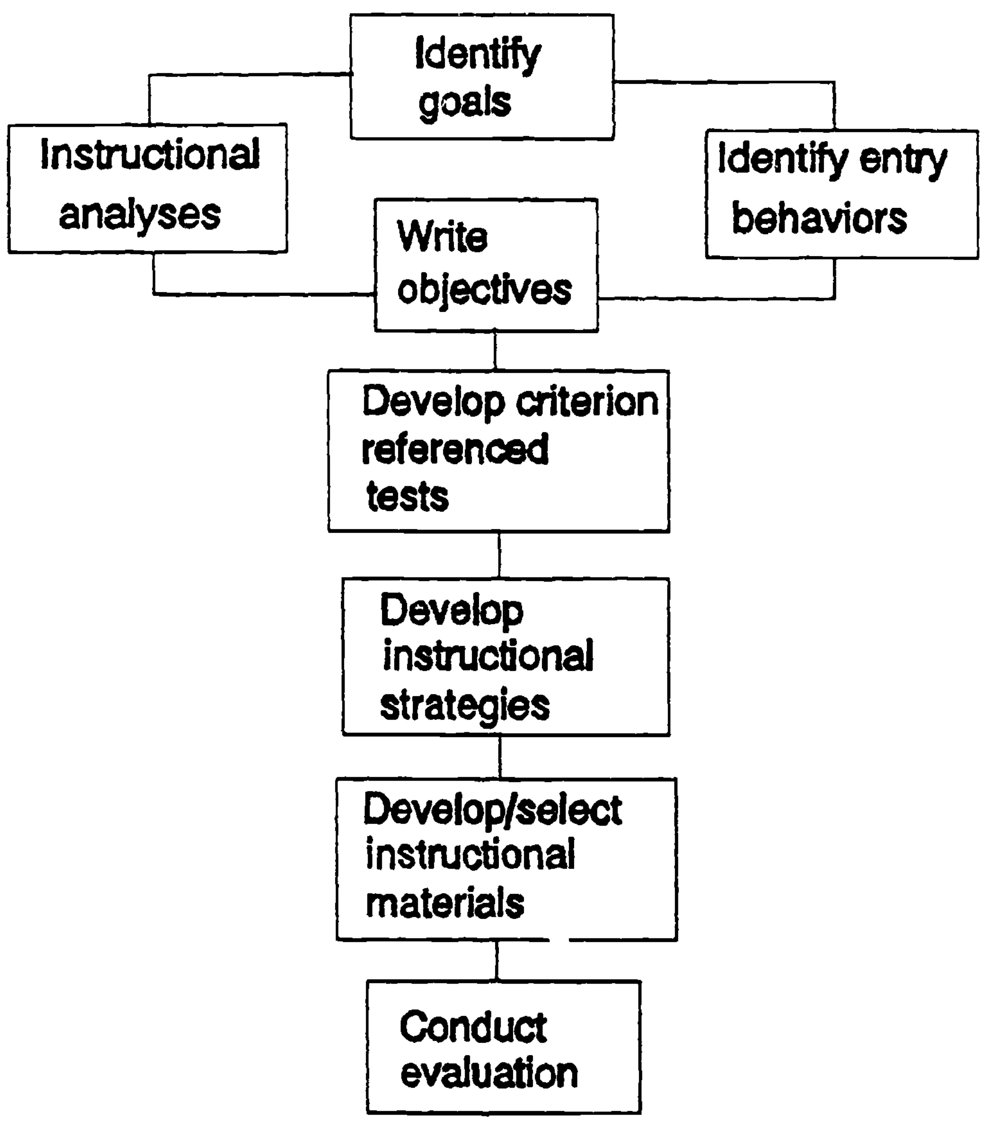
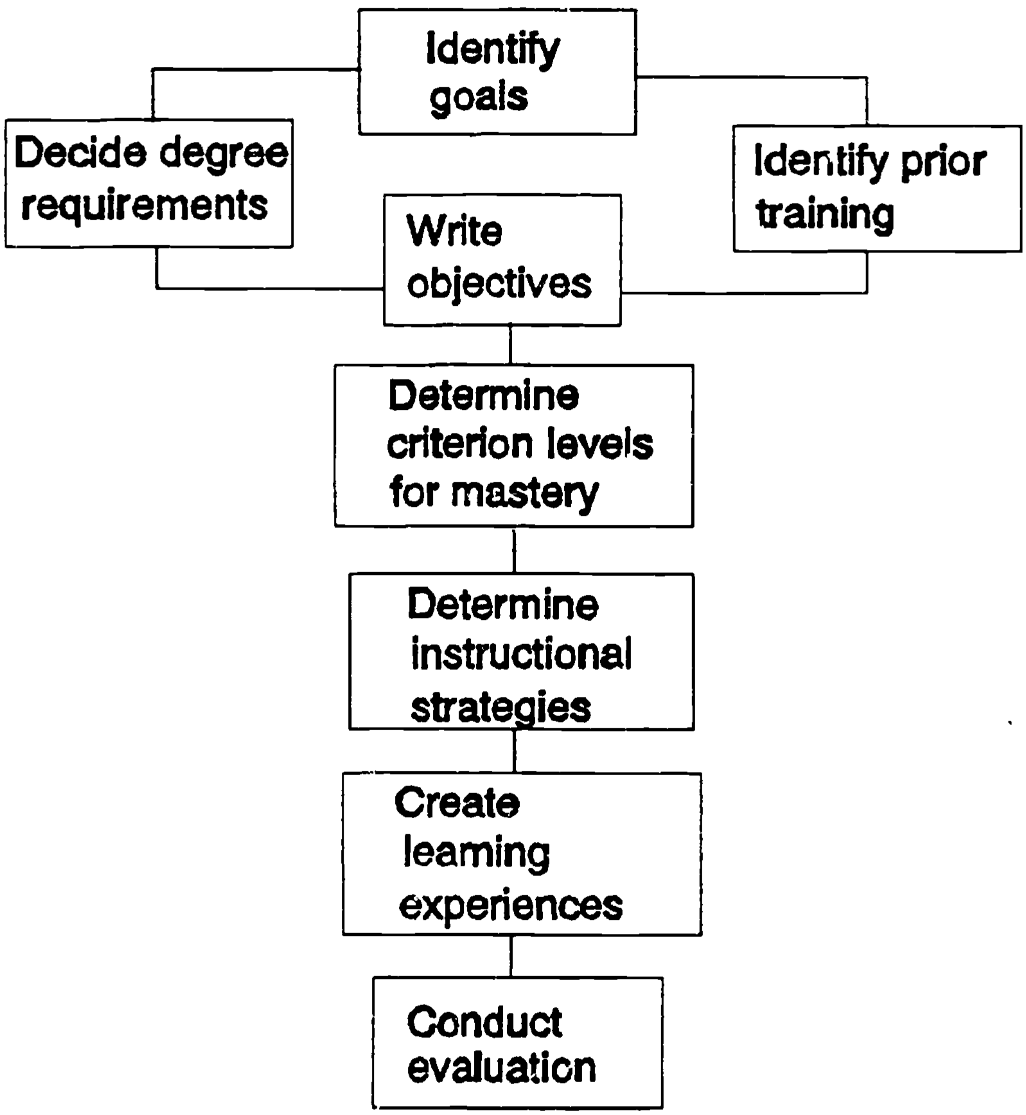


Figure 4:
Proposed model for the Design of Nontraditional Degree Programs



Title:

Visualization as an Aid to Problem-Solving: Examples from History

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Visualization as an Aid to Problem-Solving: Examples from History

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This paper presents an historical overview of visualization as a human problem-solving tool. Visualization strategies, such as mental imagery, pervade historical accounts of scientific discovery and invention. A selected number of historical examples are presented and discussed on a wide range of topics such as physics, aviation, and the science of chaos. Everyday examples are also discussed to show the value of visualization as a problem-solving tool for all people. Several counter examples are also discussed showing that visualization can sometimes lead to erroneous conclusions. Many educational implications are discussed, such as reconsidering the dominant role and value schools place on verbal, abstract thinking. These issues are also considered in light of emerging computer-based technologies, such as virtual reality.

The increased availability of multimedia tools in education permit the design of instructional systems that incorporate unlimited variations and forms of textual, visual, aural information for both presentation and feedback. However, our sense of vision arguably represents our most diverse source of information of the world around us (Sekular & Blake, 1985). Society, including education, transmits tremendous amounts of information in visual form. Visualization is most frequently used in instruction in the presentation of information. However, visualization techniques are also powerful problem-solving tools, though they are rarely promoted as such in learning and instruction. This is unfortunate, as history is full of fascinating examples where visualization has been one of our most important arsenals of problem-solving tools (Koestler, 1964).

The purpose of this paper is provide a historical context for current efforts by instructional technologists to exploit the full potential of visualization techniques, especially those that tap the computational and graphical power of the computer. This paper will present a variety of cases where people have used visualization techniques throughout history to solve a wide range of problems. The term visualization is used broadly here to include all nonverbal cognitive strategies, including mental imagery. In addition, some counter examples will be discussed to show how visualization can sometimes lead us astray. The paper will conclude by discussing the implications of visualization in education and instructional design. These issues will surely increase in importance and complexity as highly-visual computer-based systems continue to evolve, such as in the case of virtual reality. This paper suggests that history might be able to help us as we struggle for the most appropriate applications of visualization in education both now and in the future. This paper begins with a few general examples that illustrate the role of visualization in human problem-solving at the everyday level.

Visualization as a General Problem-Solving Strategy

Although historical examples of famous people using visualization to solve complex problems are often the most dramatic, everyday people using the same visual skills to solve everyday problems are the most poignant. Some problems, of course, are inherently spatial. Consider giving or getting directions to an unfamiliar part of town. It is interesting how often the "direction giver" usually starts with a pure verbal description, but then quickly reverts to visualization "tricks" extemporaneously (such as pointing in the air to illustrate the many turns and distances). It is almost as if the person is going on a brief, imaginary trip to the final destination on behalf of the lost individual in the hope to show, by example, how to get there. The "direction getter" is at the same time trying to mentally form a visual imprint of the trip while memorizing key verbal labels (such as landmarks and street names).

Researchers who study the problem-solving process have long recognized visualization as a problem-solving tool (Finke, 1990; Finke, Ward, Smith, 1992). People often times forget to use such inherent capabilities, perhaps because schools tend to emphasize verbal skills over visual skills and abstract reasoning over concrete reasoning. Unfortunately, the idea of using simple visualization as a cognitive strategy to help ourselves solve a problem is often times either overlooked or discouraged. For example, consider the following problem (from Bransford & Stein, 1984):

> A man had four chains, each three links long. He wanted to join the four chains into a single, closed chain. Having a link opened cost 2 cents and having a link closed cost 3 cents. The man had his chains joined into a closed chain for 15 cents. How did he do it?

Take a few moments to try to solve the problem before reading ahead for the solution. As you do so, reflect on the strategies that you are using to solve the problem.

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Most people find the problem very difficult to solve mentally. The first possible solution of four links opened and closed would cost twenty cents. For most people, a good first step is to draw the four chains on paper — to construct a visual representation of the problem's entry conditions. After working through opening and closing links with a visual model, one discovers that the solution rests in opening all three links of one of the chains. These three links can then be used to join the other three chains. When the problem is converted into visual form, the solution is easy to derive.

Lave (1988) has described the ways everyday people solve problems by exploiting all of the resources present in the problem situation. For example, people were presented with an everyday problem of fixing food for three people when the recipe listed amounts for four people. One recipe called for two thirds cup of cottage cheese. One person quickly solved the abstract problem of finding "three fourths of two thirds" by first measuring out two thirds cups onto the table, patting it into a circle, and marking a cross on it. The person then removed the one excess quarter and was left with the correct portion! Lave's work is often cited by proponents of situated cognition (e.g. Brown, Collins, & Duguid, 1989), though these examples also show how everyday people use spatial and concrete reasoning abilities to grapple with problems often expressed in abstract form in traditional mathematics. The concrete solutions are just as sophisticated and complex as those expressed abstractly, yet such a visualization strategy would probably not be allowed by most math teachers.

Here is another example that aptly demonstrates the power of visualization in problem-solving (Norman, 1988). Even more so, it reveals the power of the human perceptual system to deal with problems efficiently and effectively when presented in visual form. The problem is a simple math strategy game for two players. The game starts by writing the numbers one to nine on index cards — one number per card. The nine cards are laid out on a table with the numbers facing up. The players then take turns choosing a number. Each number can only be chosen once in a game. The first player who gets *any* combination of three numbers that add up to 15 is the winner. The game is quite a challenge even for adults. One must anticipate appropriate combinations of three numbers summing to 15, while also anticipating possible winning combinations by their opponent. Numbers are chosen either to advance one's own hand or to block an approaching win by the opponent. Try playing this game a few times with a friend before reading further.

Playing this game in the pure mathematical form described above is quite difficult. Many adults do not remember ever playing this game, though most find it strangely familiar. The reason for this is that the game has another, more familiar form — tic-tac-toe. The commonalty of the games can be recognized by carefully arranging the nine numbers so that all vertical, horizontal, and diagonal combinations of three squares add up to 15, as illustrated in Figure 1 (this special combination is also known as a "magic square.") Strategies from one version of the game quickly transfer to the other. For example, capturing the middle square or the number "5" gives the player a distinctive advantage. Most adults consider tic-tac-toe to be a simple child's game not worth playing anymore because the game will inevitably end up in a draw once both players understand the "secret" to successfully blocking the opponent at every move. Interestingly, the pure math version of the game remains a challenge even knowing that it is a "disguised" version of tic-tac-toe. The point is that the game becomes "childish" only when the perceptual ability of pattern recognition is used. The game itself has not changed, only the cognitive tools used by the individual to play it.

Visualization by Scientists and Inventors

Some of the most fascinating accounts of human problem-solving show remarkably simple examples of how visualization coupled with imagination led to brilliant discoveries and flashes of insight (Burke, 1985; Shepard, 1988). It is interesting that we often refer to these people as "visionaries," somehow being able to see what others cannot. The use of this description may not be as metaphorical as one might first think. It is stunning how many scientists and inventors placed a great deal of importance on the nonverbal in the act of creative imagination. Many describe the phenomena of sudden "illumination" where solutions just "showed themselves" or came to them in sudden bursts of insight. Indeed, many famous scientists describe grasping a solution instantaneously and as a whole, and then having to face the arduous task of putting the idea already completely conceived into an appropriate verbal form to share with others. Although this section does not pretend to present an exhaustive and comprehensive account of visualization by scientists and inventors, the few examples that follow make a convincing point about the value of visualization in cognition.

Albert Einstein's unique methods of wrestling with the most puzzling problems of physics, such as light taking on characteristics of both particles and waves simultaneously, are among the most well-known. Einstein was known for using "thought experiments" to work out problems in a uniquely nonverbal manner. Perhaps his most famous thought experiment was imagining what it would be like to ride on a beam of light. This allowed him to make the conceptual leap of "seeing" light as though it were in static form. This helped him to resolve the paradoxes underlying what was to become his Special Theory of Relativity. In another example, he imagined how two people would describe the behavior of a light flashing inside a moving truck if one person was riding in the truck and the other was standing on the street to help understand the absolute nature of the speed of light.

The German chemist August Kekulé is another scientist famous for his reports of imagery. He often described how atoms appeared to "dance before his eyes." He is said to have discovered the ring-like molecular structure of benzene by gazing into a fire and seeing in the flames a ring of atoms looking like a snake eating its own tail. His accounts of problem-solving through dreamlike visual imagery are echoed in the case stories of many other scientists, including Isaac Newton.

Roger Shepard (1988) offers one of the most interesting and detailed discussions of how famous scientists and inventors have been predisposed to visualization in their acts of creative imagination and discovery. Beyond those of Einstein and Kekulé, Shepard describes the creative inventiveness of dozens of famous scientists, such as: Michael Faraday's

8	1	6
3	5	7
4	9	2

Figure 1. A "magic square:" All number across, down, and diagonal sum to 15.

visualization of the lines of magnetism: Nikola Tesla's invention of the self-starting induction motor; Omar Snyder's solution to the containment problem of uranium in the Manhattan project; James Watson's conception of the double-helix shape of DNA; and Richard Feynman's invention of "Feynman's diagrams" for use in quantum electrodynamics. A curious similarity of many of these famous thinkers is that they were often able to grasp their solutions instantly as a whole.

Based on his investigations, Shepard described a "composite caricature" of individuals who have reported extraordinary instances of visual-spatial creative imagery. Three commonalties can be found in these people's early formative years. Many were kept home from school in their first years and had limited contact with peers of their own age. Many were below average in verbal ability, such as language development. Finally, most were fond of engaging in play with concrete physical objects, such as blocks, cubes, and mechanical models. Most of these skills, abilities, and strategies were developed apart from the educational systems of their day.

Shepard goes on to suggest some provocative implications of this composite profile of a highly creative, nonverbal thinker. Working in private without much contact with formal educational institutions (such as schools), these people are likely to engage in unorthodox and nontraditional thinking which, unfortunately, may be met with disapproval or punishment in a traditional classroom. These individuals are more likely to engage in concrete visual imagery, instead of the more abstract, verbal strategies commonly promoted in the schools. Consequently, these people are likely to bring the unique human competency of spatial intuition and manipulation to bear on a problem. Finally, the dominance of visual imagery in problem-solving is more likely to trigger the motivational and affective forces thought to be more aligned with visual elements of the human psyche.

Shepard also discusses some of the educational implications of his research on the creative imagery of famous scientists. Not surprisingly, he criticizes traditional education for failing to promote visually-based creative tendencies in children. As children, the scientists he studied equated learning with becoming "engrossed in a direct, interactive exploration of such objects and events..." and were "unconstrained by conventional, verbalized, and rigidly compartmentalized interpretations..." (p. 181). He suggests education must find a way to nurture creative imagination without sacrificing formal education, though the two often appear to be in direct conflict with one another.

Other Examples

This section briefly considers the historical value of visualization as an aid to problem-solving from very diverse areas of inquiry. These examples are presente.. in chronological order beginning with the Cholera epidemic in the mid-1800's and ending with the new science of Chaos, an emerging field of study in which people and computers work together in partnership through scientific visualization.

The Cholera Epidemic of London in the mid-1800's. One of the classic examples of how visualization aided human problem-solving was Dr. John Snow's plotting of cholera deaths in the mid-1800's on a map of London. The obvious clustering of deaths around the Broadstreet water pump, as shown in Figure 2, sufficiently convinced authorities to remove the pump's handle even though a direct link had not been made between the disease and a contaminated water supply. Within days, the epidemic in the London neighborhood ended (Tufte, 1983).

Wilbur Wright's Wing-Warping System. The story of the invention of the airplane contains many interesting insights to design and technology. One simple example aptly illustrates the role of everyday visualization and imagination. Controlling an airplane in its three-dimensional environment (i.e. pitch, roll, and yaw) was one of the most difficult problems the Wright Brothers and others faced. The Wrights had already successfully used a rudder to control yaw and an elevator to control pitch, but were having much difficulty controlling the plane's yaw (i.e. the motion along the axis going through the fuselage from the plane's nose to tail). Wilbur Wright solved this problem of human-controlled powered flight by seeing the remarkable "wing-warping" system used by the Wright Brothers' Flyer I at Kitty Hawk while holding and twisting an inner tube box in his bicycle shop in Dayton, Ohio. Moolman (1980) writes:

> Then one day in the latter part of July 1899, while Wilbur was alone in the bicycle shop, a customer came into buy a new inner tube. Wilbur chatted with the customer awhile, idly toying with the empty inner tube box before throwing it away; as he talked he realized that he had absently twisted the ends of the narrow cardboard box in opposite directions. When the customer left, Wilbur tore off the ends of the box and saw in his mind's eye a pair of biplane wings, vertically rigid yet twisted into opposing angles at their tips (p. 112).

Plate Tectonics. It was long believed that the earth's continents had remained in their general positions immediately after the surface of the earth cooled, even though the vertical shape of the land masses had been subjected to dramatic changes, as evidenced by finding dried-up sea beds in the mountains. However, some peculiar facts puzzled scientists. For example, identical fossil evidence was found on the east coast of South America and the west cost of Africa. These were explained in various ways such as migratory animals who used now submerged land bridges. Other evidence, such as striking geological similarities, were much more difficult to explain away.

In 1915, Alfred Wegener, a German meteorologist, proposed a different solution (Burke, 1985). He noticed how

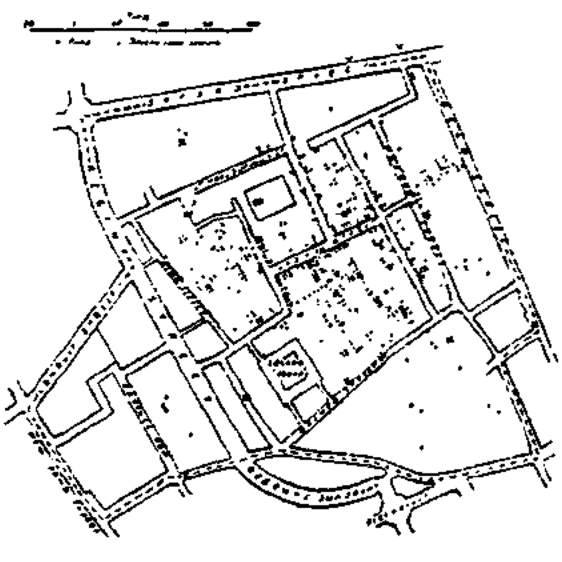

Figure 2. The famous dot map of Dr. John Snow plotting the cholera deaths in London in relation to neighborhood water pumps. This map provided strong evidence that the water in the Broad Street pump was contaminated.

many of the outlines of the continents seem to fit together like a giant jigsaw puzzle, the most dramatic example being how the east coast of South America seemed to fit the west coast of Africa. Perhaps, he suggested, at one time there was one large land mass which eventually broke apart. At the time, Wegener's proposal was ridiculed by geologists. The idea of continents drifting through solid rock seemed ludicrous. It was not until about 50 years later that Wegener's visual solution was accepted based on the discovery of mid-ocean ridges and evidence of sea floor spreading. Rock samples increase in age proportionally to the distance in which they are taken away from the mid-ocean ridges. Also, evidence indicates that the earth's magnetic field apparently changes direction every few hundred million years or so. Since rocks maintain their magnetic "finger print" it is possible to correlate the ages of rock with their inherent magnetic direction. When sections of the sea floor are mapped using this magnetic evidence, magnetic "stripes" appear on each side of mid-ocean ridge showing that sections of the sea floor alternate in their magnetic direction. As molten rock emerged from the mid-ocean ridges and cooled, it captured the earth's magnetic direction at that geological period of time. Current theories now accept that the earth's crust is made up of distinct plates that "float" on the earth's mantle. Wegener elegant solution was based on the most visual of available evidence.

Armor Plating of World War II Aircraft. A very practical example of visualization's role in problem-solving comes ·n World War II. A novel strategy was used to better armor ..bat planes. The bullet holes on returning aircraft were plotted on crude pictures of the planes. Using this information, it was determined to add armor to planes in places *other than* those indicated by the bullet holes. The idea was that since it was assumed that the planes were all hit more or less at random, the planes that did *not* return must have been hit in vital places not marked on the picture (Wainer, 1992).

The Science of Chaos. Some consider computers as the tool by which the world will be turned into a mechanized and inhuman place to live, but a contrasting view considers the computer as our liberator by performing the tedious, routine tasks poorly suited to humans and freeing us to more fully realize our potential. This collaboration between people and computers is perhaps best illustrated in the founding of the new science of Chaos, which is the study of nonlinear systems (Gleick, 1987). Such systems, though seemingly random and haphazard on the surface, actually have a hidden order lurking below. The universe is inundated with such systems, though some of the best examples are from the everyday world, including the weather, flags waving in the breeze, ribbons of smoke, and dripping water faucets. Even human problem-solving is believed to be a nonlinear system. The study of nonlinear systems has only been made more accessible with the advent of computers. The patterns of complex, nonlinear systems often only show themselves when the raw data is converted into visual form. The innate human ability of pattern recognition in combination with the computer's forte of working through millions of iterations with complex data structures have allowed many of the mysteries of chaotic systems to be explored and better understood.

One of the most interesting examples is fractal geometry, where a pattern repeats itself to infinity, such as the figure known as the "Sierpinski gasket" shown in Figure 3. This figure is created through an astonishingly simple set of rules (Michael Barnsley, as cited in Gleick, 1987, referred to this as "The Chaos Game"). The game starts by drawing three "game dots" on a piece of paper (such as those at the three corners of an equilateral triangle). Another dot, call this the starting dot, is drawn at random on the piece of paper. Then, randomly choose one of the three game dots (such as by throwing a die). Next, carefully draw another dot at the midpoint between the randomly chosen game dot and the starting dot. This midpoint now becomes the next starting dot. Finally, repeat this procedure for thousands of trials. Although the rules of the Chaos game might lead one to expect a random collection of dots on the paper, a "hidden order" emerges when the numeric information is converted into a visual form — the Sierpinski gasket.

Of course, few people are willing to invest the time or energy necessary to the play the Chaos game (and its many variations). That is where the computer comes in. Computers are wonderfully equipped to handle the tremendous number of accurate calculations necessary in the chaos game whereas people are wonderfully equipped to interpret the visual patterns that emerge. The science of chaos represents a powerful partnership between people and machines by letting each do what they do best.

Visualization Gone Awry: Some Counter Examples

It seems only fair to consider some examples of where the powers of visualization actually worked against some people.

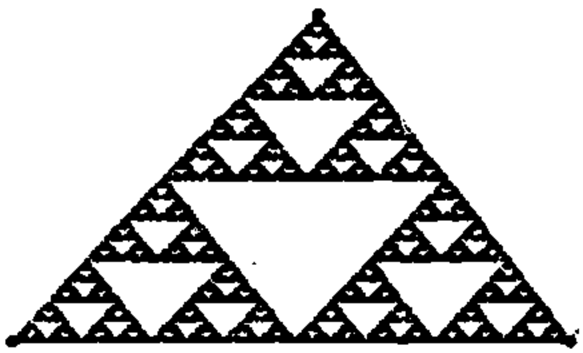

Figure 3. The Sierpinski Gasket: This fractal geometric figure repeats itself to infinity.

Visualization, like perception, is not like a camera objectively capturing images on film. Interpretation and understanding are continually filtered through one's entire knowledge, values, and beliefs. People often see and imagine what they *want* to see and imagine. Visualization, like any cognitive process, is greatly influenced by prior knowledge. Two examples are presented here where visualization led to erroneous conclusions. The result of one example led, however briefly, to wide pandemonium, excitement, and fantastic stretches of the imagination — Percival Lowell's report of seeing artificially constructed canals on Mars. The repercussions of the other example, in contrast, dramatically changed the world forever — Columbus' voyage to find a westward route to China and India.

Percival Lowell was a prominent astronomer at the turn of the century (he founded the Lowell Observatory in Arizona). Lowell became interested in the planet Mars based on early observations in 1877 by Giovanni Schiaparelli that showed some interesting fine lines on the Martian surface (Ronan, 1983). Lowell subsequently studied the planet in the early 1900's using the most sophisticated telescopic equipment available at that time. Lowell, like Schiaparelli, also observed the peculiar long crossing lines on the Martian landscape. Lowell became convinced that these were the remnants of canals constructed by some ancient civilization. The purpose of the canals, Lowell inferred, was a desperate attempt to bring water down from the polar caps to the desert-like continental areas. Unfortunately, the "canals" turned out to be an optical illusion. This example is a classic case of jumping to conclusions based on initial and ambiguous evidence, known by cognitive psychologists as "top-down processing" — initial information triggers an early interpretation against which all subsequent information is judged. This is an important psychological mechanism that helps us to find order and organization in an otherwise chaotic environment. Of course, sometimes it works against us. This same phenomena produces people's tendency to see dead presidents in fluffy white clouds.

The story of Columbus is not as amusing or innocent, if only because his adventures changed forever the global view of the world. The intent here is not to discuss the details of his trip or its ramifications, but simply why Columbus chose to make it in the first place. It seems that the most compelling reason Columbus dared to risk such an expedition is simply that he greatly underestimated the size of the earth coupled with a dramatic misconception of what proportion of the earth consisted of water and land (of course, we should not forget how important the potential wealth and fame figured in his decision-making as well) (Dor-Ner, 1991). Had he accepted an accurate account of these two facts, it is almost certain he and his sponsors would have felt the trip impractical and foolhardy at best and impossible at worst.

Historians believe that Columbus' views were heavily influenced by the writings of Marco Polo, Pierre d'Ailly, Pope Pius II, Pliny, and Ptolemy. Both Polo and d'Ailly overestimated the size of Asia considerably. The question of the earth's circumference had been a source of scientific debate for centuries, going back at least to the Greeks. The true figure is 60 nautical miles per degree of longitude at the equator. Though Eratosthenes had come close to estimating the true circumference of the earth (about 59.5 nautical miles per degree), Columbus chose figures closer to that estimated by Ptolemy (50 nautical miles). Columbus also and inexplicably downsized the figure even further, to about 45 nautical miles per degree of longitude. Therefore, Columbus envisioned a globe that was only about two thirds its true size and most of that, he thought, was covered by land. Columbus estimated a journey from the Canary Islands to Japan to be only about 2,400 miles instead of the 11,000 miles it actually is. Using this information, Columbus successfully argued his case for such a journey. The result of his journey was, of course, the accidental discovery of a new continent, though he died believing instead that he had reached islands near the coast of Asia. Of course, one could argue that Columbus used these misconceptions on purpose to persuade King Ferdinand and Queen Isabella of Spain to fund the trip as well as to find a crew even partly willing to join him. For example, Columbus admitted to falsifying information kept in the log to alleviate the crew's fears (Fuson, 1987). Even if this were to be true, Columbus' use of visualization for deception deserves equal attention.

Conclusions and Implications

The purpose of this paper has been to present some simple examples of how visualization has served as an important problem-solving tool for people throughout history. An historical context not only provides the most dramatic examples of visualization in problem-solving, but also helps to promote reflection on one of our most distinctly human abilities. Though we may never adequately understand the psychology of visualization, it will and should continue to serve as one of our most versatile problem-solving tools. Instructional designers, teachers, and all educators are therefore encouraged to consider innovative visualization strategies to nurture the creative problem-solving process. Concrete, visual solutions should not be considered inferior to those that are abstract. Of course, the two counter examples also serve to caution against unwarranted and inappropriate applications.

Despite the relatively small number of examples presented here, one soon discovers the pervasive nature of visualization in scientific discovery and invention. The examples presented here were meant only to suggest the case for the continued value of visualization strategies and should not be mistaken for an exhaustive survey. The list of examples not accounted for is, of course, large. Some domains, like geometry, are inherently spatial in nature and have their own visualization histories to tell. Some other notable examples missing from this paper include the following: Kepler's formulation of the laws of planetary motion; the discovery of chemical "fingerprints" of elements as lines in a spectrum (another good example of pattern recognition); and the spatial arrangement of the periodic table of elements. In contrast, some concepts seem impossible to visualize, such as the idea of curved space or a physical universe consisting of more than three dimensions, concepts suggested by Einstein and modern day physicists. Similarly, other historical problems, such as accurately describing the motion of a projective through space (such as cannon balls), provide interesting insights to people's attempts to visualize phenomena that have few visual clues.

There are many important implications that one can draw from this review. The trends in multimedia learning environments, especially those that are computer-based, are slowly moving from verbal to visual, from analog to digital, and from passive to interactive. The implications for the learning process are more far reaching than media dominance, however, especially when the computer's processing and graphical abilities are considered. The computer has the potential to become one of our most important cognitive tools, similar to the way paper and pencil reduced demands on human memory. Highly visual computer-based learning environments, such as *Geometer's Sketchpad* and *Interactive Physics*, allow individuals to grapple with sophisticated ideas from math and science in visual ways that are all at once concrete and intuitive. Computers and people working closely as "partners in cognition" have the potential for fundamental qualitative changes to how we view human cognition (Salomon, Perkins, & Globerson, 1991).

The implications for instructional designers are likewise exciting and challenging. Highly visual and interactive computer-based tools may allow the user to take on an unprecedented role in the design process. Rather than merely strive for learner-centered instruction that takes into account individual differences, instructional technology may be poised to let the user become a true "co-designer" of our learning environments. Similarly, some of the emerging technologies, such as virtual reality, point to design considerations that have never been asked before (Heim, 1993). Some of these are also among the most exciting, though we should be quite cautious early on. The nature of how people construct their own reality may become muddled when immersed in visually overwhelming environments. The question of whether "telepresence," the state of interacting in one location (even an imaginary one) while physically located in another, will be an acceptable state of "existence" in the future should not be casually considered. Some feel that telephones already achieve a degree of telepresence since people focus on their conversation with the person on the other end and not on the distance which separates them. Yet, when brought to the awareness level of an adult, there is no mistaking one's physical reality while using phone technology. This distinction may become blurred with the advent of virtual reality technology. This is a particularly important issue as our children begin to experience virtual reality. There is the risk that their cognitive development of reality may become confused, similar to very young children who become angry that "grandma cannot come through the phone receiver" to be with them at that very moment. Intellectual development of space and time are important issues to consider. The implications of these technologies demand attention and guidance by instructional technologists today in preparation for tomorrow.

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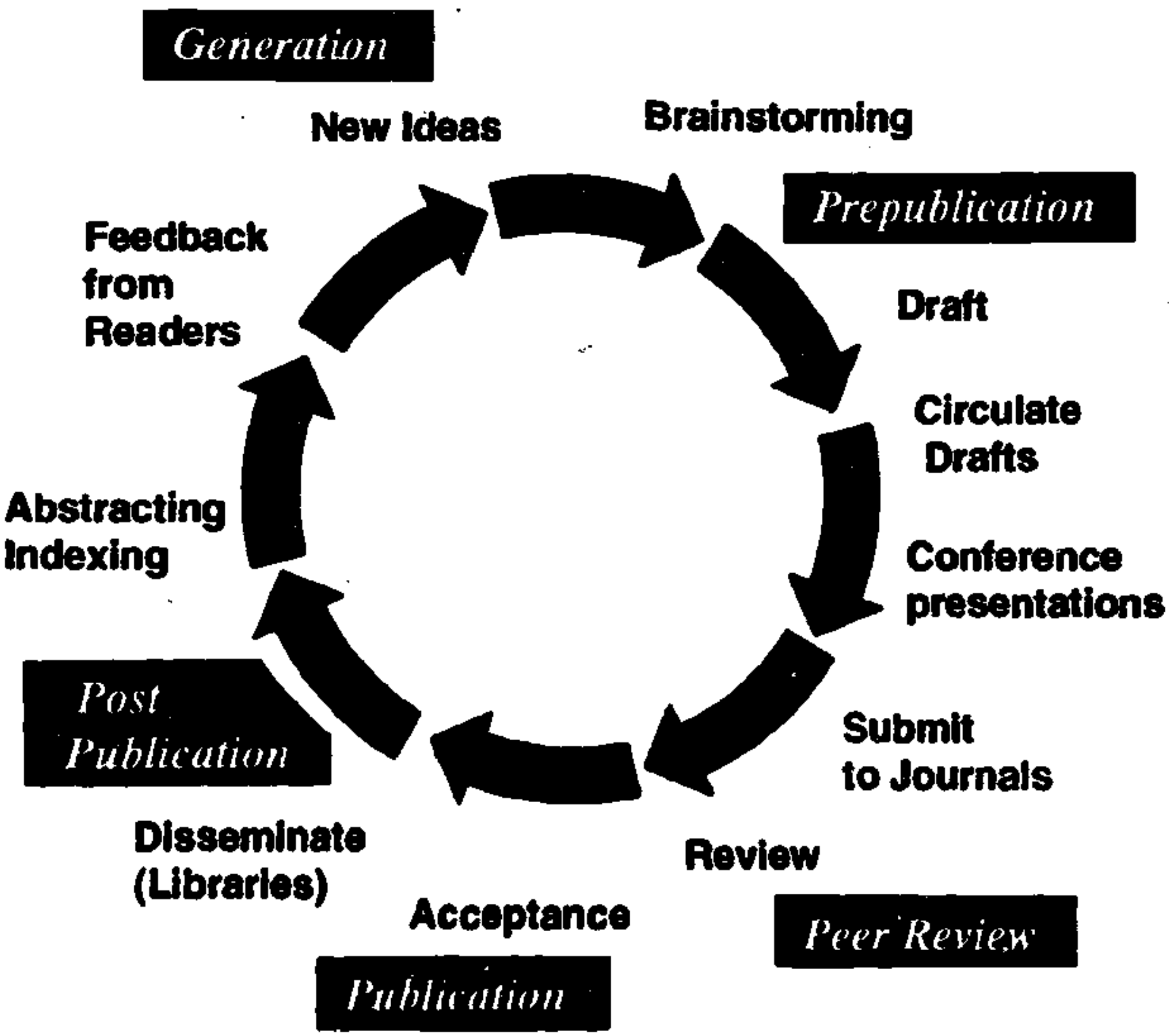
Appendix A
(Zane Berg and Mauri Collins)

Scholarship



Appendix B
(David A. Goodrum, Laura T. Dorsey and Thomas M. Schwen)

Figure 1

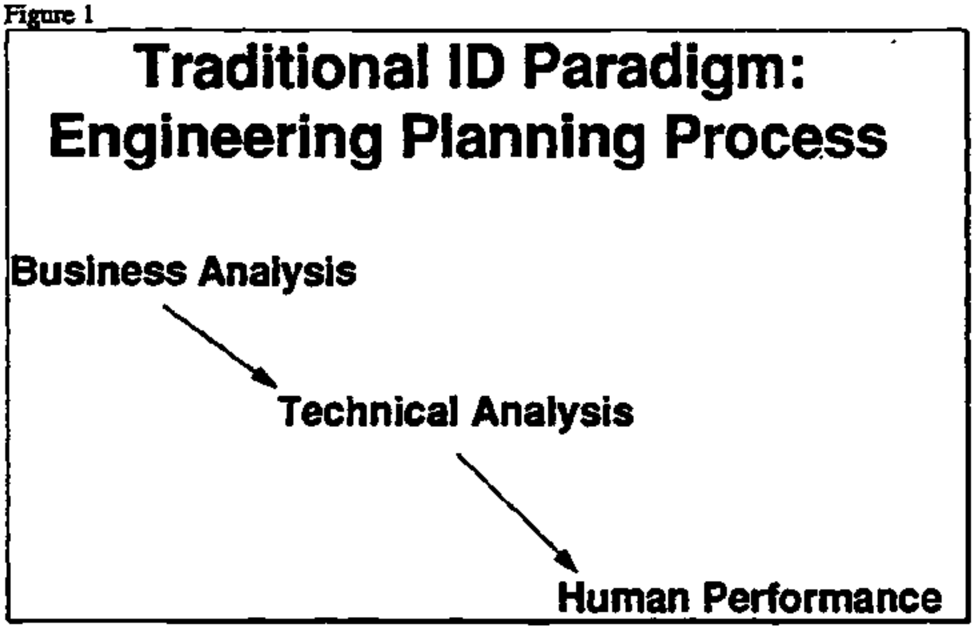
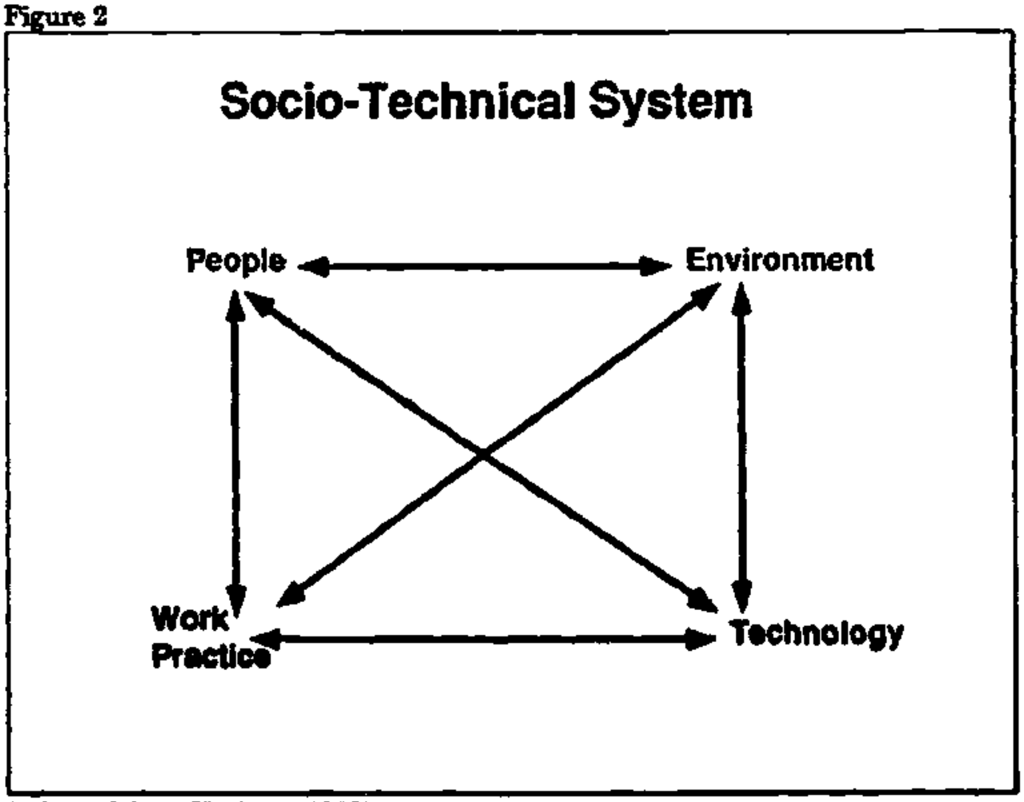


Figure 2



(Adapted from Harbour, 1992)

Appendix B

Figure 3

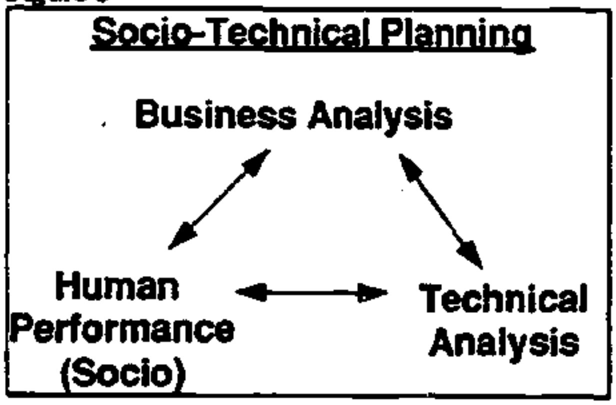


Figure 4

Participatory-Stakeholder Design Team

Roles	Contribution		
	Knowledge	Stakeholding	Participation
Customers (Direct & Indirect Users)	Organization & work practice specific knowledge	Living with the consequences of the change for tasks, jobs relationships, etc.	User representatives involved in all stages and aspects of development
Technical Community	Information skills Technological skills	Skill advancement and vested interest in the solution	Analyze, design, deliver and support information components
Training Community	Task & content analysis skills Knowledge of human learning	Skill advancement and vested interest in the solution	Analyze, design, deliver and support training/learning components
Social Systems Change Experts	Organizational analysis skills Knowledge of human adaption & interaction	Skill advancement and vested interest in the solution	Analyze, design, deliver and support organizational and social change.

(Adapted from Eason, 1988)

Appendix B

Figure 5

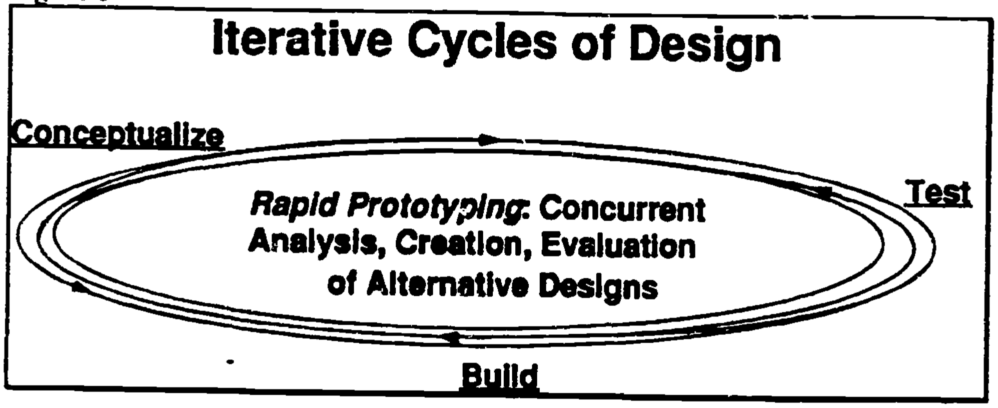
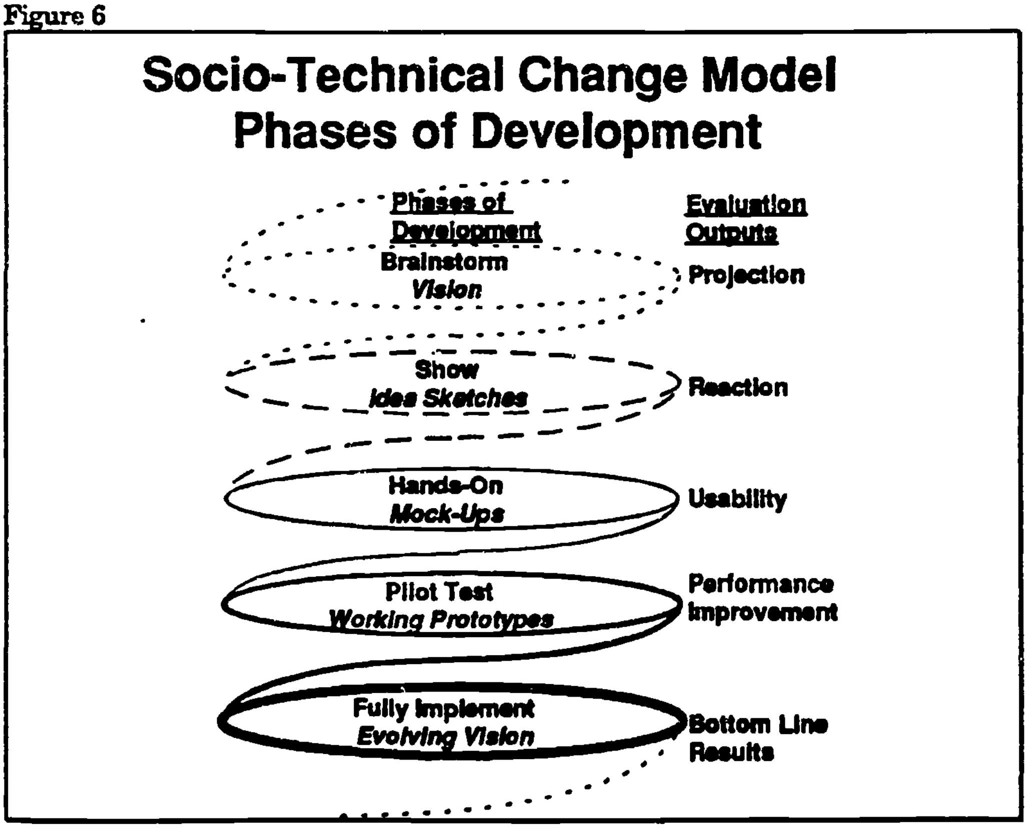
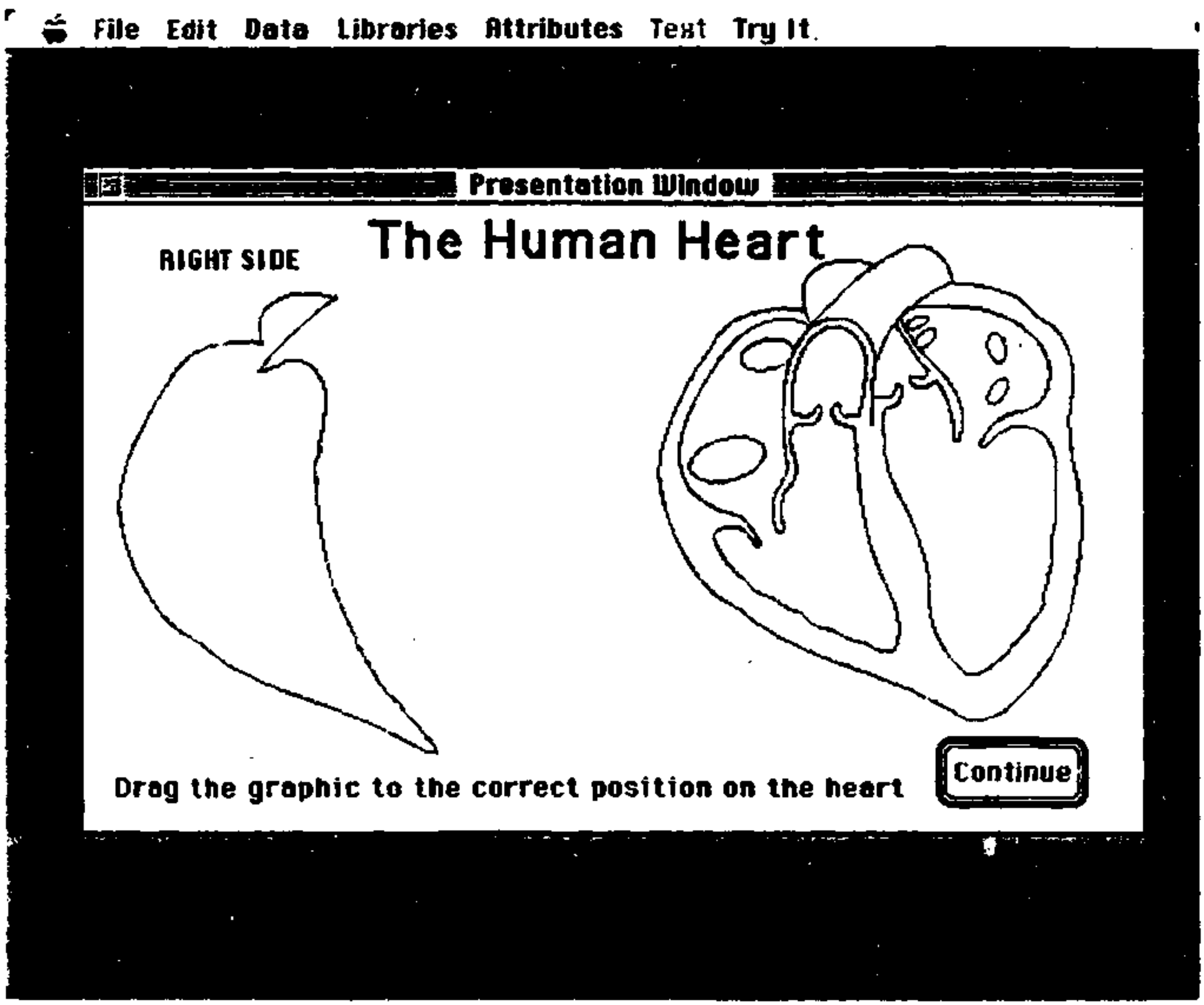
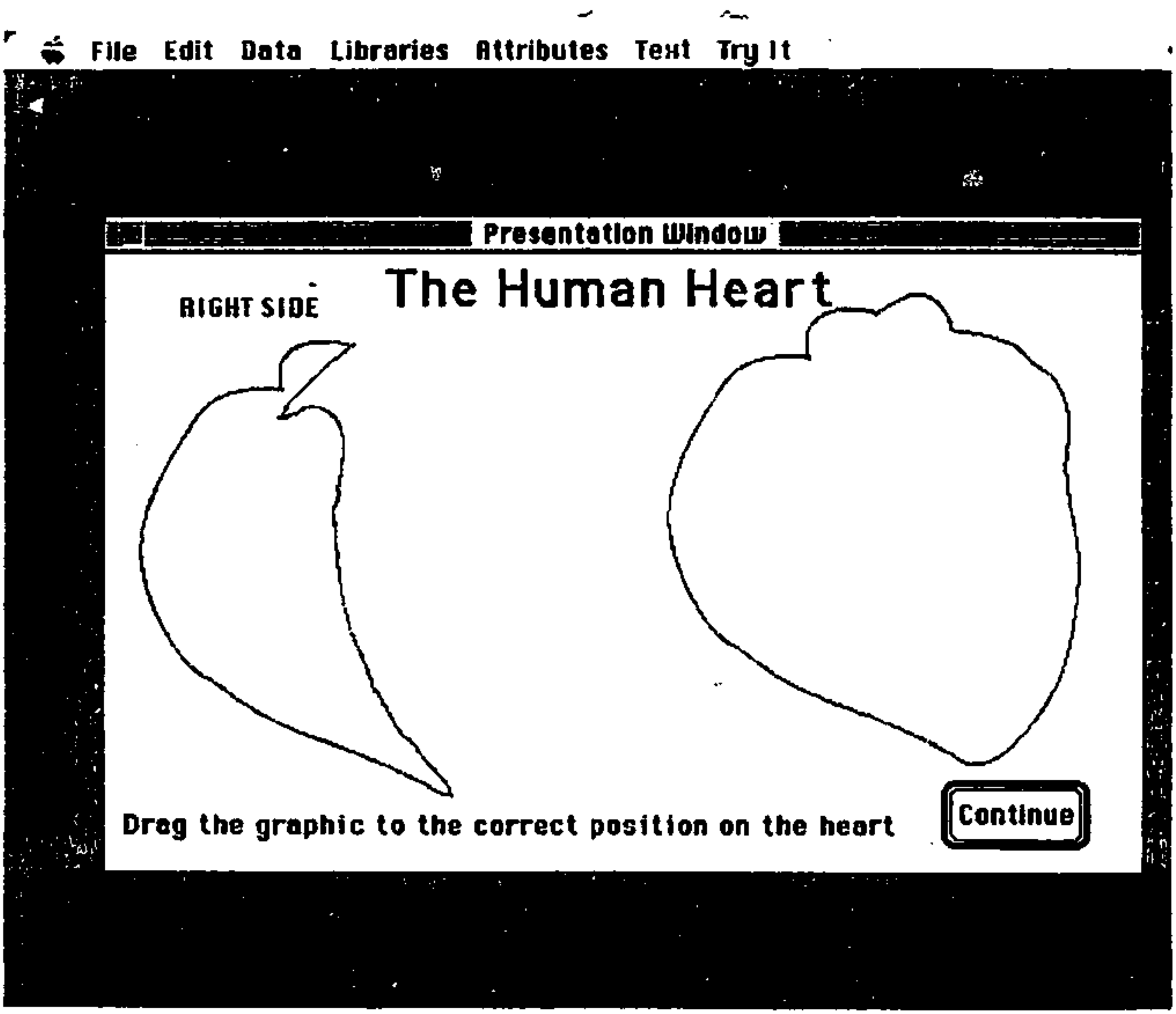


Figure 6



Appendix C
(Brenda Bannan Haag and Barbara L. Grabowski)




File Edit Data Libraries Attributes Text Try It
Presentation Window
The Human Heart
RIGHT SIDE
Drag the graphic to the correct position on the heart
Continue

Appendix D
(Philip A. Koneman and David H. Jonassen)

Figure 1. Sample PFNet.

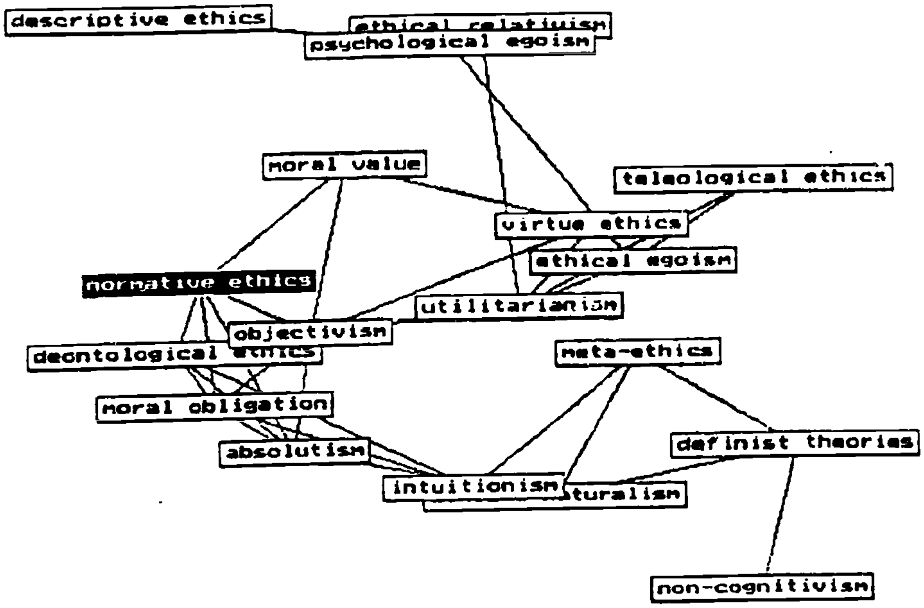
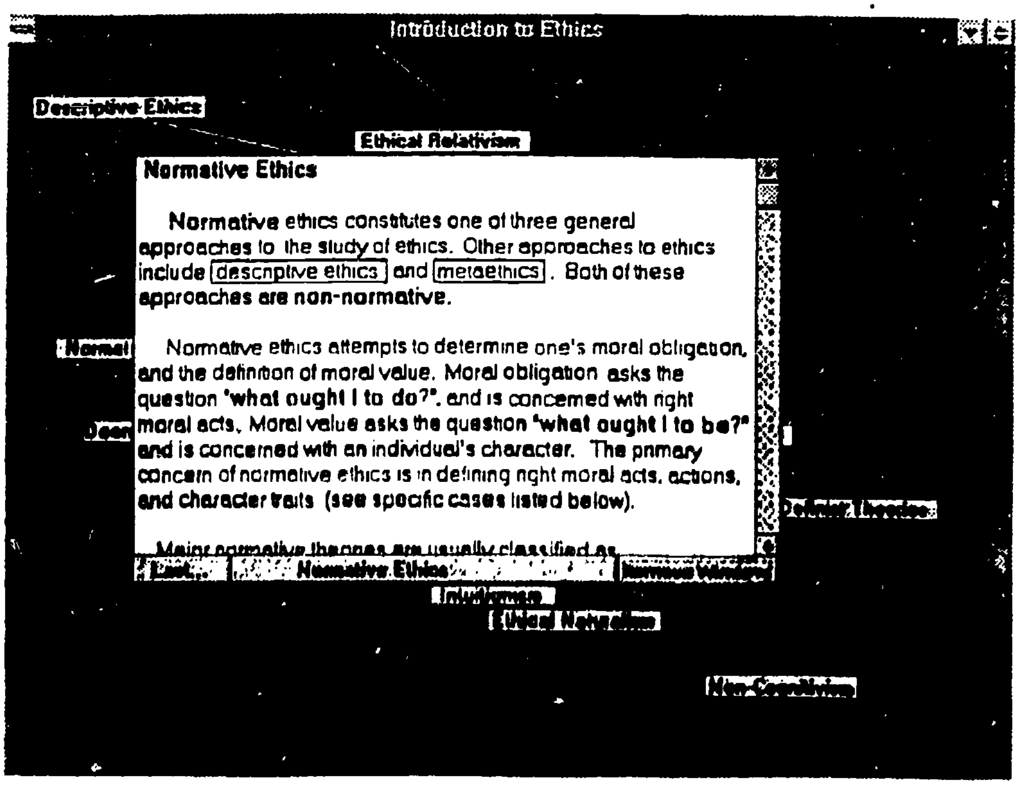


Figure 2. Text window with structured interface in the background.



Appendix E
(Robert V. Price, Judi Repman, and David White)
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Appendix F
(Scott L. Schneberger and Karen Lee Jost)

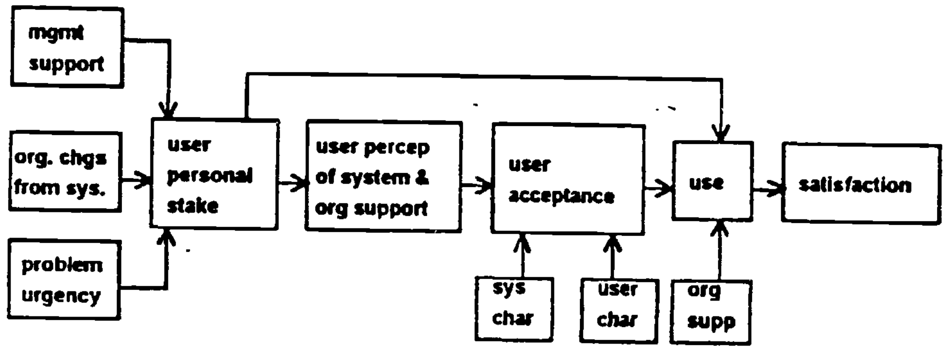

Figure 1. Information Systems Implementation Factor Model

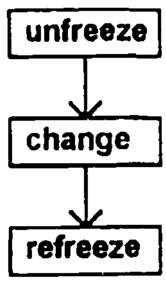

Figure 2. Organizational Imperative Model for IS Adoption and Implementation

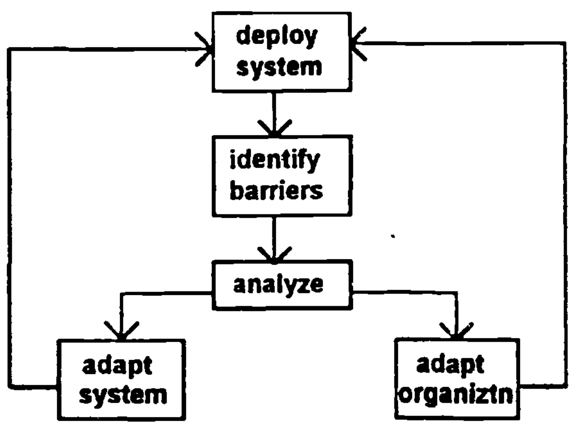

Figure 3. Emergent Perspective Model for IS Adoption and Implementation

Appendix G
(Ruth V. Small and Sueli M. Ferreira)

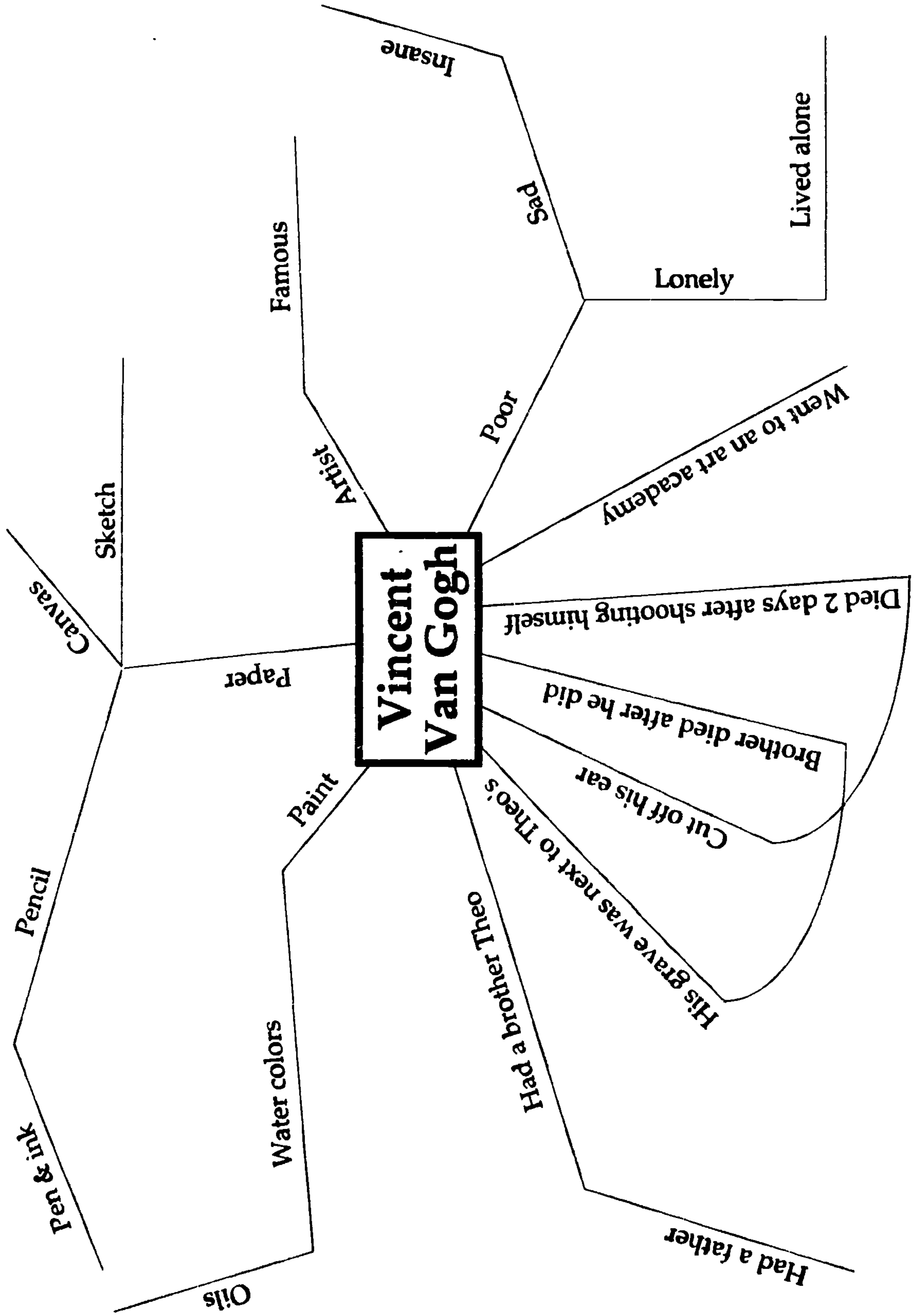

Figure 1. Sample Pattern Note

Appendix G

Group	n	Find			Engage			Extract		
		Tot	%	Mean	Tot	%	Mean	Tot	%	Mean
Pr/Ch	43	819	29%	19.0	1375	49%	32.0	599	22%	13.9****
Mm/Ch	46	2095	35%	45.5****	3851	64%	83.7****	40	1%	0.9

* p<.05
** p<.01
*** p<.001
**** p<.0001

Table 1. Information Location and Use Activities (Find, Engage, Extract) by Children in Print and Multimedia Treatment Groups

Group	n	Find			Engage			Extract		
		Tot	%	Mean	Tot	%	Mean	Tot	%	Mean
Mm/Ch	46	2095	35%	45.5	3851	64%	83.7	40	1%	0.9
Mm/Ad	35	2320	30%	66.3**	5578	70%	157.6****	23	0%	0.003

* p<.05
** p<.01
*** p<.001
**** p<.0001

Table 2. Information Location and Use Activities (Find, Engage, Extract) by Children and Adult Multimedia Treatment Groups

Appendix G

Group	n	Engage					
		Text			Nontext		
		Tot	%	Mean	Tot	%	Mean
Pr/Ch	43	758	55%	17.6	617	45%	14.4
Mm/Ch	46	978	25%	20.8	2873	75%	62.5***

* p<.05
** p<.01
*** p<.001
**** p<.0001

Table 3. Engaging Activities for Text and Nontext Information by Children in Print and Multimedia Treatment Groups

Group	n	Engage					
		Text			Nontext		
		Tot	%	Mean	Tot	%	Mean
Mm/Ch	46	978	25%	20.8	2873	75%	62.5
Mm/Ad	35	1521	28%	43.5****	3998	72%	114.2***

* p<.05
** p<.01
*** p<.001
**** p<.0001

Table 4. Engaging Activities for Text and Nontext Information by Children and Adult Treatment Groups

Appendix G

Group	n	Instr.	Total	Value	Expectancy
Pr/Ch	43	Pretest	75.5	34.9	40.5
Pr/Ch	43	Posttest	71.2	34.2	37.1
		Pre + Post Mean	73.4	34.5	38.8
		Pre- Post Change	-4.3	-0.7	-3.4
Mm/Ch	46	Pretest	79.8	37.4	42.5
Mm/Ch	46	Posttest	83.4	40.9	42.3
		Pre + Post Mean	81.6*	39.1*	42.4
		Pre- Post Change	3.6	3.5	-0.2

* $p<.05$
** $p<.01$
*** $p<.001$
**** $p<.0001$

Table 5. Total Motivation Scores, Value and Expectancy Subscale Post-Pr Mean, and Pre-Post Change Scores for Children in Print and Multimedia Treatment Groups

Appendix G

Group	n	Instr.	Total	Value	Expectancy
Mm/Ch	46	Pretest	79.8	37.4	42.5
Mm/Ch	46	Posttest	83.4	40.9	42.3
		Pre + Post Mean	81.6	39.1	42.4
		Pre- Post Change	03.6	03.5	-00.2
Mm/Ad	36	Pretest	91.0	46.1	45.1
Mm/Ad	36	Posttest	88.7	46.8	41.9
		Pre + Post Mean	89.9*	46.5**	43.5
		Pre- Post Change	-2.3	0.7	-3.2

* $p<.05$
** $p<.01$
*** $p<.001$
**** $p<.0001$

Table 6. Total Motivation Scores, Value Expectancy Subscale Post-Pre Mean, and Pre-Post Change Scores for Children and Adult Multimedia Treatment Groups

Appendix G

				Knowledge Levels							Knowledge Representations								
				Main			Branch				Word			Phrase			Sentence		
Group	n	Instr.	Total	Tot	%	Mean	Tot	%	Mean	Links	Tot	%	Mean	Tot	%	Mean	Tot	%	Mean
Pr/Ch	43	Pretest	315 (7.3)	146	46%	3.4	169	54%	3.9	13	172	55%	4.0	76	24%	1.8	67	21%	1.6
Pr/Ch	43	Posttest	555 (12.9)	282	51%	6.6	273	49%	6.4	33	141	25%	3.2	192	35%	4.5	222	40%	5.2
Mm/Ch	46	Pretest	353 (7.7)	186	53%	4.0	167	47%	3.6	18	214	61%	4.6	75	21%	1.6	64	18%	0.02
Mm/Ch	46	Posttest	531 (11.5)	264	50%	5.7	267	50%	5.8	31	214	40%	4.6	162	31%	3.5	155	29%	3.7

* $p<.05$
** $p<.01$
*** $p<.001$
**** $p<.0001$

Table 7. Total, Main, and Branch Terms, Linking Terms and Words, Phrases, and Sentences for Pretest and Posttest Pattern Note Scores for Children's Print and Multimedia Treatment Groups

Appendix G

Group	n	Instr.	Total	Knowledge Levels						Links	Knowledge Representations								
				Main			Branch				Word			Phrase			Sentence		
				Tot	%	Mean	Tot	%	Mean		Tot	%	Mean	Tot	%	Mean	Tot	%	Mean
Mm/Ad	35	Pretest	407 (11.6)	170	42%	4.9	237	58%	6.8	45	237	58%	6.8	152	37%	4.3	18	4%	0.5
Mm/Ad	35	Posttest	780 (22.3)*	205	26%	5.9	575	74%	16.4***	80	491	63%	14.0	246	31.5%	7.0	43	5.5%	1.2
Mm/Ch	46	Pretest	353 (7.7)	186	53%	4.0	167	47%	3.6	18	214	61%	4.6	75	21%	1.6	64	18%	0.02
Mm/Ch	46	Posttest	531 (11.5)	264	50%	5.7	267	50%	5.8	31	214	40%	4.6	162	31%	3.5	155	29%	3.7

* p<.05
** p<.01
*** p<.001
**** p<.0001

Table 8. Total, Main, and Branch Terms, Linking Terms and Words, Phrases, and Sentences for Pretest and Posttest Pattern Note Scores for Children and Adult Multimedia Treatment Groups

1994

AUTHOR INDEX

1994

DESCRIPTOR INDEX