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ABSTRACT

These proceedings present 74 selected abstracts and 47 selected formal papers under 14 special interest group headings. Topics addressed by the papers include constructing multimedia; interactive video; computers in secondary school mathematics; access in computer-based instruction; implementing computer-based technology; advisor development; cognitive maps; software development by faculty-student teams; learning environments for interactive technologies; computer assisted design; presentation techniques; integrating controversy skills into computer conferencing; updating hypertext systems; navigation maps and cognitive styles; utilizing hypermedia; computer supported learning in administrative organizations; creating courseware catalogs; an international multimedia resource center; programming paradigms; using the authoring system Quest; developing a multipurpose multimedia lab; computer graphics; courseware evaluation; computer-based tools for methodology teaching; emerging technologies; interactive multimedia courseware; an intelligent framework for computer-based instruction; patient simulations; interactive audio; managing multimedia resources; Digital Video Interactive; metacognitive skills; the instructional design taxonomy; users' mental models; building expert system rule bases; creating an intelligent authoring/instructional system; intelligent tutoring systems; a philosophy of education; computer-mediated small-group discussion; computer-mediated conferencing; and networks and multimedia systems. Many of the papers contain references. (ALF)

Empowering People Through Technology

Conference Proceedings of the
34th International Conference of the

Association for the Development of Computer-Based Instructional Systems

ADCIS

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Genesis Management

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Special Interest Group for Elementary, Secondary, and Junior College (ELSECJC)

Three CAI Program to Teach Chinese to Primary School Students in Taiwan, Republic of China

Yu Kao

The ideals of "Teaching without discrimination" and "Teaching according to talents" have always been the core of the educational system in Taiwan. Computers, with the characteristics of individualization and interaction, can fulfill the demands to a satisfactory degree. The Ministry of Education in this country has acknowledged the international trend to use computers in education and has made plans to promote computer-assisted instruction (CAI) at all levels of school in Taiwan.

The purpose of this research is to develop CAI software for primary school students. In order to help the children in Taiwan learn through computers in the easiest way, the Information Science & Technology Center has developed three CAI programs to teach primary school students Chinese.

These three programs are Chinese Phonetic Symbols, Chinese Four-Word Phrases, and Tang Poetry. These programs enable the students to learn both the basic knowledge of the Chinese language and the operation of the computer. Moreover, English directions are available. Students can learn in a bilingual environment. Afterwards, four approaches including analysis, design, implementation and evaluation are adopted to develop a game model of CAI software for future reference.

Finally, conclusions and implications of this research are discussed. Further studies are suggested.

Quality Courseware for Facilitating Teachers' Computer Skills

Doris Lee, Penn State Great Valley

Many educators have revealed that often school teachers are not will trained to use computers due to inadequate training methods. Common problems found in training software are inadequate context and help, one type of instructional lesson for diverse learners, insufficient practice opportunities for novice users and inappropriate responses to learners' learning difficulties.

Quality courseware that is the systematic design of computer software should be used for facilitating school teachers' computer skills. These skills may include operating hypermedia, desktop applications, instructional courseware, or acquiring simple hardware and programming techniques. Effective courseware can be designed to have a comparison between the new technology and other mechanisms with which the learner is more familiar. It should offer a higher level of learner control in which learners can plan their own learning activities. Finally, quality courseware should provide learners with more query and responding opportunities for encouraging self-correction.

PCpattern as a Vehicle for Providing Students with CAD Experience

Isabelle M. Lott and George E. Lott, Pattern Works International

The challenge to teachers in the 1990's is to see that educational vehicles are available which will provide all students with a means to acquire requisite computer literacy.

Many secondary schools and junior colleges have installed computer laboratories and computer-aided design software. However, the majority of the use of these laboratories is by individuals interested in construction, engineering, and the design of manufacturing equipment and parts. Students with other career goals are not acquiring CAD skills.

PCpattern, an AutoCAD add-on garment design software product, is the ideal vehicle to use to open the world of computer-aided design to this untapped student population. The flexibility and low cost of PCpattern means that teachers can quickly and easily capitalize on the inherent student interest in clothing. The potentials of the software can be used to design relatively simple garment patterns in a short space of time, thereby exposing students to AutoCAD.

Students who have a more intensive interest can continue to learn the process of garment design. The software can be used for an entire course in garment design using CAD, or it can be quickly and easily adapted to the independent study approach using our educational materials and tutorials.

Using Hypermedia and Computer-Based Instruction with Elementary Children

Mark Sikorski, Knapp Elementary School; R. Scott Grabinger, University of Colorado

HyperCard and HyperTalk are often used to create lessons for use with middle and high school students. Little documentation exists on their use with young elementary age learners. The purpose of this session is to report on two teacher-created activities that meet specific needs of first through fifth grade students in mathematics and reading/writing.

The relevancy of interactive technology like hypermedia and computer-based instruction is a key to maximizing learner interest and choice in the learning environment. This presentation demonstrates a program used to teach second grade students about place value. Anecdotal data will be presented to describe the effect on these young students. Data from another program used with fifth graders in reading and writing activities will also be presented.

The session will be presented in a lecture format using handouts and overhead transparencies (see appendix for samples). Content of the session includes:

- I. Introduction
    - -description of learning environments, children and programs
- II. Needs Analysis Results and Objectives Development
- III. Program Design Decisions
- IV. Program Creation
- V. Results of Program Use
    - -test results
    - -anecdotal data
- VI. Conclusions and Future Possibilities

High School Students Using Supercomputers: New Horizons

Mary Trainor and Don Willerton, Los Alamos National Lab

As computers are used in almost every workplace today, it is important that high school students obtain exposure to computers. That exposure normally ranges from use of a word processing to programming. Microcomputers can, however, handle only a small fraction of the nation's problems. Supercomputers are heavily used to solve major research problems of national interest. These problems vary from analysis of new automobile engine designs to modelling of the earth's atmosphere to see the effects of different pollutants. It is important therefore for students to understand and experience the range of compute power.

Los Alamos National Laboratory is now in its third year of supporting the New Mexico Supercomputing Challenge. This academic-year long program open to any high school student in the state provides student teams the opportunity to devise a research problem, write a program to solve that problem, and run the program on a supercomputer. The teams work under the supervision of their teacher and with the help of a professional scientist coach. Support for the Challenge is complex, in light of the varied equipment and connection needs of the schools, the varied backgrounds of the students and teachers, and the range of problems chosen by the teams. This support is provided by a partnering of academic, government, and industrial sponsors in the state of New Mexico. Los Alamos provides use of the computers, consulting and coaching support, administration, security, and education.

The Challenge doubled in size from the first to second year. In 1991-92 there were 419 student participants on 112 teams from 51 schools. These students used over 250 CPU hours on the Crays at Los Alamos this year. Each year, awards are given to many of the teams. The projects of the teams that won the grand prize were: "The Critter: An Artificial Life Project" and "The Rings of Saturn: A Simulation." This success of the Challenge has been attributed to the nonselective nature of the Challenge, the teamwork format, and the degree of excitement and opportunity associated with using a supercomputer.

The panel will not be a project report, but rather a discussion of issues associated with use of computers in secondary education.

Using the PHOENIX CBT System in a College Learning Environment

Gary Vaughn, University of Cincinnati

This oral presentation will discuss the issues and concerns involving the usage of a mainframe computer-based training system in a two-year college environment. The Computer-Assisted Instruction Lab of the University College of the University of Cincinnati provides learning opportunities for students enrolled in programs offered by the Language Arts, Mathematics, Business, and Humanities departments. The lab has over forty mainframe modules available to students who drop in on their own initiative, who are referred by their instructors individually or as a class, or who register for accredited courses held solely in the lab. Software ranges from developmental to intermediate skills levels, in keeping with the college's mission to prepare students for transfer into the various baccalaureate colleges. The lab has a total of sixteen terminals, eight IBM dumb terminals and eight Zenith 236 PC's which are used for microcomputer learnware as well as terminal emulation. The PC's connect to the University's Amdahl mainframe via Procomm communication software, a new digital phone system that enables transmission at 9600 baud, and three IBM 7171 Protocol Converters with over ninety ports. The IBM terminal emulation also allows students to connect with UCLID, the University's on-line library catalog system. The lab is staffed by three to four students proctors and a faculty director supervised by the Assistant Dean for Academic Services and guided by a Computer Advisory Committee.

Selected Formal Papers from the

Special Interest Group for Elementary, Secondary, and Junior College (ELSECJC)

CONSTRUCTING MULTIMEDIA: SOLUTIONS FOR EDUCATION

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TOPIC PRESENTATION
COMPUTERS IN EDUCATION DIVISION, ELSECJC (ELEMENTARY/SECONDARY)

ABSTRACT:

Our objective is to show how educators can help students to achieve desired pedagogical goals by explicit classification and definition of objectives, coaching students in the construction of their own multimedia essays, and encouraging a practice of reflection. Rather than hearing details about new multimedia hardware and software, readers and session attendees will learn about a framework of goals and a process for teachers. We will relate results of our experiences in using these techniques with educators.

THE PROBLEM

Many educators have heard that using new multimedia technologies helps students learn, not only by motivating the students to spend more time on task, but also by taking advantage of students' ability to interact closely with different media such as text, audio, graphics, images, animation, and video. A great deal of multimedia hardware and software products are available, along with some information about how to make them run. Much less information is available about how to use them to achieve particular desired student outcomes. A New York City Public School educator, Dr. Florence Mann, responsible for the Technical Assistance Centers' staff development program, crystallized this problem for us by stating that teachers needed to understand "why", not just "how" to use multimedia effectively in the teaching and learning environment. This became our challenge.

OUR SOLUTION

We surveyed many multimedia products and many possible ways to use them in classrooms. We concluded that one of the most promising ways to use them was for teachers to coach and facilitate students in creating their own multimedia materials. We found that we could devise projects that would help students meet useful pedagogical goals in three very distinct categories. One is a very broad set of objectives, which we term higher order thinking, meta-cognitive, and human dynamics skills. A second category includes the content area or discipline specific concepts and facts which would be described in a curriculum. Lastly, we have the category of technical / mechanical skills. Here are examples within each of the three categories:

Under the higher order category, we include ability to use complex concepts; knowledge of vocabulary, symbolism, and interpretation; choices of ways to organize information; understanding navigation and tours through information; ability to summarize and choose, ability to present information appropriately; working successfully in a group; and so on.

The content are includes the objectives of the subject area addressed, such as science, math, social studies, literature, etc.. These would be the significant facts and concepts on specific or interdisciplinary topics and also any use of media to exhibit the sense of an era or drama.

Constructing multimedia or any other type of essay involves specific technical or mechanical skills. Examples are authoring of multimedia projects; good use of an multimedia authoring tool's capabilities; hypermedia linking to organize materials; good planning of interim milestones; appropriate use of audio recording, pictures, and video; knowledge of some technologies used in multimedia systems.

Of course, people will differ on this type of taxonomy. We offer this as a model and strongly urge teachers to develop their own.

We devised and refined four projects that could be used not only to introduce successive multimedia technical skills but also to meet higher order thinking skill goals and content goals in four lists such as the one above. We decided to teach teachers how to use these projects by giving them the opportunity to spend a week acting as if they were their own students and actually creating the projects. Dr. Mann agreed to provide some members from her group of highly competent technical support personnel and a class of interested teachers, so that we could see if our combination of ideas worked. This paper reports that it was not easy, but it worked.

UNDERLYING THEORY

Student creation of multimedia fits well with current trends in educational reform and findings in pedagogical research. These approaches include learning by doing, group work and cooperative work, multisensory learning, learning by constructing knowledge, performance based learning, and portfolio assessment. These types of activities can be and have been done without things like computers, but it appears that students and teachers benefit from the use of technology.

Today's multimedia technologies enable students to perform activities that are motivated by the following theories. Students learn best if they create their own representations of knowledge, and interact with it, rather than passively receiving representations created by others. Additional advantages exist if these representations employ multiple sensory modalities, including not only audio, but also different applications of vision such as text, graphics, images, animation, and video. Some theorists claim that different students benefit from different combinations of the various sensory modalities, so providing for multiple media allows more students to participate with excellence. Interacting actively with material, both during and after creation of its representations, is critical.

Hypertext links among different parts of the material can represent the wide variety of relationships that can exist among different pieces of information. For examples, a link can run from a cause to one of its effects, from a general idea to a specific illustration of it, from a general discussion to a more detailed explanation, from one example of a concept to other examples of the same concept, or from an opinion to a contrary opinion. Students find these links most useful if they create the links themselves to represent relations that they have discovered and want to record.

This is the theory but what do we do in the classroom? Actual achievement of the pedagogical benefits requires teachers to move beyond the function of the technologies and address the issues of articulating the goals, formulating a workable process, and assessing the results. Explicitly stating the desired goals, paying close attention to process and its results, and producing continual improvement are all supported by the principles of good instructional design as well as by common sense. We concluded that educators can help students to achieve desired pedagogical goals by defining the goals, helping students to construct suitable multimedia projects, and assessing the resultant projects against the goals.

THE PROCESS

This section briefly describes a process or framework containing the steps that teachers and students can perform to benefit from constructing multimedia. It then gives examples of two of the steps. Subsequent sections illustrate these concepts with reference to four student projects.

This process description is intended only as a guide. Teachers will certainly vary what they do based on circumstances and experiences and their own style of teaching. We see the process as consisting of four steps: preparation, assignment, creation and reflection.

The preparation step requires the teacher to consider goals, topic, and organizations for the project. She or he must also thinking about the grouping of students, what is to be required ("compulsories" in Olympic parlance) and what would be the characteristics of outstanding projects.

The step of actually assigning the project involves announcing topic, educational goals, and exhibits. The teacher may or may not furnish an organizing principle, template, or 'storyboard'. One tactic is for the class as a whole to generate the project structure and then have individuals or groups work on assignments. The assignment step also requires the teacher to indicate the sources of materials in various media and specify the project deadlines.

The creation step is, naturally enough, when the students create. It may include a cycle when the group members bring together materials, make a plan, develop sample, hold a group critique, listen for comments, determine additional work, and so on. The cycle may be repeated in a larger group. For example, the whole class can discuss extra inter-connections and build new links. The final exhibition is when the class uses and enjoys their products.

The final step, which proceeds smoothly from the prior one, is for reflection and assessment. It is when students are encouraged to reflect on their work and their contribution. The teacher reflects on student performances but also on the project process itself. Assessment can include the class evaluation, public performances, interactive multimedia built-in testing, and Olympic games-type scoring. If the student and the teacher can make the assumption that there will be a next time, then criticisms can be cast in the form of ideas for improvement in the next project.

There is a great deal that could be said about each of the above steps and its sub-steps. Let discussions of an early sub-step and the last step suffice.

In the "Teacher assigns project" step of the process a teacher must select the groups of students who will work together. Practical experience has indicated that, unlike some other uses of computers in education, students genuinely benefit from constructing multimedia projects in groups that range in size from three to five. The group size that is optimal for a given project depends on the natural number of roles that students can play within a group while creating the project product. Limitations on the availability of equipment usually bias the number of students in a group toward the high end of the optimal range. Assigning the project to a group gives teachers the opportunity to allow individual students to develop specialties, but also gives the challenge of making sure that each student eventually plays each of the several possible roles.

The "Reflection and assessment" step applies feedback across an entire step, in addition to reflection that occurs at each step as part of deciding when to go on to the next step. Constructing multimedia projects gives students the opportunity to learn more thoroughly by actively organizing and manipulating information. Similarly, applying objective criteria to such projects gives teachers an opportunity to evaluate students' learning more authentically. Some useful assessment criteria are as follows.

- Teachers should be careful to measure what they want students to improve. Especially in this step, teachers must keep in mind the academic goals that are the real purposes of doing each multimedia project.

- Serious, defensible assessment is necessary in order to move creating projects from the role of a fun thing to do to the role of a standard part of the curriculum.

- Teachers should strive for repeatable, explainable, objective assessments; but both teachers and students must understand that authentic assessment is always more subjective than a percent correct figure for a multiple choice test. A school is likely to need the equivalent of an appeals court or an ombudsman to handle cases where students feel that an assessment has been unfair.

- Teachers must often assess a collection of projects created by different groups, in order to assess the performance of each individual. In particular, individual assessment may require overt interference in the groups, to make sure that each individual eventually plays all roles. Some specialization is desirable, but both learning and assessment require that specialization must not be overdone.

- Teachers must be aware of the dark side of decorative media: these can distract both students and teachers from serious content. Teachers must make sure that the "compulsories" are completed and the media must illustrate mastery of the content, not mask lack of understanding.

Multimedia is fundamentally a mode of communication. Teachers must check that each project actually communicates the important information to the relevant audience, be it the teacher, peer students, or a wider audience. Assessment can help students to improve their use of different media to convey different types of information most effectively.

THE FOUR PROJECTS:

"Current Events" project with hypertext, optional scanned photographs

The "Current Events" project is a multimedia version of the standard assignment to bring in newspaper articles, post them on a bulletin board, and connect related articles with colorful tapes. Different colors distinguish different types of relationships among articles.

The multimedia project replaces the bulletin board by a computer disk. Each student summarizes an article on one page of a multimedia folder, optionally adds a scanned picture, and then creates hypertext links from the article to other articles and to such things as timelines, maps, concept maps, and word definitions. The result of this project is a continuously expanding multimedia database that is available for students to navigate through, to find specific information.

The technology and the multimedia goal framework of this project enhance the articles' pedagogical value by focusing on in depth understanding of the articles and of their connections to other articles and to concepts. Related contributers to increased learning include the sustained attention to a topic over time, paying attention to differing points of view, independent but cooperative work, articulating connections between different points of view, determining multiple contexts, and attention to potential sources of bias.

A teacher selects a domain or subject for the newspaper articles, depending on the teacher's educational objectives and the students' interests. The teacher should consider suggesting articles from ethnic newspapers, including non-English newspapers in the case of language classes, where summaries need not be in the same languages of the articles. The teacher should insist, as one of the compulsories (using the Olympic games terminology) that each article include a citation, a link to at least one other article, and a link to both a timeline and a map. An excellent contribution to this project could include also creating a concept map and adding links from nodes of that map to many relevant articles, adding a scanned picture or graphic to the summary, and linking difficult words to their definitions in a growing class dictionary.

The teacher has to be prepared to answer questions about why the project emphasizes text summaries of articles, augmented by only an occasional scanned picture or graphic, rather than scanning in the actual articles. The answer is that a fairly dense screen containing a typed summary can be stored in under one thousand bytes of disk space, whereas a scanned image of a newspaper article, with sufficiently high resolution to be readable, can occupy one million bytes of space. With text summaries, a given computer can store a thousand times more typed summaries than scanned articles. For example, a moderately large hardfile would be filled by about 100 scanned images of articles, but could hold one hundred thousand text summaries. Technically, typing in a text summary is a wonderfully effective way of compressing an image. Of course, Optical Character Recognition is a possibility. But then, student generated summaries also can provide a higher order thinking skill goal as well.

In the "Reflection" step of the process, teachers should look for ways to encourage improvement in the richness of the connections among articles, incrementally adding to the assignment such things as supporting analysis essays and factual quizzes on the contents of the archive. With this continual follow-up the archive will grow ana becomes more useful and interesting.

"Critics' Circle" project with digital audio, photographs, graphics

This project can be applied many times to many different subjects. Their common element is the opportunity to record and analyze difference of opinion about the subject. We applied "Critics' Circle" to opinions about a movie. The same techniques can be applied later to serious political, social, ethical, or even technical issues.

The teacher divides the class into groups of five students. Each group prepares a multimedia folder that records three orally expressed points of view on the movie. For each person who records an opinion, the project includes either a scanned or frame grabbed picture or a graphic sketch, to be displayed while that person's opinion is being played back. The group also provides an introductory page from which a reader can select any of the recorded opinions and prepares a (formal) written summary of the differences of opinion that were expressed using the (in formal) oral medium.

Creating this project includes selecting a subset of the group's views that represent the spectrum of opinion and that are individually and collectively interesting and entertaining, and that can be compelling expressed using a combination of text, graphics and audio. The project requires that the chosen "critics" be named or characterized and the clash or relationship of opinions be described. The group members must come to terms with the experience of different roles. In some situations, members will consider role-playing to present a view different from their own.

Each of the projects can be used to achieve a particular list of goals of the three types discussed above. For "Critics' Circle" the goals are as follows:

- Higher order thinking skills
  - Working successfully in a group
  - Making choices in a group
  - Recognizing spectrum of views and presenting them in a meaningful way
  - Imagination and empathy
  - Ability to summarize
  - Role playing
- Content
  - What different people react to in a given topic or movie
  - Deeper understanding of intrinsic content of topic
  - Dramatic / production values in films
- Technical

Basic authoring of folders; linking to provide coherent and logical organization of materials on opinions of the movie
Creation of graphic buttons (icons)
Use of and creation of pictures
Use of and creation of audio recording
Total effect of text, graphics, and audio

"Trailers" project with control of commercial video, recorded audio

Each of several groups creates a trailer for a given movie. A trailer is a short set of clips and voice-overs that the group designs in order to make a given audience want to go see that movie.

This project is organized as a specific tour that the authors prepare in order to have a particular effect on the selected audience, so user-driven navigation through hypermedia gets to take the day off.

Technically, the tour consists of a sequence of instructions that cause a laserdisc player to play particular video clips, synchronized with instructions to replay digitally recorded voiceovers. Even simple multimedia authoring tools provide good ways for students to prepare such a tour. However, tools differ significantly in the amount of effort they require. The less capable tools require students to time the lengths of their digital audio recordings, and their selected video clips, and then to tell the system how long to wait for playing to finish, in what looks suspiciously like a programming language. More capable tools represent each segment of digital audio and each video clip by a visible icon, and allow a student to prepare a tour by simply dragging icons into juxtaposition along a timeline.

Teachers must be prepared to answer a question such as "Why must this project use a computer-controlled laserdisc player when Video Cassette Recorders and their media are so much more widely available?" The answer is that a direct-access medium, such as a laserdisc, can find the next desired clip in less than a second, by moving a head radially across the tracks of the disc. Contrast that to a VCR which (even if controlled by computer) may require several minutes to find a desired clip by passing over all of the intervening tape. People can maintain a train of thought during a wait that lasts a second but not during a wait that lasts several minutes

"Planning" project with organization of materials, getting started

Each group prepares a multimedia presentation on its plans for using multimedia in a particular discipline, with emphasis on how the information is organized. For students who were not actually teachers, this project would have been directed to presenting some content from a discipline selected by each group.

In this project, the teacher discusses several examples of projects that use different organizations of material. The examples range from work by 4th graders and 7th graders to fairly professional materials. Each group was asked to prepare a multimedia presentation on their plans for the coming year, with buttons on schedules and milestones, and with possible roadblocks identified. They then give the presentation and discuss their plans.

THE WORKSHOP

We had decided to teach student creation of multimedia projects to teachers by example, that is, by having them pretend to be their students and actually create a sequence of multimedia projects of increasing difficulty. We did not know whether teachers could do this, in a strange environment of hardware, software, and multiple media, and also be able to think about how they would subsequently coach their own students in doing similar projects. To make success more likely, we split the workshop into three parts and provided templates for the teachers to use.

The workshop's parts were as follows.

- In early June, 1992, we spent a day introducing the authoring system and the four projects to a half dozen technical support staff. For this session, we set up two multimedia computer systems in a conference room in IBM Watson Research Center's Hawthorne Lab.
- One week later, we held an orientation day for all of the teachers and staff people in the Yorktown Heights Lab. In the morning, we presented the framework and projects described above to one half of the group, in a large room equipped with a multimedia system and a large overhead projector. Next door, the other half of the group used a dozen machines that had no special hardware, to work through the online tutorial that is a part of our selected multimedia authoring system. The halves reversed roles in the afternoon. Staff people helped make sure that everybody finished the tutorial successfully and also took video pictures of the teachers for them to use later in the "Critics' Circle" project.
- Finally, in mid-July, the teachers and staff people spent a week at the Hawthorne Lab, where we had set up seven fully-equipped multimedia systems in different small rooms for their use. We started each day with a brief lecture and longer group discussion. Then the teachers broke into groups and created one of the projects. Finally, the groups came back together and presented their results. We allocated an entire day to creating the third, "Trailers," project, and held its presentations the following morning.

We provided the workshop attendees with templates for three of the projects. A template is an example of a usable project, on a diskette, that the teachers could modify. Especially for the first few projects, using a template is an attractive alternative to starting from scratch to create a project. In a sense, templates constitute their own layer in the software hierarchy, just above authoring tools and reference materials, but below unmodifiable professionally created titles.

The workshop's first three projects form a sequence, starting with a quite complete template, in which students create their first project by simply doing more of what the template's author did, and ending with a completely optional template, where students are encouraged to look at an example and then do their own thing for the third project. For the fourth project, we just showed several examples, but handed out no diskettes. The primary purpose of providing a complete template for early projects is to allow students to concentrate most of their attention on the subject matter, rather than struggling with the details of operating the software. Secondarily, of course, templates also teach by example. A complete template includes a printed "cook-book" telling what keystrokes and mouse motions are involved. These are the instructions, that everyone reads only when all else fails. Of course, actual templates and cook-books are specific to one authoring tool, but the concept has general applicability.

RESULTS OF THE WORKSHOP

This workshop was considered a success by the participants, the staff of the NYC Public School Technical Assistance Centers, and the instructors, who learned as much as the attendees about the reality of the classroom. We will touch on only a fraction of the issues which surfaced, including the wide variety of teacher experience, the challenges of scheduling time and space, the usefulness of completed projects, and the role of competition among students and among students and teachers.

We had expected that the circumstances of this workshop would mean the attendees would be self-selected and all would have considerable experience with computers. We found instead a great variety: even today there are many teachers with little computer experience and perhaps even some computer phobia. We think that by the end of the week, through the experiences and the gentle introductions, everyone was comfortable and eager to do more. Honesty prevailed. At the end, one of the teachers said "I think now I'm ready to do the tutorial again". It is important to make sure that even the beginners benefit.

At the start, we realized that potentially there were three categories of "problem" workshop participants: teachers who were not computer literate, perhaps even still computer phobic; the opposite, that is, teachers who were already familiar with multimedia and who might thus resent a slow pace; and people who had strong allegiances to other products and product lines. We were quite gratified that at the close of the workshop, all of the participants, including the technical staff, expressed strongly positive assessments about the workshop, the method of teaching, and even of the products used.

We were especially gratified that the minority teachers indicated that they felt that multimedia projects would especially benefit the inner-city children. The teachers and staff, were committed to overcoming obstacles of budget, time and bureaucracy to implement these programs in their schools.

Scheduling of time and place remain a problem, either in a school or in a corporate research lab. Time must be scheduled in long enough blocks to allow sustained creative activity. Equipment must be placed close together so that one person can coach and advise several groups, yet use of sound in most projects favors some separation of the groups from one another and from class discussions. Student created multimedia projects can become important parts of the teaching and learning process only if the projects are integrated into the general curriculum of various disciplines and combinations of disciplines, rather than being separated out into computer literacy classes. This works far better if the equipment is available in the regular classrooms, rather than being relegated to a computer lab or library audio-visual center.

One teacher brought up the disadvantage that a completed multimedia project can be enjoyed only by people who have the right technology available, unlike reports written using paper and pencil, that anyone can read. Several of the teachers countered that the pencil and paper reports were so uninteresting that no one read them, whereas people would go out of their way to see a multimedia report. They emphasized that the expectation of an audience strongly encouraged students to improve their results.

A surprise at the workshop, though the instructors should have expected it, was the negative reaction to voting on the best "Trailers" project. The discussion divided into two distinct issues: competition among young students and competition among teachers. The instructors believe that competition has its place in school, because the fact is that there is much competition in life. The advantages of distinct competitions among well-chosen groups is that the students know the rules and they can come back to compete another day. In contrast, for many children much of the competition is subtle and on-going and they can never win. However, it is our opinion that the real issue at the workshop was the second, competition among teachers themselves. These teachers, like many others, feel they are constantly being judged and it is often unfair. Though we saw this as a "fun" thing, and did not think there was an obvious winner, that is, practically all the projects were contenders, a significant portion of the attendees preferred to pass on the voting.

We feel that we validated the concept of using student created multimedia projects to meet academic goals and also validated the approach of teaching the concept to teachers by means of examples. We are continuing to receive feedback from the teachers and would appreciate comments from readers.

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A Programmatic Approach to Research in the Application of Interactive Video to Social Learning

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ABSTRACT

This paper seeks to describe the benefits associated with a programmatic approach to educational technology research. Session participants will be provided with an example of a programmatic approach which is being employed to address limitations in existing media comparison and replication research. The paper describes some fundamental practical problems in conducting research on technology and will employ specific examples from studies in the application of interactive technology to social learning to illustrate key points and suggest ways in which problems can be addressed.

Concerns about the source of achievement effects have emerged as a frequently discussed issue in technology research (Clark, 1983; Kozma, 1991; Hasselbring et al, 1987-88; Reeves, 1986). Much of the conjecture is based upon the observation that many media comparison studies are confounded by design weaknesses, which in part, result from a failure to consider and/or control for rival hypotheses (Kearsley & Frost, 1985). A conclusion which is commonly drawn is that the critical variable in media comparison studies is not the medium but associated factors such as: instructional design (Hasselbring et al, 1987-88), treatment implementation effects, the uncontrolled effects of novelty associated with the application of new technology (Clark, 1983), and effects associated with the teachers engaged in implementing the interventions. These explanations, amongst others, have been used to account for the results of studies which have reported support for their respective hypotheses, but have failed to control for sources of bias. Clark (1983) strongly suggested that given these problems, studies involving media comparisons are inadvisable and that medium is not a significant factor in explaining achievement outcomes. More recent work by Kozma (1991) challenges this assertion by suggesting that learning requires an interaction between the characteristics of the learner and the medium which can exert an influence on cognitive processes and subsequent learning. Kozma suggests that rather than dispense with media comparison research, the nature of the media-learner interaction should be subjected to further investigation. A programmatic approach may be required in order to undertake a full exposition of this relationship. Such an approach would seek to systematically link theory, content, teaching and learning.

Over the past six years we have been conducting a very practical investigation of the type of social skills which are problematic for adolescent-aged students and their teachers in school settings and the role of interactive video in assessing and teaching those skills (e.g., Bain, 1990; Bain, Houghton & Farris, 1991, Carroll, Bain & Houghton, 1992; Bain, Houghton, Foo & Carroll, 1992). It should be noted that throughout the paper the pronoun "we" will be used to acknowledge the input of my co-researchers to the research program.

To date the project has involved eight related studies, one of which is currently in progress which have examined factors associated with the application of interactive video technology to social learning. Our research has sought to link theory, content, and the characteristics of teacher/learner and teaching/learning interactions in order to provide meaningful conclusions about the role of interactive media in social learning. This work has been undertaken at the University of Western Australia and Lehigh University with involvement from faculty at Western Michigan University. The project has resulted in the development of a 28 lesson curriculum which employs the Hypercard and Hypercard II programming languages. Animated sequences and graphics included in the lessons were developed using Macromind Director and Supercard programs. The program is approximately 30 megabytes in size and includes 2 hours of disc-based video material. The program is a level three interactive video application which runs on a Macintosh II computer incorporating a MASS colorspace video board and linked with a Sony 3600D multistandard video disc player.

While for the purposes of this presentation, it is not possible to describe in full detail the methodology and results associated with each of the studies undertaken, the ongoing nature of the project has provided us with what we believe to be some important insights into the difficulties associated with drawing meaningful conclusions about the role of media in instruction and has provided a basis for the continued investigation of the role of interactive technology in teaching and assessment in the field of social skills. The purpose of this paper is to share those insights with you.

The paper will focus directly on a number of problems we believe to be characteristic of research involving the application of technology to instruction. I will describe the ways in which those problems were addressed in undertaking our own research. Our studies and their findings will be used to illustrate our approach and to serve as evidence for general recommendations regarding the conduct of future research programs.

Problem 1

The application of technology to instruction is commonly based on its perceived potential as a solution to an applied problem. Unfortunately, research often proceeds without recognition of important theoretical and applied research which may have a critical bearing on the long term outcomes of a project. There is, in many instances, a failure to provide an adequate theoretical link between the technological medium, teaching and learning, and the application. This is a fundamental construct validity question which is commonly left unattended. Research commonly proceeds on the basis of intuition and assumption.

Our own research is underpinned by the extensive body of research on social learning, particularly the work of Albert Bandura and his multiprocess theory of observational learning. However, the project, like many others, began as as a response to a practical problem. In teaching social skills to young people we found that their capacity to obtain benefit from the instruction seemed limited by our capacity to adequately depict social situations in a manner which was perceived by adolescent-aged students to be be meaningful and impactful. Students with attentional difficulties for example have significant needs in the areas of social skills (Sagvolden & Archer, 1989) and commonly have difficulty in connecting their behavior with the social contexts in which they function. There was a clear intuitive and inviting precedent and rationale for the application of video technology to this area in order to depict interesting social situations which would be hard to describe in class discussion or recreate in roleplay.

However, before pursuing information on the role of technology, we sought to identify links between the nature of social learning and the potential role of media in that learning. Bandura's social learning theory (1986) provided the theoretical rationale and a guide to the application. By referencing our intuition to a theoretical perspective we opened our project up to a wealth of research on the way people learn from models, the types of models which are most effective and the cognitive processes which translate observation into behavior. For example, we found studies on the effects of gender, model type (positive or negative), peer versus adult models and model attractiveness. From Bandura's theory we learned many things about the way video could be most effectively deployed to assist with increasing attention to models and to serve as a basis for the rehearsal and production of social behavior. We also used previous studies in the areas of social learning and modeling to articulate the type of content to be developed and the way in which it would be presented, including some very practical considerations associated with the age of the kids who would participate and even what kids should wear for our video sequences.

In order to further develop the theoretical rationale for our own research, we investigated the effects of model type and linear and interactive video medium on the attention and recall of early adolescents with attentional difficulties. This study provided us with additional information on the effects of model type. We found for example, that juxtaposing positive and negative video models resulted in higher levels of comprehension than a positive-neutral model sequence. We also found that attention and comprehension were statistically significantly higher for interactive video when compared to linear video, findings which provided us with the empirical basis to employ interactive over linear video in the development of training materials.

In summary, our first recommendation is simply, attend to construct validity. Generate a theoretical link between the suppositions and assumptions associated with the application of technology to instruction and use preceding research to identify key considerations in implementation as well as to provide a sound theoretical basis for the work.

Problem 2

The content of the application needs to be validated with respect to the population with whom it will be used. To what extent is the content of the application relevant to the population of interest?

Our second problem pertains to the interaction between the theory, the population of interest and the content of the application. Where one is confident about the relationship between theory, medium and the application, a need exists to subject the content of the application to a validation which seeks to link theory, application and target population. It is at this point that we recognize the interaction between the needs of a population and the application. Again, with respect to our own project, the wealth of research in the area of social learning provided us with a foundation on which to build. We also recognized the more fundamental need to validate the contents of any materials we would develop. While a theoretical rationale may exist for the application in question, a rigorous examination of the content is necessary if the application is to work.

One of our first major studies sought to address this issue by empirically validating those social situations which were problematic for early adolescents in school settings. In an article published in the British journal, Educational Psychology, we described the application of the Behavior Analytic Method (Goldfried & D'Zurilla, 1969) to identify and validate the content of those social situations which occur in school and are problematic for early adolescents. In order to achieve this objective we reviewed assessment devices, curricula and the social skills literature to identify a pool of relevant social skills and then sampled the opinions of over 100 students and teachers in order to elucidate, in a disciplined manner, those skills and situations which would serve as the basis of our assessment and curriculum materials. This research resulted in the development of a matrix of 16, content validated skills and situations which served as the basis for our application. These situations and skills were turned into video sequences which in turn served as the basis for our assessment device and curriculum.

Just as one cannot assume a relationship between theoretical constructs and practice, nor can one assume the validity of the content derived from the theory. Our second recommendation is to attend to content validity. Use a disciplined approach to validate the content of the application.

Problem 3

Any application of technology to teaching and instruction must derive its design from empirically supported principles of instruction. Applications which involve the combination of instructional technology commonly proceed on the basis of assumptions about the design of instruction which often have little in the way of empirical support regarding their effects on educational productivity. It should come as no surprise that research on the effectiveness of instructional technology has been equivocal, when one considers the paucity of studies which have adequately considered the instructional design variable and adequately controlled for factors associated with the design and implementation of instruction.

For the purposes of our most recent study involving a comparison of interactive and linear video we developed carefully scripted lessons based upon the principles of Structured Learning and Direct Instruction. The lesson formats were piloted with early adolescent aged students as part of a formative evaluation procedure and prior to the development of any video materials. We used the evaluation to ascertain the extent to which the design of lessons was sound and the delivery clearly understood by students who would be the consumers of our interactive video-based social problem-solving curriculum materials. When studying the effects of the curriculum, we also sought to establish the integrity with which teachers' implemented lessons, not only in the interactive condition but in all 3 of the conditions under investigation. This involved reviewing videotapes and matching the observed behavior with the scripted sequences for each lesson (see Bain, Houghton, Foo & Carroll, 1992).

Our thiru recommendation is to pay strict attention to those characteristics of effective instruction and design applications on the basis of procedures and practices which have been shown to work.

Problem 4

Any investigation which implies an interaction of technology, teaching and learning must address both the processes of teaching and learning as well as their products. Few studies have sought to address these variables and to replicate findings in order to improve reliability.

The multiplicity of factors which have been shown to correlate with student achievement and the failure to explain achievement effects in IV research (McNeil & Nelson, 1991) would suggest a need to consider the effects of process variables in media comparison studies. Contemporary research on teaching has focused on the search for influential variables associated with school learning which optimize educational outcomes across school settings (Wang & Walberg, 1991). For example, the extensive body of educational productivity research has recognized the contribution of such process variables as: teacher feedback and encouragement, classroom organizational factors and student attention, all of which are significantly correlated with learning outcomes (Frazer, Walberg, Welch & Hattie, 1987).

The contribution of these variables to the outcomes of instruction and educational productivity broadens the term of reference for researchers interested in examining media effects, particularly if one accepts that a substantive change in the delivery of instruction also represents a major change in the stimulus conditions under which instruction is to occur and as such, may also influence achievement-related variables. For example, group based interactive video instruction can alter the role and behavior of the teacher and students in classroom instruction. Where under a more traditional didactic model the teacher may be totally responsible for the delivery of content, when using interactive video the teacher may share that responsibility with the interactive video delivery system in the form of a video narrator (e.g., Systems Impact, 1985). Such a change may influence the way in which students attend to the stimulus information presented and the type and amount of interaction which occurs between student and teacher or student and interactive video. By including both process and product variables in research studies involving technology, it may be possible to obtain a clearer picture of the effects of the medium on student outcomes (e.g., attitude and achievement) and factors known to be related to those outcomes (e.g., attention, opportunities to respond).

In our last two studies we sought to measure both process and product factors as part of the investigation. In a study by Carroll, Bain & Houghton (1991) which compared the effects of interactive and linear video with 72 children with Attentional Difficulties, we selected attention as a process variable in addition to measuring comprehension of social interactions. We used a direct observation approach to measure the levels of attending under both interactive video and linear video conditions and found a statistically significant effect in favor of the interactive video condition. In a second, more applied study by Bain, Houghton, Foo & Carroll (1992) we conducted a comparison between interactive, linear and non-video conditions for teaching social problem-solving to early adolescents in classroom settings. The study measured attitude and achievement as the product variables and also included measurement of teacher encouragement and questioning, attending, lesson duration and student participation, all of which have been described as process variables in the educational productivity research. The results indicated statistically significant differences between the conditions for attitude and achievement in favor of interactive video with differential effects across the three conditions form the process variables. For example, attention levels were highest in the interactive video condition, although active student participation was lowest. These were interesting findings given the previously described effects of student participation on achievement. They are also suggestive of the complexity of the interaction between teaching, learning and technology which underscores the need to treat investigations of the effects of instructional technology in a programmatic manner. In addition, these results point to the need to replicate studies in order to increase the reliability of findings. Replication should focus on the extent to which findings are consistent across process and product variables and subject populations.

Our fourth recommendation is to consider both process and product factors in any research which involves an interaction between teaching, learning and technology. In order to improve the reliability of findings in these areas replication is necessary.

At present we are continuing to examine the effects of our interactive video-based materials on social problem-solving and social skills assessment. Our most recent study, which is currently under analysis, extended our application of the curricular materials to adolescents who have attentional difficulties. It is our intention to both develop our line of work and to fill in some gaps through extension and replication of existing studies. In concluding, a final recommendation is in order. Simply, design good studies. This is a goal for us all given the logistical constraints we operate under which may force compromises in a number of critical areas (e.g., selection and number of participants, time for implementation and replication). Many of the existing criticisms of media comparison research (e.g., novelty and teacher effects) apply equally to all educational research and pertain more to experimental design issues than to fundamental conceptual flaws in media comparisons.

In summary, the purpose of this paper has been to describe a line of research which has sought to address problems associated with the existing status of research on instructional technology. The paper identified a number of problems associated with the failure to consider issues of construct and content validity and the interaction of teaching and learning in the research process. Examples from a program of research on social learning through interactive video were provided to illustrate the ways in which those problems could be addressed.

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The Process of Implementing the Use of Computers in Teaching Secondary School Mathematics and the Effect on Student Learning: A Field Study

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Abstract

A three year project involving the collaboration of Stevens Institute faculty with 30 mathematics teachers at 5 New Jersey high schools resulted in the implementation of computer use in the teaching of mathematics. During the academic year 1990-91, two before-and-after, with-and-without studies of student performance on in-class tests investigated the effect on student learning. Each student in the two samples of 108 and 71 students were given a pre-test, a post-test, and a delayed post-test (to measure retention). The analysis was performed on the improvement of post-test scores over pre-test scores, and on the improvement of delayed-post-test scores over pre-test scores. Each student in the sample of 71 students participated both in the treatment condition, using computers, as well as in the control condition, not using computers, on different topics; these students showed a statistically insignificant 7% better performance on the in the treatment condition over the control condition on the post-test improvement and a statistically significant 18% better performance on the delayed-post-test improvement. The sample of 108 students were split between the treatment condition (41 students) and the control condition (61 students); the students who studied with the use of computers showed a 45% better performance on the post-test improvement and a 70% better performance on the delayed-post-test improvement over the students who studied without the use of computers. For the latter sample, these results represent almost a full standard deviation better performance. Data showing the relationship between performance and other factors, such as subject matter, school, treatment order, and extent of computer use are also presented.

1. Introduction

During a three year period from 1988 through 1991, faculty and staff from the Center for Improved Engineering and Science Education (CIESE) at Stevens conducted a project at five New Jersey high schools intended to explore the effects of the introduction and use of computers in high school mathematics.

Evaluation of this project focused on three aspects: student performance (conducted by Jurkat, Skov, and McGinley from CIESE); teacher knowledge, activities, attitudes and beliefs (conducted by Morris (1992) from Educational Testing Service); and the administration and conduct of the project by Brunner and Henriquez (1991) from Bank Street College of Education. In addition, a detailed case study of the activities and effects of the project was done at one of the schools [Allum (1991)]. This paper will concentrate on student performance results, summaries of the other studies are included in Appendices I, II, and III.

2. Summary of Results

Student performance was evaluated using a combination of before-and-after, with-and-without computer use design. Two separate samples of students were used.

In one sample of 108 students, the students in classes where computers were used showed 45% better performance improvement (on post-test minus pre-test scores) over students in classes where computers were not used, and 70% better retention (measured by delayed-post-test minus pre-test scores). These represent approximately 1 standard deviations in both cases.

In another sample, each of 71 students were taught and tested on a topic where computers were used and on a different topic where computers were not used. The same teacher taught both topics in both conditions. Overall in this sample, the performance of students on topics where computers were used was a statistically insignificant 7% better than the performance of the same students on topics where computers were not used, but retention was 18% better. Performance showed a wide range of results which varied with experimental conditions, from a 67% reduction in performance (in a small class of 11 students) to a 140% increase in performance (in another small class of 10 students). Both of these extremes occurred in the same school.

3. Background

The standard approach to testing the results of an educational innovation consists of testing student performance before and after the introduction of the innovation and comparing those results to a control group taught without the introduction of the innovation.

Many such studies have evaluated the use of computers as the innovation being tested, and several authors have evaluated the studies themselves. J.A. Kulik and associates in a series of reviews [Kulik and Bangert-Drowns (1983), Kulik, Bangert, and Williams (1983), Bangert-Drowns, Kulik, and Kulik (1985), Kulik and Kulik (1989)] found the use of computers to be generally effective in improving performance. In their most recent report [Kulik and Kulik (1989)], which reviewed 91 studies in mathematics, they concluded that the typical student who learned or was taught with the use of computers would outperform 60% of the students who learned or were taught without the use of computers.

In a more recent paper, J. Phillip Bennett (August, 1991) reviewed the reviews of Kulik and associates mentioned above as well as the reviews of M.D. Roblyer and associates [Roblyer (1988), Roblyer, Castine, and King (1988)], and H.J. Becker (1991). From these he concluded that in mathematics the use of computers increased achievement when used as a supplement to other forms of teaching. More generally, Bennett also concluded that the use of computers improved students' attitudes toward computers and instruction but not necessarily toward mathematics, that students learn more quickly when computers are used to supplement other instruction, and that computers have a greater effect on the learning of disadvantaged and low ability students than the average student.

Several reasons have been mentioned as to why the use of computers might help student learning. Some specifically related to the operational aspects of computer use have been discussed by Kaput (1991) and include the ability of the computer to support the visualization of intermediate steps in mathematical processes, to implement constraint-support structures on both mathematical objects and actions in microworlds, to help overcome cognitive overload due to keeping connections between structures and actions in two or more representations of mathematical ideas (*e.g.*, algebraic equations of functions, their graphs, and a simulation of the physics of the situation being modeled), and the general ability of computers to make explicit such multiple linked representations.

On a more situational and social/classroom organizational level, the use of computers makes it possible, and maybe easy, to support teachers in forms of instruction and student learning other than the traditional lecture-problem-test paradigm. Although not explicitly part of our research, we have observed examples of visual learning [as described by, for example, Collins, Brown, and Holum (1991)], constructivism [as described by, for example, Cobb, Yackel, and Wood (1992)], and collaborative learning [as discussed, for instance, in Davidson and Kroll (1991)].

The seemingly simple approach of comparing student performance after learning or being taught "with" *vs.* "without" is not without its problems. The most intractable is that it is impossible to make the students and situation faced by those students in the experimental group truly comparable to the students and the situation faced by the students in the control group. Different groups of students are used because little insight can be gained when the same student is taught the same material twice, once "with" the use of computers and once "without". In addition, if alternative teaching and learning paradigms are used, maybe even without meaning to, when computers are introduced into the learning situation, it is difficult to separate the effects of the alternative paradigms from the use of computers themselves.

In another review of Kulik and his associates' work, Clark (1985) concluded that there were many differences other than the use of computers in the groups of the studies examined by Kulik *et.al.* Betty Collis (August/September 1988) lists student cognitive and social characteristics, teacher characteristics, overall instructional strategy, social organizations of classes and classrooms, social and physical organization of the computer work, and the characteristics of the hardware and software as variables that will confound the results of with and without studies.

It may be concluded from this brief review that "with" and "without" studies are valuable, but care needs to be taken so that the effect of the innovation can be isolated as much as possible. They should be supplemented by evaluations that focus on the process of the innovation itself and the educational and social situations in which the teachers and learners find themselves. In addition, student and teacher knowledge, beliefs, attitudes and behavior before, during, and after the introduction of the innovation should also be studied.

The evaluation of the CIESE project, attempting to take these concerns into account, was organized into the three activities mentioned above at the beginning of the paper. We did not attempt to separate the effects of the introduction of computers from any associated use of teaching and learning methods not present before the introduction of computers. For this evaluation, the use of computers includes the physical use of the machines as well as any new or alternative teaching and learning paradigms.

4. Project Rationale

The mathematical skill and knowledge of students in the United States at the beginning of this project, and still now, leaves much to be desired. Lapointe, Mead, and Phillips (1989) reported that, on the average, U.S. students are achieving at a substantially lower level of mathematics proficiency compared to students in many other industrialized countries. In a recent study by the New Jersey Basic Skills Council [as reported by Braun (1992)], 46% of new college students fell into the "lack proficiency" category in computational skills, and that only 30% of all new college students are completely proficient in basic math skills. It was reported that mathematics proficiency had actually decreased in the most recent academic year.

There are compelling reasons to think that using computers in mathematics education will help students learn more and perform better. The studies cited above by Kulik *et.al.* and Bennett support this. In addition, the U.S. Congress Office of Technology Assessment (1988) encourages greater use of computer technology in mathematics instruction and several studies [*e.g.*, Kaput (1988) and Rubin (1988)] have substantiated the potential to improve mathematics instruction through the use of computer technology.

In addition to the possibility of enhancing student knowledge of mathematics, there are two other reasons for using computers to teach mathematics: computers are considered a valuable artifact of our society, lending seriousness (sometimes spuriously) to any activity involving them, and they are personally engaging for many people, particularly youngsters [Lepper (1990)]. Both of these attitudes seem to enhance motivation and hence attention, which is generally considered a necessary prerequisite for learning.

Finally, computers are underutilized in mathematics education. Collis (1988) reports that 80% of the students had never used a computer in the context of their mathematics, science, or English instruction. Kenneth Goldberg (1990), in an update of earlier work, reported that among 480 mathematics teachers in New York State, only 28% had a computer in their classroom and only 54% used computers at all to supplement their teaching. Becker (1991) reported that less than half of all secondary school mathematics teachers had ever used a computer at least once in teaching and that few teachers used computers systematically.

This underutilization of computers was observed by the authors' in the five high schools of the project. Even though a considerable number of the 30 teachers involved in the study taught programming, none of them used computers to teach math prior to the project.

5. Project Description

The project has been described in detail earlier [Jurkat *et.al.* (1990)]. It concentrated on 30 9th-12th grade mathematics teachers at five New Jersey high schools, and involved up to five CIESE faculty and staff and more than a dozen school systems administrators. Some characteristics of the school systems are given in Table 1.

Table 1. Participating High Schools and District Characteristics

School:	I	II	III	IV	V
District Population	19,000	38,800	42,000	320,000	15,000
School Population	1329	1664	1236	1438	842
Average Combined SAT	778	914	700	634	1026
College Bound	26%	84%	55%	48%	91%
White	41%	73%	18%	2%	75%
Black	49%	20%	9%	93%	1%
Hispanic	10%	4%	67%	3%	1%
Asian	-	3%	6%	2%	23%

Schools II and V are in affluent suburbs, School I is in a small city with high unemployment surrounded by farms and poor rural areas, and Schools III and IV are in disadvantaged urban areas.

Activities of the project included:

- making teachers aware of the potential of computers in mathematics education - at monthly meetings, the teachers with the CIESE staff and faculty examined the mathematics curricula at the various high schools to seek appropriate opportunities for computer use, and CIESE people acquired and demonstrated appropriate software and suggested alternative presentation techniques and student activities;

- giving teachers time and the opportunities to examine and become familiar with the hardware and software useful for mathematics education - CIESE organized summer workshops allowing teachers ample time for individual and group exploration and practice with the more than 250 software programs in the CIESE library; during the academic year teachers could borrow the software for exploration with their regular classes when department heads and administrators could not buy the software until the teachers were sure they were going to use it; and

- interceding with school boards and administrators to support the teachers' exploration and implementation of computer use in mathematics teaching - CIESE personnel were instrumental in persuading school boards and administrators to make hardware and software available to teachers and acquiring outside grants for hardware and software; CIESE staff gained administrative commitment for teachers' stipends for workshops and substitutes' availability for project meetings; and the Stevens President and CIESE Director made presentations to school boards and PTA's to have this support maintained throughout the project duration.

During the first year of the project teachers became aware of the possibilities of using computers in their mathematics classes. During the second year they explored such use in regular classes. During the third year they implemented this use in many modules of the entire curriculum. Throughout the project, school administrators established practices and budgets that would help institutionalize the use of computers beyond the time of the project.

The data gathering for the student performance evaluation study occurred during the second and third marking periods of the third year of the project. Teachers were asked to participate on a voluntary basis; seven teachers did so.

The teachers were asked to choose a topic for which they either had used computers or were going to use them. For that topic they were asked to give a pre-test before they started teaching it, a post-test at the end of the unit, and a delayed-post-test some weeks later after other topics had been covered. The data gathering was to be as unintrusive as possible; teachers were asked to follow their regular or intended teaching practices. The teachers designed each test as if they were giving it for their own grading, the pre-test could be given as part of the unit test on the previous unit, the post-test was to be their regular end-of-unit exam, and the delayed-post-test could be part of their marking period exam. Teachers were asked to follow their regular practice in regard to announcing the tests or giving them as pop-quizzes. As it happened, only one of the teachers was in the practice of giving a pre-test so students "knew something was up". Several of the teachers concluded that pre-tests were a good idea and are continuing to give them. All tests were to be graded on a scale of 0 to 100%. Time between post-test and delayed-post-test, and the number of intervening topics, were not controlled across schools.

No attempt was made to regiment the teachers into similar practices, approaches, or styles when using computers. The entire thrust of the CIESE Project was to empower the teachers to develop effective styles with which they were individually comfortable. This evaluation did not try to eliminate the diversity in search of research results based on commonality.

The software used in the sections taught with the use of computers is listed in Appendix IV.

6. Project Results

6.1 Sample 1

For this sample of 71 students, a teacher who is teaching two sections (say, A and B) of the <u>same</u> course, taught each section of the course as follows:

	Topic I	Topic II
Section A	with	without
Section B	without	with

This arrangement, with enrollment in both classes kept constant from topic I to topic II, guarantees that the experimental and control groups consist of exactly the <u>same</u> students <u>and</u> teacher, with only the topic and the order of computer use differing. This design is an extension of a design recently used by Ganguli (1990).

Unfortunately, only one teacher (at School I) with three sections was able to meet all these conditions during the time of the study. By allowing the teacher to be different in the two sections, three other sections, one at School I and two at School II, were able to be included.

The teacher at School I taught Congruence and Similar Triangles and Angles Related to Circles in Geometry 1, Geometry 2, and Geometry Honors. Two teachers at School II taught Geometric Vocabulary, Angle Measures, Parallel Lines, Area, Perimeter, Similar Triangles, and Polygons in various combinations to two sections of Math 9.

The dependent variables for Sample 1 are:

PRE_W	= student score (0-100%) on pre-test for topic taught <u>with</u> the use of computers
POST_W	= student score (0-100%) on post-test for topic taught <u>with</u> the use of computers
DEL_W	= student score (0-100%) on delayed-post-test for topic taught <u>with</u> the use of computers
POSDIFW	= performance improvement with the use of computers (POST_W minus PRE_W)
DELDIFW	= retention improvement with the use of computers (DEL_W minus PRE_W)
PRE_WO	= student score (0-100%) on pre-test for topic taught <u>without</u> the use of computers
POST_WO	= student score (0-100%) on post-test for topic taught <u>without</u> the use of computers
DEL_WO	= student score (0-100%) on delayed-post-test for topic taught <u>without</u> the use of computers
POSDIFWO	= performance improvement without the use of computers (POST_WO minus PRE_WO)
DELDIFWO	= retention improvement without the use of computers (DEL_WO minus PRE_WO)

Independent variables included:

SCHOOL	= school student attended (I and II above)
COURSE	= one of Geometry Honors, Geometry I, Geometry II, and 9th Grade Math
TOTDAYS	= number of instructional periods during which some use of the computer was made during the time the topic was taught with computers
SEX	= sex of student
GRADE	= grade level of student (9 through 12)
GRADPMRK	= student grade in math course in the previous marking period (0-100%)
ORDER	= order in which use of computers was made in sections that participated in both "with" and "without" conditions (1 = computer first, 2 = computer second)

Student performance as related to levels of these independent variables is given Tables 2 through 9.

Table 2. Overall variation with and without Computer Use for Sample 1

	Students	Mean	S.D.	
POSDIFW	71	32.0	20.2	
POSDIFWO	71	29.9	14.1	
			t = .94	p = .352
DELDIFW	71	27.5	15.2	
DELDIFWO	71	23.3	15.3	
			t = 2.00	p = .049 *

One star (*) denotes statistical significance at the .05 level and two stars (**) denotes statistical significance at the .01 level. In subsequent tables, the significance level is calculated from statistical tests conducted on the percentage scores transformed with the arcsine transform: y = 2arcsin(sqrt(x)). This is done to regain the statistical independence of the mean and variance which is lost when the data are ratios and percentages.

Table 2 shows that the student performance on the post-test minus the pre-test is a statistically insignificant 7% better in the "with" condition while student retention (delayed-post-test minus pre-test) is 18% better with the "with" condition, significant at the 5% level.

Table 3. Variation With Days of Computer Use During Unit

Computers Used For Part or All of:

Performance Measure	6 Periods (0-100%)	10 Periods (0-100%)	19 Periods (0-100%)	Signif Level (F ratio)
Number of Students	11	46	14	
GRADPMRK	69.0	75.4	72.9	2.34
PRE_W	25.0	35.9	40.1	2.48
POST_W	34.3	73.8	70.5	20.74 **
DEL_W	38.6	67.3	65.7	11.14 **
POSDIFW	9.3	37.9	30.4	8.81 **
DELDIFW	13.6	31.4	25.6	5.18 **

Table 3 shows that in topics during which the computer was used for part or all of 10 and 19 periods, significant improvement in performance, as seen in the post-test improvement (POSDIFW) and the delayed-post-test improvement (DELDIFW), was exhibited by the students. More details on this effect will be shown by the interaction analysis in Tables 8 and 9 below.

Table 4 shows that student gain on unit test scores (POST_W and POST_WO) and retention test scores (DEL_W and DEL_WO) over pre-test scores is about the same, even though the School I scores were significantly higher than the School II scores on the raw test scores. Also, there is no effect of school on improvement "with" or "without" or retention "with" or "without".

Table 4. Variation with School

Performance Measure	School I Avg Score (0-100%)	School II Avg Score (0-100%)	Signif Level (F ratio)	
Number of students	50	21		
GRADPMRK	74.1	73.4	.001	
PRE_W	40.6	27.1	33.10	**
POST_W	73.5	51.6	17.55	**
DEL_W	69.5	46.0	30.44	**
POSDIFW	32.8	29.9	.060	
DELDIFW	28.9	24.2	.012	
PRE_WO	38.7	25.0	15.90	**
POST_WO	68.3	55.8	10.20	**
DEL_W	61.9	48.7	9.62	**
POSDIFWO	29.6	30.8	2.01	
DELDIFWO	23.2	23.7	1.04	

Table 5. Variation with Course

Performance Measure	Geometry Honors (0-100%)	Geometry Geom I (0-100%)	Geometry Geom II (0-100%)	Math Math 9 (0-100%)	Signif Level (F ratio)	
N of students	15	21	14	21		
GRADPMRK	79.7	71.0	72.9	73.4	2.94	*
PRE_W	52.5	32.5	40.1	21.8	17.50	**
POST_W	76.8	73.0	70.5	51.6	6.28	**
DEL_W	73.3	69.2	65.7	46.0	11.01	**
POSDIFW	24.3	40.6	30.4	29.9	.99	
DELDIFW	20.8	36.8	25.6	24.2	2.13	
PRE_WO	54.1	30.7	34.0	25.0	13.87	**
POST_WO	69.3	67.6	68.1	55.8	2.41	*
DEL_WO	63.0	61.4	61.3	48.7	3.19	*
POSDIFWO	15.1	36.9	34.1	30.8	7.46	**
DELDIFWO	8.9	30.7	27.3	23.7	6.25	**

GRADPMRK is used as a proxy for the basic level of performance of the students in each section. As might be expected, the Geometry Honors students performed better in the previous marking period, on the average, than the students in the other classes. There were no significant effects on performance or retention improvement for the topics for which computers were used. However, there were significant effects of topic on performance and retention improvement for those topics taught without the use of computers. The lower level students (those in Geometry I and II and in Math 9) improved significantly more than the Honors students.

It is interesting to note that although there is a statistically significant difference in the average test scores of the classes in the section taught with the use of computers, these differences are no longer evident in the POSDIFW and DELDIFW. These differences are small in the Honors class, which can be attributed to the high pretest scores, PRE_W and PRE_WO, which does not allow for much improvement. These Honors students knew quite a bit of geometry before they began the topic.

Table 6. Variation with Sex of Student

Performance Measure	Female (0-100%)	Male (0-100%)	Signif Level (F ratio)	
Number of Students	37	23		
GRADPMRK	76.2	72.4	2.19	
PRE_W	41.1	30.1	9.54	**
POST_W	74.1	71.1	.56	
DEL_W	70.0	61.8	3.58	
POSDIFW	33.1	41.0	4.78	*
DELDIFW	28.9	31.7	1.84	
PRE_WO	40.1	32.8	.05	
POST_WO	67.7	67.4	.91	
DEL_WO	59.7	58.1	.54	
POSDIFWO	27.6	34.6	.03	*
DELDIFWO	19.7	25.3	.15	

The only statistically significant differences shown in Table 6 indicate that the females had a higher average score on the pretest, PRE_W, in those topics during which the computer was used, but that the males improved significantly more, POSDIFW. However, this difference in improvement between the sexes was no longer evident in the delayed post test, DELDIFW.

Table 7 shows that grade level, which also indicates age, had no statistically significant relationship with performance.

For sample 1 there was a significant three-way interaction between SCHOOL, ORDER, and computer use ("with" vs. "without") on both performance and retention improvement, significant two-way interactions between ORDER and computer use ("with" vs "without") on both performance and retention improvement, and a significant main effect of ORDER on performance improvement. The performance improvement interactions are shown in Table 8 and the retention improvement interactions are shown in Table 9.

It can be seen, particularly from Table 8.2, that greater student performance improvement is gained "with" the computer than "without"; the effect is mainly due to the 16.5% improvement "with" compared to "without" in order 1: with computer first.

Table 7. Variation with Grade Level

Performance Measure	9 th Grade (0-100%)	10 th Grade (0-100%)	11 th Grade (0-100%)	12 th Grade (0-100%)	Signif Level (F ratio)	
N of students	28	25	4	3		
GRADPMRK	77.9	72.4	67.5	75.0	2.98	*
PRE_W	37.8	36.2	33.0	38.7	.10	
POST_W	74.6	71.1	71.5	75.7	.31	
DEL_W	66.2	67.0	67.0	72.0	.07	
POSDIFW	36.8	34.8	38.5	37.0	.53	
DELDIFW	28.4	30.8	34.0	33.3	.08	
PRE_WO	42.3	33.5	27.5	35.3	.86	
POST_WO	67.4	67.0	67.5	74.0	.26	
DEL_WO	56.8	60.3	61.5	67.3	.37	
POSDIFWO	25.2	33.4	40.0	38.7	1.20	
DELDIFWO	14.6	26.8	34.0	32.0	2.84	*

Table 8: Post-test Improvement Interactions for Students who were Taught both With and Without the Use of Computer

(The number of students in each cell is given in parentheses after the post-test improvement average for that cell

8.1 POSDIFW vs. POSDIFWO by ORDER and SCHOOL:

	School I		School II	
(F = 19.89, p = .000)	with	without	with	without
order 1: with computer first	30 (14)	34 (14)	53 (10)	34 (10)
order 2: with computer second	34 (36)	28 (36)	9 (11)	28 (11)

8.2 POSDIFW vs. POSDIFWO by ORDER:

(F = 7.30, p = .009)	with	without
order 1: with computer first	39.6 (24)	34.0 (24)
order 2: with computer second	28.1 (47)	27.9 (47)

8.3 POSDIFW and POSDIFWO average by ORDER: (F = 16.06, p = .000)

order 1: with computer first	36.8 (24)
order 2: with computer second	28.0 (47)

Both Tables 8 and 9 show that there is some tendency for the students in sections where the computer was used first to perform better on both the unit tests and retention tests. This order effect was not expected, nor are we aware that it has been mentioned in the literature. A partial explanation might be that the teachers may have preferred to use the computer in the stronger sections first.

Table 9: Delayed Post-test Improvement Interactions for Students who were Taught both With and Without the Use of Computers
(The number of students in each cell is given in parentheses after the post-test improvement average for that cell)

9.1 DELDIFW vs. DELDIFWO by ORDER and SCHOOL:

(F = 32.24, p = .000)	School I with	School I without	School II with	School II without
order 1: with computer first	26 (14)	27 (14)	36 (10)	15 (10)
order 2: with computer second	30 (36)	22 (36)	14 (11)	32 (11)

9.2 DELDIFW vs. DELDIFWO by ORDER:

(F = 11.27, p = .001)	with	without
order 1: with computer first	30 (24)	22 (24)
order 2: with computer second	26 (47)	24 (47)

Sample 2

Not all of the 30 teachers in the CIESE Project taught 2 sections of the same course, nor were able to be paired with other teachers under Sample 1 conditions. Those teachers that did not, but still wanted to participate in the study, were "paired" with others teaching the same topic to students in the same grade, but possibly to different students. This sample contained 108 students whose performance is shown in the following tables. Sixty-one (61) of these students were in sections using computers and forty-seven (47) were in sections not using computers.

The dependent variables in this sample have slightly different meanings; they were given different names to remind readers (and the investigators!) of the distinction. In Sample 1 each student took a pre-test, post-test, and delayed-post-test for both "with" and "without" conditions, whereas in the current sample, Sample 2, each student took the tests for only one of the "with" or "without" conditions. The dependent variables for Sample 2 are:

PRETEST	= student score (0-100%) on pre-test
POSTTEST	= student score (0-100%) on post-test
DELTEST	= student score (0-100%) on delayed-post-test
POST_PRE	= performance improvement (POSTTEST minus PRETEST)
DEL_PRE	= retention improvement (DELTEST minus PRETEST)

Table 10 shows that post-test improvement with the computer was about 45% greater than the improvement without the computer, and the delayed-post-test improvement with the computer was 70% greater than the improvement without the computer. These difference represents about 1 pooled standard deviation, which is at the high end of the range of such results reported by various studies reviewed in Roblyer, Castine, and King (1988). This latter result may be interpreted as saying that the median student under the "with" condition performed at a level that exceeded 83% of the students under the "without" condition.

Table 10. Performance and Retention Improvement for Students Who Learned or were Taught either With or Without the Use of Computers

	Number of Cases	Mean	S.D.
POST_PRE "with" (TOTDAYS > 0)	47	72.4	19.1
POST_PRE "without" (TOTDAYS = 0)	61	49.9	24.7
difference		22.5	
pooled s.d.			22.9
t-value: 5.08 df: 106 2-tail P: .000			
DEL_PRE "with" (TOTDAYS > 0)	47	66.3	23.1
DEL_PRE "without" (TOTDAYS = 0)	61	39.5	29.0
difference		27.8	
pooled s.d.			26.8
t-value: 4.83 df: 106 2-tail P: .000			

Table 11. Variation with Number of Periods during Topic Unit in which Computers were Used

Performance Measure	No Use	3 Periods	15 Periods	Signif Level (F ratio)	
N of students	61	27	20		
GRADPMRK	79.8	86.9	74.0	9.00	**
PRETEST	32.1	19.6	15.0	5.32	**
POSTTEST	82.0	92.2	87.2	3.92	*
DELTEST	71.6	91.5	73.8	8.06	**
POST_PRE	49.9	72.6	72.2	13.03	**
DEL_PRE	39.5	71.9	58.8	13.96	**

Table 11 shows that the improvement in performance, POST_PRE and DEL_PRE, are significantly higher for the two levels of computer use compared to no use. The students in sections taught with the use of computers (3 periods and 15 periods) had significantly lower PRETEST scores, showing they started with less knowledge of the topic, and performed better on the POSTTEST and DELTEST than the students in the No Use sections. Also, performance and retention was not greater when 15 periods were used as compared to 3 periods.

No interaction effects between School and Number of Periods computers were used were calculated due to empty cells in the matrix of interactions.

Variation with SCHOOL is coupled with variation with COURSE in that the sections in these schools were from the following courses:

School I	General Math I
School II	Math 11
School III	Algebra 2

Table 12. Variation with School/Course and Number of Periods Used

Performance Measure	School I (0-100%) No Use	School I (0-100%) 15 Pers	School II (0-100%) No Use	School II (0-100%) 3 Pers	School III (0-100%) No Use	Signif Level (F ratios) Main Effects School		Use	
GRADPMRK	76.7	74.0	86.2	86.7	72.7	10.17	**	.53	
PRETEST	26.7	15.0	26.9	19.6	50.0	4.62	*	2.19	
POSTTEST	78.0	87.2	85.8	92.2	81.1	1.62		1.82	
DELTEST	72.9	73.8	77.7	91.5	58.5	3.53	*	2.26	
POST_PRE	51.3	72.2	58.8	72.6	31.1	6.61	**	7.34	**
DEL_PRE	46.2	58.8	50.8	71.9	8.5	12.76	**	6.21	**

There were no significant differences found in the variation of performance and retention with SEX of student or GRADE, and there were no significant interactions between SEX and TOTDAYS or GRADE and TOTDAYS.

A regression was performed on the performance and retention of these 108 students, resulting in the following two equations. The numbers in parentheses under the coefficients represent the probability of having the observed coefficient due to chance alone when its true value is actually zero:

$$\text{POSTTEST} = 13. + \underset{(.0000)}{.80}*\text{GRADPMRK} + \underset{(.0053)}{.20}*\text{PRETEST} + \underset{(.0142)}{.87}*\text{TOTDAYS}$$

Multiple R = .587 Standard Error = 15.3

This equation shows that, after taking into account how good the student is (GRADPMRK) and how much the student knew about the subject before it was taught (PRETEST), each period during which the computer was used (TOTDAYS) is associated with a .87% point gain; ten periods of use would be related to an 8.7% gain in performance.

$$\text{DELTEST} = -39.8 + \underset{(.0000)}{1.38}*\text{GRADPMRK} + \underset{(.3354)}{.10}*\text{PRETEST} + \underset{(.1392)}{.76}*\text{TOTDAYS}$$

Multiple R = .628 Standard Error = 18.4

In this equation, neither of the coefficients of PRETEST nor TOTDAYS can be concluded to be significantly different from zero; no linear relationship is concluded. This means that the student's grade in the previous marking period (GRADPMRK), which is a proxy for how good each student is in mathematics, is the only one of these variables that is related to retention (DELTEST).

6.2 Related Studies

Three additional research studies on the CIESE project were in progress at the same time as this student performance analysis. An Educational Testing Service study on teacher and student attitudes was conducted by Lori Morris [Morris (1992)]. A study of overall school system response and interaction with the CIESE project was conducted by researchers from the Bank Street College of Education [Brunner and Henriquez (1990)]. The third study was an in-depth analysis of the CIESE project on the behavior and relationships among mathematics teachers in one of the CIESE high schools. This work was done by Keith Allum as his Ph.D. dissertation for the Sociology Department of Princeton University [Allum (1991)].

Excerpts from the writings of these researchers are included with this paper as Appendices I, II, and III. These excerpts are not intended to provide definitive summaries of each research analysis. Rather, they are provided in order to supply the reader with a sense of the context in which this student performance research was conducted.

7. Conclusion

A premise of the CIESE project has been that the teaching/learning process in secondary mathematics could be enhanced through judicious use of computer technology. This student performance field study provides strong support for that position. We have observed significant enhancements in student performance, particularly in long-term retention in a study which examined a variety of computer integration strategies in a mix of school settings and curricula applications.

A fundamental aspect of this study, which differentiates it from many others, is that teachers involved had been part of a computer-mediated education development project for more than two years. Other studies [Sheingold and Hadley (1990)] indicate that it takes teachers several years to become mature in their use of computer technology in the classroom. The question then arises regarding possible further gains in student performance after these teachers have had additional time to refine their computer-mediated instructional approach.

Additional issues for future research include refinements regarding the relative advantages of computer laboratories versus the one computer classroom, as well as analyses of how computers facilitate particular learning strategies, such as visualization, constructivism, and collaboration.

Finally, it is important to note that this study of student performance was carried out in a context in which teachers were engaged in an in-service project which was supported by their administrators as well as by their school boards and local communities. These external factors helped teachers pursue instruction as they wished and motivated their utilization of technology. The impact of school environment and the potential for school restructuring to promote student performance through more effective integration of technology in instruction are emerging as key issues for researchers and policy makers in the years ahead.

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9. Appendix I: Teacher Knowledge, Activities, Attitudes and Beliefs

By the third year of the project all but two of the thirty teachers who started the project (one of which left the project in the first year) were using computers throughout the school year. Each had access to a computer projection station to use in their lectures and group problem solving sessions and four of the high schools had computer laboratories available to which mathematics teachers could bring their entire classes for individual student use of computers. All had the software they wanted available to them.

This software and hardware was acquired through school system capital budgeting and annual operational funding, as well as from grants and gifts. All department heads and mathematics supervisors were budgeting for software acquisition and hardware maintenance. Nearly all the teachers expressed plans to continue using the computers after CIESE support was curtailed.

The following observations and beliefs were elicited from teachers and administrators during private interviews with Dr. Lori Morris from Educational Testing Service [Morris (1992)] throughout the project's three years. She adopted a stance apart from the CIESE staff and faculty, becoming a confidant of the teachers and administrators which allowed them to comment on and criticize project activities without confrontation. When appropriate, Dr. Morris made the CIESE staff aware of complaints and dissatisfactions which were then addressed by the staff.

The teachers generally indicated that they adopted different teaching styles when the use of computers was integrated into their classes and laboratories and that the use of computers had an effect on their teaching assignments and approach to their craft.

Computer use was not integrated to the same extent among all of the project teachers. Some, particularly those that had equipment and software available early, began to experiment with computer use in the second semester of the project and may be considered experienced users by the end of the third year. Others, both due to their own inclination and/or lack of equipment, were not able to routinely use computers until the third year of the project, and should still be considered novices at the time the evaluation took place. These differences could account for some of the variability in the student performance results presented above.

CIESE staff in general adopted a non-directive approach which was credited by the teachers in empowering the teachers and providing them with enough confidence to independently develop their own criteria for "good" and "bad" software. The formal presentations to each school's board of education and informal discussions with administrators was credited by those involved in the project with playing an integral role in resolving the two most critical issues of having sufficient time for teachers and money for hardware, software, and supplies.

Both summer workshops were deemed successful by the teachers because time was provided for teachers to reach their goals; the workshops were flexible enough for teachers to informally work in groups or alone; teachers were provided with an opportunity to interact with other math teachers outside of their schools, and all teachers felt they were treated like professionals.

The advantages of the computer mentioned most frequently by teachers were that computers enhanced the quality and quantity of visual examples (its speed allowed more examples in the same amount of time), enabled more material to be covered in a shorter amount of time, offered students autonomy, enabled students to make mistakes privately in front of a computer rather than in front of the entire class, increased discussion of mathematics among students, and changed the role of the teacher from an authoritarian to a coach.

Teachers of lower academic level students noted that the effects of the computer were subtle but important, claiming that the computer improved student's self-esteem and attitudes toward mathematics and lessened discipline problems within the group.

Teachers of higher academic level students tended to use the computer to encourage higher order thinking skills through the use of the discovery method of learning.

Integrating computers into the curriculum encouraged teachers to self-reflect on their teaching styles and pedagogies. Becoming involved with computers, learning about them, and exploring their use in teaching served to rejuvenate many of the teachers.

The process of integrating computers encouraged collaborative relations among the teachers, and in some cases, between administrators and teachers. Project staff successfully established a professional, collegial relationship with the teachers.

Morris, L.V. (1992) Final Evaluation Report of the CIESE Project. Princeton, NJ: Educational Testing Service

10. Appendix II: Project Administration and Conduct

This evaluation was carried out by staff [Brunner and Henriquez (1991)] of The Center for Children and Technology at Bank Street College of Education. Fourteen administrators in all five schools were interviewed: six of these were department heads, two were assistant principals, two were district-wide curriculum coordinators, and four were district superintendents.

Questions, in addition to the school's administrative structure, student body, and assessment techniques included inquiries about the educator's overall expectations of the collaboration, their evaluation of its success, their definition of its major challenges, and their future expectations.

A major finding was that the regular school visits, technical support, training, summer workshops and conferences provided opportunities for teachers to meet, discuss common issues and experiences, and to solve common and individual problems. This created the preconditions for positive collaboration between project staff and school personnel.

The administrators generally felt that the collaboration between CIESE personnel and the high school teachers was the major reason for the degree of success in the integration of technology into the participating schools. They considered the training in the use of pertinent software as highly useful, and they regarded the regular meetings with CIESE staff as a valuable source of support and inspiration to their staff members.

The great majority of the educators interviewed consider technology integration critical to the education of their students. Those that were not entirely convinced were from the school which was the most remote of the project schools, whose administrators were the most traditional, and whose management style was the most top-down and hierarchical.

Most of the district level administrators joined the project when it was already in progress; the school level administrators and teachers obviously had joined the project at its beginning. The school level administrators considered themselves closely tied to the project; they felt they were hand-picked because they were in agreement with the project's goals and were in a position to implement them. In this regard, the project, in some sense, was "doomed to succeed". The district level administrators, joining the project when it was moving toward success, had no reason to distance themselves from it.

The collaboration seemed to have a positive effect on the relationship between schools and their district offices. Neither level believed they "owned" the project; each thought the other was important for its achievements.

When asked how the project fitted into the administrators' plans they responded variously with the hope that it will improve the image of the mathematics department, the expectation that there would be a positive change in standardized test scores, the perception that the project supplemented ongoing efforts in technology integration or the chance to get any kind of technology into the department at all.

In addition, the expectations for the project included a demonstratable improvement in the teaching skills of the teachers and a positive change in the teaching methods used in mathematics classes.

Most administrators saw an improvement in teaching methods as technology was integrated into the mathematics curriculum and some mentioned the improved collegial relationship among their teachers.

A third of the administrators were not aware of any particular contribution their schools made to the integration of technology into the mathematics curriculum.

The implications of these perceptions was that the administrators saw the CIESE Project most responsible for the improvements they mentioned. A few of the administrators complained about the lack of time and difficulties in involving other, non-project teachers in similar activities.

Staff development was cited most often as the most rewarding aspect of the collaboration. The training, collegial contacts, the introduction of computers, and access to the CIESE staff were all considered rewarding.

Time and money were considered the major obstacles to the success of the project as a whole. Teachers needed more time to learn, more time to meet, more time to plan, more time to digest what they have learned, and more time to experiment with applications in the classroom. Money was needed for more computers and software.

Problems included jealousy among the teachers who were not part of the project, the unwillingness of some teachers to become genuinely involved in the project, and the lack of cooperation from the administrators of a particular school.

Most of the educators thought there was some lack of clarity about the goals of the collaboration. This was deliberate on the part of the CIESE staff since, at the beginning, it was not evident that all the participating schools would buy into a common set of goals other than to improve mathematics education. Respondents talked about setting clearer goals at the beginning of the project, implying that at the end the goals were clear, but that it took awhile for this to happen. It is possible that they consider the lack of objectives an issue of management style.

Brunner, C. and Henriquez, A. (1991) Evaluation of Stevens Institute of Technology's "Integration of Computers into Mathematics Education" Project. New York, NY: Bank Street College of Education, Center for Children and Technology

11. Appendix III: Technological Innovation in a High School Mathematics Department: A Cultural and Structural Analysis

Excerpts from the Ph.D. Dissertation of Keith F. Allum, Department of Sociology, Princeton University.

Discussing the interaction between the CIESE project and "Conant High School", one of the five initial sites collaborating with Stevens:

"Simply stated, CIESE philosophy matched Conant culture. The preliminary comments made by the project director and the subsequent discussions they sparked, set a tone which resonated within the bounds circumscribed by the cultural forms of the mathematics department. The confession of fallibility (by the CIESE project director) emboldened the teachers to contribute to the planning and direction of the project*. Moreover, the project staff's treatment of teachers as professionals encouraged and strengthened teacher commitment to the project. The teachers thus gained a sense of joint ownership which led them to increase their commitment to the project. Most prior inquires into externally directed change reveal that there is seldom a period of consultation with the classroom teachers and perhaps for this reason, such strategies often failed.

*Under other circumstances, such an admission by a project director would indicate poor planning and eminent disaster. Yet it may be argued, and some data bear this out, that the external expert's denial of omniscient expertise paradoxically lead to a greater likelihood of success."

"It is important to note that some members of the mathematics staff commented that CIESE merely allowed them to do what they had always intended. This claim allowed teachers to define themselves as innovators and the CIESE staff as fellow change agents."

"Teachers could not integrate technology into their classroom practice without (1) institutional support form the district (i.e., time and resources) and (2) knowledge and experience in the form of training. Both were obtained through participation in the CIESE project. CIESE virtually guaranteed support as a precondition for participation."

Quote by Allum of a teacher referred to as "Ted": "Stevens did a very smart thing by getting the Board to commit themselves to the project. Commitment from the Board is really crucial in a major program like this."

"Generally speaking, the CIESE project has served to focus attention on the importance of mathematics and thus increased the status of the discipline in the school and community and expanded options of teachers in presenting the subject matter to their students."

"The school-wide survey indicated that 91% of the student body perceived computer-based technology to be a positive addition to the school environment and 84% indicated a desire to use the PC's more often (especially in Mathematics and English classes). The receptivity of students led teachers to use computer applications as a technique to capture interest and gain cooperation."

"Classroom management cannot be sacrificed in the name of innovation. By contributing to the control and motivation of students, microcomputers have been perceived as useful tools in the management of the classroom."

"The CIESE Project continues to develop 'successful models' of computer implementation in the hope that other districts will be able to emulate a tested and effective prototype. Plans for assessment and evaluation were built into the original project design. Now in its third year, qualitative and quantitative studies are being conducted to discover the effects of classroom computer use on student achievement and school organization."

Allum, Keith (1991) Technological Innovation in a High School Mathematics Department: A Structural and Cultural Analysis, Dissertation in partial fulfillment of the Doctor of Philosophy requirements, Department of Sociology, Princeton University

12. Appendix IV: Software Used in the Sections Taught with the Use of Computers

Discovery Learning in Trigonometry, developed by John B. Kelley and distributed by CONDUIT.

Geometry Proof Tutor, distributed by Advanced Computer Tutoring, Inc.

Geometric Supposer: Triangles, developed by Education Development Center, Inc. and distributed by Sunburst Communications.

Green Globs and Graphing Equations, developed by Sharon Dugdale and George Kibbey and distributed by Sunburst Communications.

Mathematics Exploration Toolkit, developed by WICAT Systems, Inc. and distributed by IBM Corporation.

Ratios and Proportions, developed by Intellectual Software and distributed by Queue.

THE EFFECTS OF QUESTIONING ACCESS IN COMPUTER-BASED INSTRUCTION

Joan C. Lee and Richard Dennis
University of Illinois at Urbana-Champaign

ABSTRACT

The present study examines the effects of questioning access on retention of information in a CBI lesson. The subjects were 15 high school students assigned to 3 experimental situations: (1) open accessible questions (no specific sequence), (2) prescribed questions, and (3) prescribed topic presentation. No differences in achievement were attained as a function of the three instructional methods. This result may be attributed to the small sample size. Findings show, however, that one student who selected a question of interest every single time greatly improved her achievement, though other students seldom made a jump (i.e., non-linear sequence of selection) during instruction. If a jump occurred, the adjacent questions were likely to be probed next; otherwise, the prior sequence was resumed. It was also found that providing questions in this CBI lesson did not improve students' self-questioning skills on a new subject matter.

INTRODUCTION

Reading expository text has been one major method of acquiring knowledge in the conventional academic setting. As a technology-based instructional mode, computer-based instruction (CBI) lessons also present students textual information for learning. The main focus of this study is to design a CBI lesson to present information in the form of questions and answers in order to facilitate the student's processing of expository text.

Hall (1983) and Merrill (1987) believe that the type of questions presented to a learner is a crucial variable in designing courseware. This particular study is therefore created with two objectives. One objective is that we intended to improve the form of questions in order to induce a learner's selective attention during the encoding process of information. Secondly, we attempted to apply the learner-control strategy to the sequencing of questions so that a learner can be actively engaged in his or her learning process. The theorization of selective attention is derived from the information processing model. Researchers in the line of reading comprehension have discussed that prequestions can be used to induce readers' selective attention. With respect to sequencing of questions, our prequestions are characterized by their open accessibility (i.e., non-linear sequence). This approach is derived from the research in locus of control. Additionally, a top-level structural map was added to aid students to learn through the lesson. The use of the map is adapted from an adjunct aid developed by Meyer (1975). The related research will be reviewed in the next section.

REVIEW OF LITERATURE

Selective Attention

Most of the instructional research today is based on an information processing model of human memory developed by Shiffrin and Atkinson in 1969. The model assumes that the human memory system consists of three memory buffers: sensory registers, short-term memory, and long-term memory. It is assumed that information travels from sensory registers to short-term memory where it is encoded. It is then transferred from short-term memory to long-term memory -- the permanent storage of the information. Learning is a process by which information is encoded and transferred from short-term memory to long-term memory (Hannafin & Rieber, 1989). In fact, short-term memory has a limited processing capacity , because it can only hold up to 7 plus or minus 2 units of information (Miller, 1956). Therefore, the learner must selectively scan the incoming information in sensory registers and move important information from sensory registers to short-term memory (Kumar, 1971). Anderson (1970) has referred to this as "selective attention". In addition to individual factors, some external factors, such as how information is presented and organized may affect one's selective encoding process (Hannafin & Rieber, 1989). Thus, Gagne & Briggs (1988) point out that one of the most important instructional objectives is to focus the learner's attention on relevant information in the instructional presentation. That is, selective attention can strengthen one's encoding process of information. Poorly coded information may not get to be transferred to long-term memory and is therefore forgotten.

Effect of Prequestions

Wager & Wager (1985) state, "Questions serve three general functions in learning: (a) To establish and maintain attention, (b) to facilitate encoding, and (c) to provide for rehearsal" (p. 4). In the line of reading comprehension research, adjunct questions are defined as questions interspersed throughout textual materials that students are instructed to answer (Hamaker, 1986). The adjunct questions are helpful to maintain students' attention and focus on important information for reading longer segments of text (Bean, 1985). One of the major findings on adjunct questions research summarized by Hamaker (1986) is that adjunct questions produce a facilitating effect on memory performance. Hamiltom (1985) who reviewed a number of studies also finds that, regardless of the placement before or after the text, questions aid retention when tested in immediate recall, delayed recall, and transfer.

A "prequestion" is one type of adjunct question that precedes the text to be read. Anderson and Biddle (1975) report that prequestions have a positive effect on retention of relevant information. But at the same time, they suggest that such prequestions may actually retard retention of unrelated information. Similarly, Kumar (1971) report that students tend to achieve better retention of relevant information cued by prequestions and do poorly on recalling irrelevant information. These results confirm the role of selective

was the question-relevant material and the depth of processing was achieved" (Kumar, 19

attention in the information processing model. Because of selective attention induced by prequestions, irrelevant information is filtered before it enters short-term memory. Kumar (1971) claims that prequestions maximize the use of short-term memory. He states, "The content of the short-term memory was the question-relevant material and the depth of processing was achieved" (Kumar, 1971, p. 408). In fact, discarding irrelevant information during the encoding process is fairly economic with regard to the limited capacity of short-term memory (Kumar,1971). In Reynolds and Anderson's (1982) study, it is found that as a result of readers' selective attention, readers pay more attention to and learn more information relevant to prequestions. West, Farmer, & Wolff (1991) summarize Hamilton's review (1987) and report that even the effects of high-level prequestions such as application or synthesis prequestions are superior to the effect of high-level postquestions. However, research has also shown that during the encoding process of information, one's frequent and overt responses to questions may interrupt his or her semantic processing of information (Wager, 1982). Questions requiring no response may become metacognitive in nature, because students are able to process learning materials in their own ways rather than be judged by correctness or incorrectness of their answers (Hannafin, 1989).

Locus of Control

In recent years, cognitive psychologists put much emphasis on the notion that a learner is not a spectator, but a purposeful participant in the learning process. There has been extensive instructional research which attempts to adapt individual differences to the instructional design. Researchers focusing on locus of control have been investigating the issue of whether program-controlled instruction is superior to learner-controlled instruction or vice versa. Under the program-controlled condition, sequence options include linear and conditional branching which is based on the learning speed and on-task performance. The learner-controlled method is non-linear in nature. One approach is to permit learners to access to-be-learned information through numerous options in terms of menus and indexes (Hannafin, 1989). The other approach is referred to by Steinberg (1989) as "dynamic locus of control," whereby useful problem-solving tools are accessible throughout the lesson so that students are able to use their own method to learn the lesson content.

Merrill, Schneider, & Fletcher (1980) suggest that individual differences can be accommodated by allowing learners to control the sequence of instruction. However, research has yielded mixed results concerning the influence of learner control on the quality of learning. Lee's (1990) study shows that a learner-controlled method increases students' metacognitive and cognitive abilities better than a program-controlled method. Tennyson (1980) indicates that students in a learner-controlled strategy master the objective of the lesson in less time than those in a program-controlled strategy. On the other hand, Clark (1984) finds that students tend to choose the type of instruction which is not helpful to their learning process. Learners may not make a good judgement on what they need from the instruction in order to improve their performance (Tennyson, Park, & Christensen, 1977). Therefore, Steinberg (1989) claims that a mediated-learner support instruction optimizes the balance between a program-controlled and a learner-controlled instruction. The mediated-learner support instruction takes the intermediate position in a spectrum that has a program-controlled instruction at the one end and a learner-controlled instruction at the other end of the spectrum. Boyd, Douglad, & Lebel (1984) designed a mediated-learner support system which included some memory aids such as a review, hints, glossaries, and charts in a learner-controlled lesson and found that the groups learning with memory aids outperformed non-aid groups. Similarly, Steinberg, Baskin, & Matthews (1985) concluded that although memory charts were not equally effective for all individuals at all stages of learning, overall these organizational memory charts aided students problem solving performance.

An Organizational Aid: Top-Level Structure

Meyer (1975) has developed a top-level structure that underlies the main ideas and details of the text. Main ideas occur at the top level of the hierarchical structure. They are better retained and also allow for the retention of related details. Wilhite (1983) states, "Superordinate units are critically important to the memory of the passage as a whole and that through these units, access to subordinate units is achieved" (p. 235). In Meyer, Brandt, & Bluth's study (1980), there is increasing probability that students remember more information if readers learn the strategic use of the top-level structure as they read the text. Mayer (1984) has suggested that one type of aid for information processing should serve as a cue to learners as to how to organize information. Brown & Smiley (1977) points out that the purpose of using any learning aids is to compensate for readers' metacognitive skills. In other words, the top-level structure as an organizational aid does not only facilitate readers to remember and comprehend the text, but also enhances readers' metacognitive skills.

Tripp and Roby (1990) suggest that advanced organizers and metaphors can provide the structure of computerized learning materials. Anderson & Armbruster (1985) argue that the structure of text should be made explicit to the readers for instructional purposes. Schloss, Schloss, & Cartwright (1984) find that questions added to a text as signals are significantly superior to a highlighting format and also superior to a straight text when tested. To combine prequestions with a top-level structure strategy, Wilhite (1983) employs quiz prequestions to make the top-level structure of the passage clear to students.

Research Questions

In a traditional CBI lesson, students encounter certain prescribed questions after they read some information and usually are not allowed to advance through the lesson unless their answers are correct. However, the CBI lesson in the present study is created differently in terms of format and sequence of questions. The format of questions is such that each question precedes a segment of text containing the answer to the question. That is, the answer has been provided by the lesson. This type of questions is designed in light of the attentional property of prequestions. Based on the learner-control strategy, there is

Moreover, as an organizational aid, the top-level structure map is created to aid students in

no specific sequence of questions in this CBI lesson. All questions (i.e., prequestions) are accessible by a menu rather than by the lesson designer deciding when and where and how many to be encountered. Students may choose any prequestion of interest in the menu and read the answer on the next screen. Moreover, as an organizational aid, the top-level structure map is created to aid students in understanding main topics presented in the lesson.

The treatments in terms of three types of instructional methods are tested in the present study. One treatment is that the lesson content is presented by open-accessible (non-linear) prequestions. The other treatment uses prescribed (linear) prequestions to present the same lesson content. Instead of uses for prequestions, prescribed (linear) topics are used in another treatment. Therefore, three research questions in this study are formed as follows: (1) Will three types of instructional methods, non-linear prequestions, linear prequestions, and linear topics produce significant differences in students' learning outcomes? (2) Which format, non-linear or linear prequestions will better improve students' performance? (3) Can providing prequestions train students to develop self-questioning skills? Furthermore, a qualitative analysis on students' cognitive styles of learning is conducted.

METHOD

Subjects

The subjects in this experiment were 15 senior high school students who enrolled in the summer internship program in 1992 at US Army Construction Engineering Research Laboratory in Champaign, Illinois. The students were randomly assigned to one of the three experimental conditions. Thus, there were five subjects in each experimental condition.

Materials

The text used in this experiment was a scientific text about earthquakes. The scientific text, expository in nature, aims at more information on earthquakes for Midwest students, because earthquakes may occur in the Midwest. The content was adapted from several earth science textbooks for high school students. This CBI lesson was programmed by using HyperCard with three different versions designed for three experimental groups. Each group received one version of the lesson. The first version contained open accessible (non-linear) questions in a menu (see Figure 1).

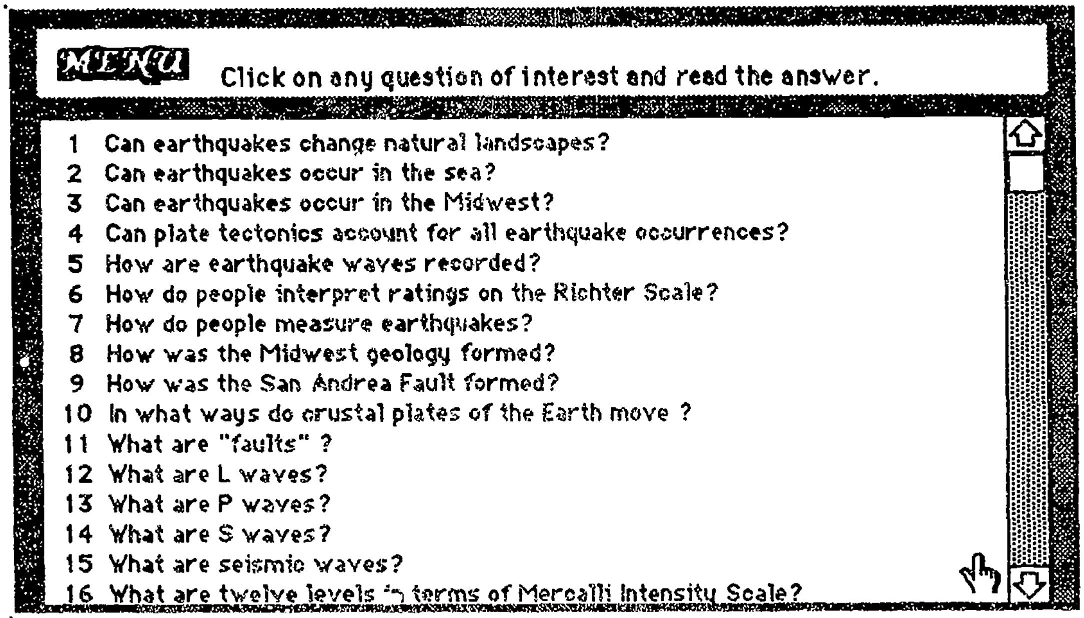

Figure 1. Menu of Prequestions in the CBI Lesson.

There were 30 questions all starting with words such as can, how, what, why, and where. An answer was presented on the screen right after a question had been chosen in the menu. The length of an answer was approximately 70 words. On the screen presenting the answer, the question in bold was displayed again. A graphic illustration was shown on the screen as well (see Figure 2). The second version of the lesson contained the same questions as the first version. But, the sequence of questions was predetermined by the lesson as to where the learner was allowed to access questions in a linear sequence. The third version of the lesson contained a menu of topics in the same sequence as the second version. Three versions presented the same information (i.e., to-be-read text) which is embedded in the answers in the first and the second versions; and in explanations about the topics in the third version.

A top-level structure map, an organizational aid, was only added to the first version of the lesson only to display the main earthquake topics in the lesson. All questions in the menu were organized hierarchically into a map (see Figure 3). Five major questions eliciting the most important information were regarded as main ideas and were displayed at the top level of the hierarchical map. They were: (1) "What causes earthquakes?" (2) "What are the effects of earthquakes?" (3) "How are earthquakes detected?" (4) "How are earthquakes measured?" and (5) "Where are earthquake zones?". Some questions which elicited the second-level information (i.e., they were not main idea questions or detailed questions) were positioned below the main idea in the hiearchy (e.g., the question 25). The detailed questions were then placed at the bottom level of the hicarchy (e.g., the questions 9,3, 6, 15, and 20). The map initially contained only structural lines with question marks which represented question numbers. After the student had read one question, one question mark was replaced by the question number associated with that question. Students could see one particular position blinking on the map screen, while this replacement was taking place. The blinking effect was used to draw subjects' attention to the top-level structure map. At the end of the lesson, the map was filled by question numbers at the proper places. Students read questions or answers on one screen and viewed the map on the other screen at the same time.

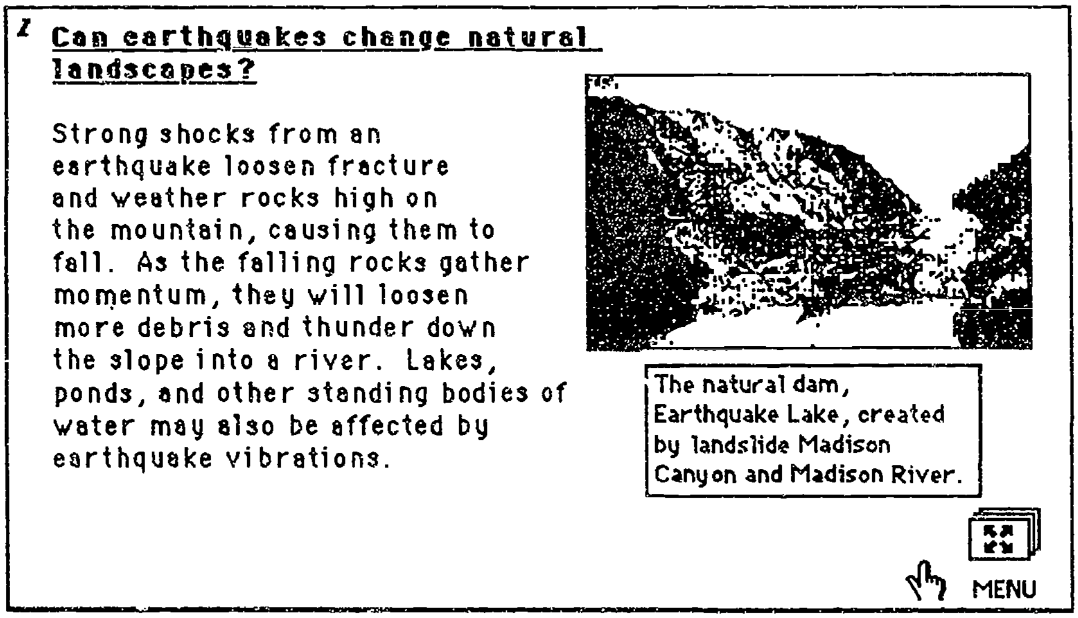

Figure 2. To-Be-Learned Text and Graphics.

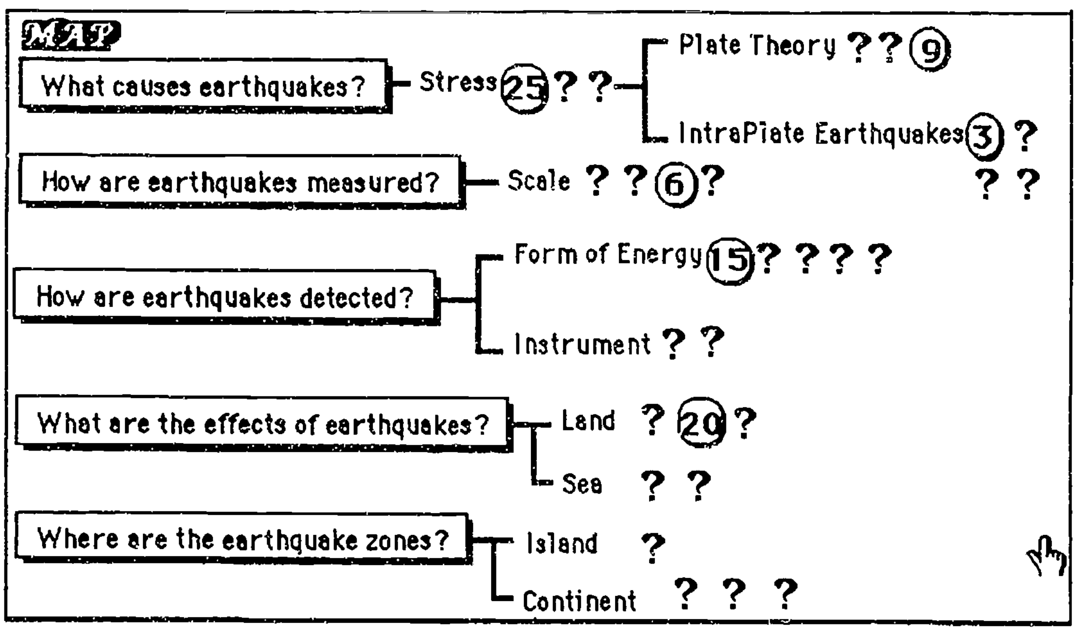

Figure 3. Top-Level Structure Map.

Pretest and Posttest

Thirteen factual test questions covering the instructional content in the pretest were repeated in the posttest but in a different format so as to eliminate the practice effect. Pretest questions were in the true-false format, whereas the posttest questions were multiple-choice questions. As a transfer test, subjects were required to generate questions regarding earthquakes in the pretest and tornadoes in the posttest.

DESIGN

The experiment used a one-way ANCOVA between-groups design. In this experiment, the independent variable was the instructional method, the dependent variable was posttest scores and the covariate was the pretest scores. In this case, the covariate (i.e., pretest scores) was to adjust the posttest means for any initial differences that may have been present in the pretest in order to yield a more powerful test.

In the study, there were three experimental conditions: open-accessible (non-linear) prequestion group (OP group), linear prequestion group (LP group), and linear topic groups (LT group). As mentioned in the preceding section, two versions of the CBI lesson contained the same prequestions that differed in sequence. The one with open accessibility of prequestions was given to the OP group. The LP group received the other version with prescribed prequestions. The third group, the LT group which served as the control group, received the third version in which topics were accessed in a prescribed sequence. Only the OP group was provided with a top-level structure map (see Table 1) in the lesson.

Table 1
Descriptions of Experimental Conditions

Open-Accessible Prequestion Group (OP Group)	Linear Prequestion Group (LP Group)	Linear Topic Group (LT Group)
Prequestions	Prequestions	Topical words
Non-Linear Sequence	Linear Sequence	Linear Sequence
A Structure Map		

Procedure

Each subject was required to take the pretest and the posttest. Subjects were tested either individually or in pairs. There was no time limit in the CBI lesson. The individual learning time that each subject spent in selecting questions and reading answers was recorded. The computer kept track of the sequences in accessing questions created by the OP group. There were three steps used by these three groups to complete the lesson:

(1) The subject selected a question / a topic in the menu (in the case of the LP group and LT group, subjects sequentially selected the next question / topic in the menu). Then, the computer displayed the to-be-learned text on the screen.

(2) After having read the text, the subject returned to the menu.

(3) Repeat (1) until all questions had been read.

Scoring

Correct answers to the factual test items in the pretest and posttest questions were scored as one point, and zero points for wrong answers. Student-generated questions in the pretest and the posttest were compared to the questions presented in the CBI lesson. Two raters examined student-generated questions to determine whether or not the questions were semantically similar to the CBI questions. It was assumed that students who learned about earthquakes through questions were likely to generate questions similar to earthquake questions but in the context of tornadoes. Therefore, a student-generated question similar to a CBI question was said to be a qualified question. The number of qualified student-generated questions was calculated.

RESULTS AND DISCUSSION

Means

Table 2 presents the descriptive statistics of pretest and posttest scores. A t-test was conducted to determine whether there is a significant difference between the pretest scores and the posttest scores. The result shows that this CBI lesson produces a significant difference in subjects' performance on pretest and posttest ($t(14) = 4.60$, ***$p < .001$).

Table 2

Descriptive Statistics on Pretest and Posttest Scores

		Pretest		posttest	
Sample	N	M	SD	M	SD
	15	6.53	2.26	9.20	2.51
Experimental Groups: OP Group	5	6.40	1.52	9.20	1.48
LP Group	5	6.80	3.34	9.20	3.96
LT Group	5	6.40	2.07	9.20	2.04

Note. Maximum score = 13.

It was also found that pretest scores were correlated with posttest scores (r = .56). Therefore, 31% (i.e., the square of the correlation coefficient) of variance on posttest scores was attributed to variability on pretest scores. ANCOVA was conducted to remove this proportion of the variance from the error term. However, one of assumptions underlying ANCOVA for one covariate requires equal population regression slopes for all groups. In this study, the nature of the linear relationship is not the same for the three experimental groups. Figure 3 reveals that the slopes are not equal. Then, ANCOVA is not appropriate. Alternatively, a one-way ANOVA on the gain scores -- the differences between posttest scores and pretest scores, was conducted to test whether the instructional method causes differences in subjects' performance. No significant difference was obtained (MS_b = .30, MS_e= 5.90, $F(2,12)$ = .05).

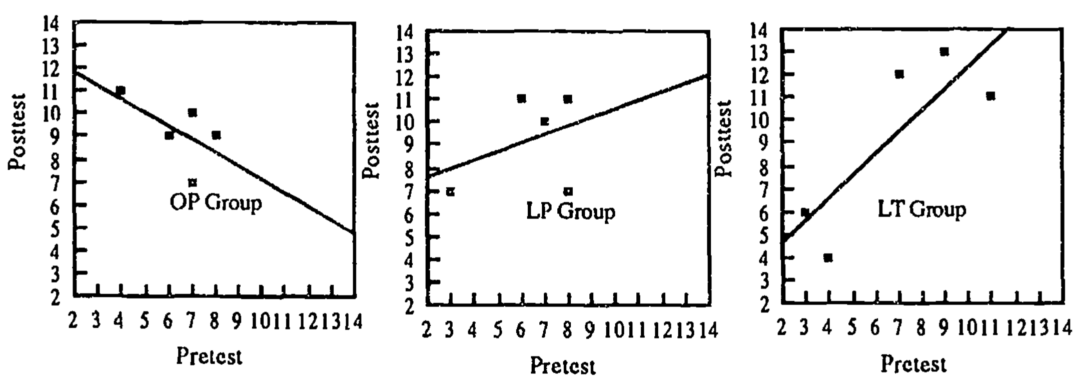

Figure 3. Regression Slopes for Three Experimental Groups.

Since this was a pilot study, a small sample was used. Because of the small sample size, a power problem occurred. In deciding the number of subjects per group needed to have adequate power, it was assumed that a medium effect size of .25 and a 70% chance (power = .70) of finding a difference should be achieved. Therefore, 42 subjects per group were needed to obtain .05 significance level and 32 subjects per group to obtain .10 significance level (Stevens, 1990).

Performances on Factual Questions of Pretest and Posttest

As mentioned in the preceding section, the pretest contained the same factual questions as the posttest. Figure 4 shows that the posttest scores scatter around higher scores such as 10, 11, 12, and 13 points than the pretest scores do.

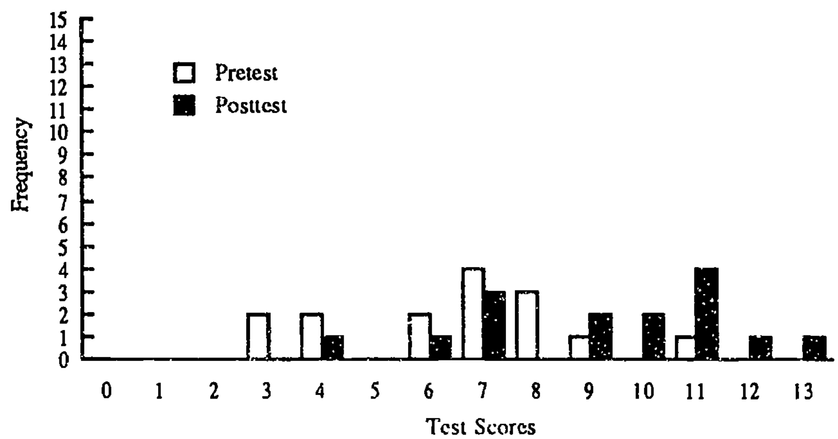

Figure 4. Frequency Distribution of Two Test Scores.

The number of correct answers to test questions across the two tests was compared (see Figure 5). None of the subjects answered test question 2 correctly in the pretest. But, this situation was greatly improved in the posttest. Similarly, the number of correct answers to test questions 1, 3, 4, 6, and 9 increased in the posttest. By contrast, the performance on test questions 7, 10, 11, 12, and 13 became poorer in the posttest than in the pretest. Although the two tests of different format were intended to eliminate the practice effect, it was suspected that the decreased number of correct answers in the posttest on the same test questions were due to the lower chance of answering multiple-choice questions correctly than answering true-or-false questions in the pretest correctly.

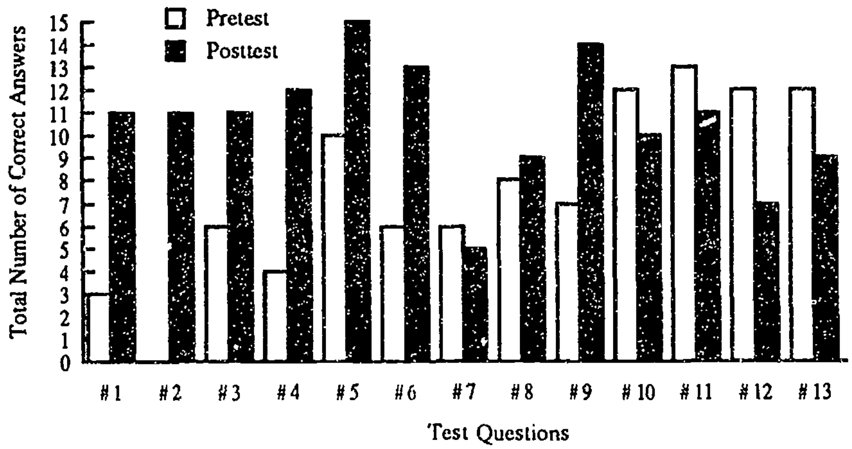

Figure 5. Total Number of Correct Answers on Two Tests

The Learning Time and Reading Time

The learning time includes the time spent in selecting questions in the menu and the time spent in reading the texts contained in answers. In other words, the learning time was time spent in learning through the lesson. Table 3 depicts the average learning time over three groups.

Table 3

Descriptive statistics of Average Learning Time by Groups

	Average Learning Time in Minutes			
Experimental Groups	Min.	Max.	M	SD
OP Group	26.30	35.73	29.12	1.70
LP Group	18.00	29.02	25.18	4.38
LT Group	15.97	32.38	23.59	7.20

The OP group had a longer lesson learning time than the other two groups. This was because that OP subjects selected questions to read while the LP and LT subjects read questions in order. Moreover, the data indicate that there is a greater variability in learning time for the LT group (SD = 7.20) than for the other two groups. It was also found that the OP subjects' learning time was highly correlated with their posttest scores (r = .79, see Table 4). The longer the OP subjects spent in learning with the CBI lesson, the better their performance.

Table 4
Correlation Between Posttest and Learning Time by Groups

	Posttest Scores		
	OP Group	LP Group	LT Group
Learning Time	.79	-.15	-.30

Since a card contained a segment of to-be-read text, the reading time was recorded on a single card basis. The average reading time spent by the three groups on reading text through the lesson is shown in Figure 6. A greater amount of time was spent in reading the texts on cards 16, 23, and 29 than the other cards. As a matter of fact, card 16 and card 23 contained longer segments of text. Card 16 contained information about the twelve levels of Mercalli Intensity Scale and card 23 described what happened in San Francisco in 1989. The text on card 29 was short but described the location of the New Madrid Fault.

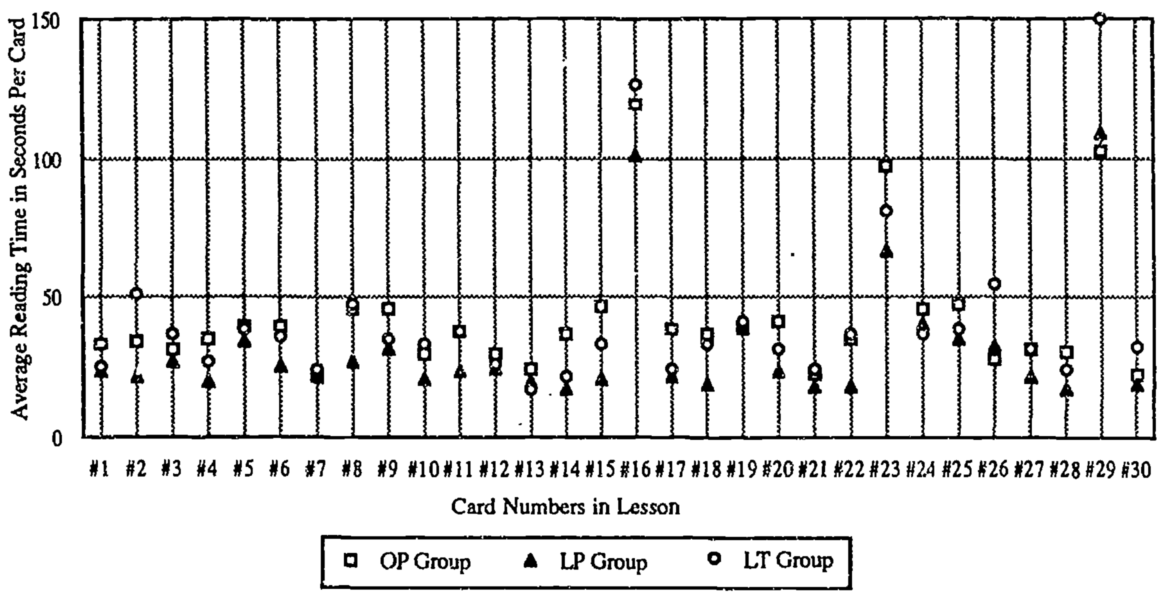

Figure 6. Average Reading Time by Groups over Cards.

The texts of these cards were more descriptive than expository in nature. They involved descriptions about people, events, damages, and places. It was found that subjects paid attention to reading the text even though the text was lengthy. Additionally, Figure 6 reveals that the LP group spent less time in reading the text than the other two groups. In reference to the means of the pretests for the three groups (see Table 2 in the previous page), the LP group had the highest mean score among the three. It confirms to the schema research that people with well-developed prior knowledge of the lesson content process a text more efficiently and rapidly.

Selection Time and Sequencing

For the OP subjects, their selection time accounted for a portion of their learning time, because they selected questions from a menu to read. Figure 7 shows that the OP subjects spent relatively less time in deciding which question to read next, ever since after they decided which question to read first. In addition, it reveals that subject 3 spent a greater amount of time in selecting questions to read than the other OP subjects. Subject 3's selection time dramatically varied from one question to another. In reviewing relevant data, it was found that subject 3 had the longest learning time of all in this experiment.

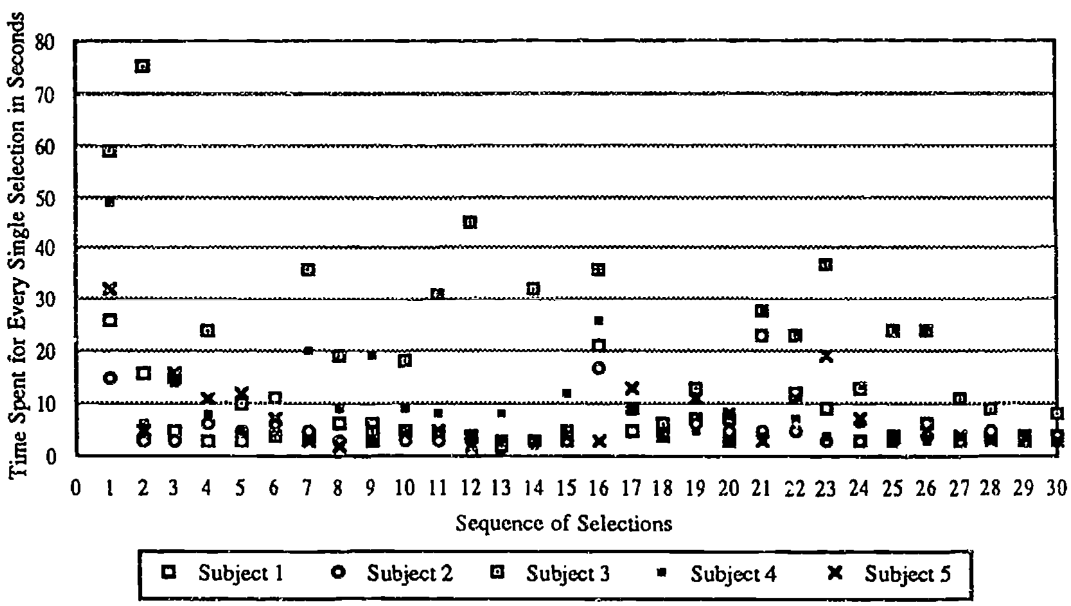

Figure 7. Individual Selection Time on Questions in the Menu.

To analyze the sequence of selecting questions, Figure 8 indicates that most subjects just selected questions in order from the menu. All subjects accessed question 16 in the same sequence and chose to read questions 28, 29, and 30 the last. Four subjects except subject 3 chose questions in order after reading question 16.

Although all of the questions were alphabetically listed in the menu, it was found that non-linear selections occurred less often during learning. If a person were to make a jump (i.e., make a non-linear selection), it was likely that he or she would continue to read adjacent questions or resume the prior sequence after the jump. For instance, subject 1 chose question 3 to read first and then sequentially read the next 8 questions, up to question 11. Subject 1 jumped to read question 2. After reading question 2, subject

1 chose question 12, returning to the prior sequence. Then subject 1 read three questions (i.e., 13, 14, and 15) followed by question 12. Later, subject 1 made a jump at the 15th selection to question 1. However, subject 1 returned to question 16, continuing in the prior sequence again. The other example was subject 4 who read questions 10, 11, and 12 sequentially after reading the first question, question 9. Subject 4 then jumped to question 7. However, subject 4 resumed the prior sequence by reading question 13 after reading question 7. Subject 4 continued to read question 14 and 15. Then again subject 4 made another jump at the 12th selection to question 6. This time, after reading question 6, subject 4 read the adjacent questions (i.e., 5, 4, and 3) in reverse order.

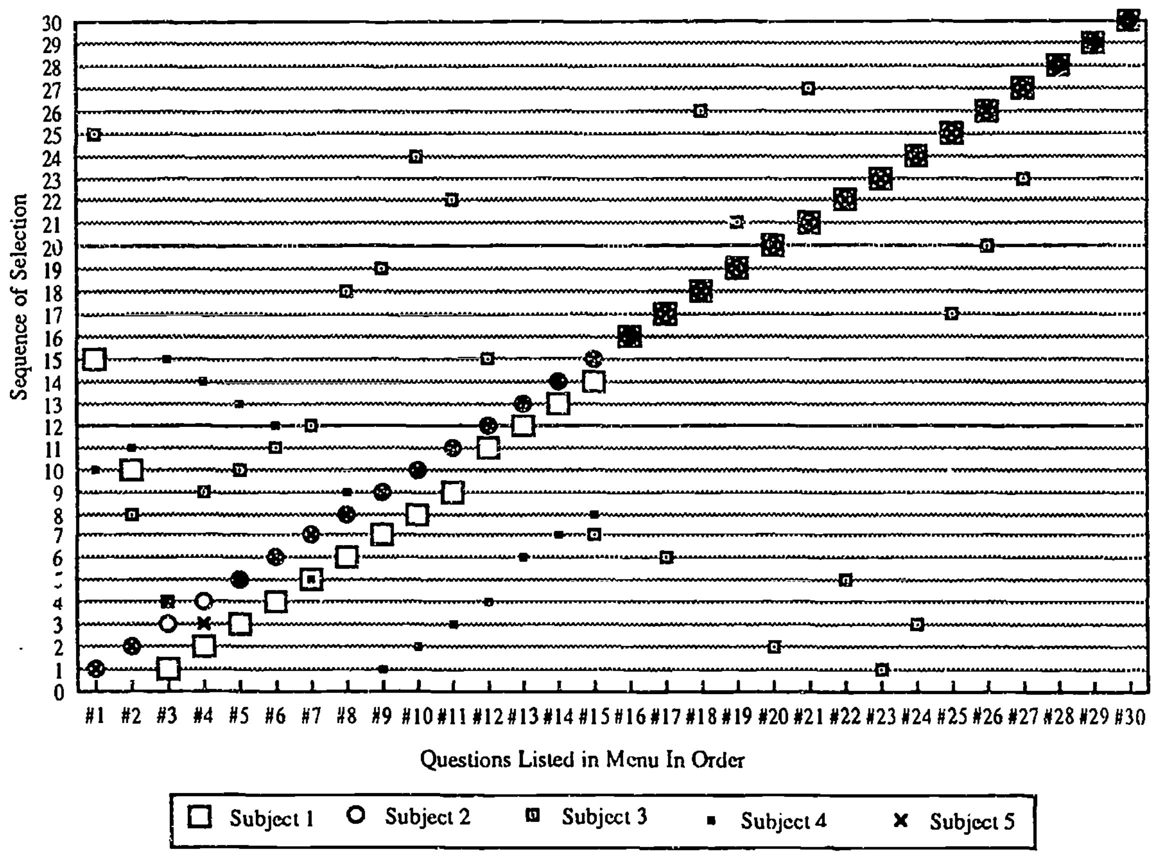

Figure 8. Sequence of Questions Selected by OP Subjects.

It was found that only subject 3 made many jumps while she was selecting questions to read. Subject 3 only read questions 4, 5, 6, and 7, as well as questions 28, 29, and 30 sequentially. As a matter of fact, subject 3 selected questions in a non-linear sequence most of the time. In terms of test scores, subject 3 improved her pretest scores of 4 points to 11 points in the posttest, which was the biggest gain of all pairs of the pretest-posttest scores. Referring back to Figure 7, one could see that when the selection time was approximately less than 10 seconds, subjects would simply select questions in order.

Self-Questioning

As mentioned in the preceding section, the number of qualified student-generated questions on a transfer test was calculated. Quantitatively, it was found that the same number of qualified questions was generated by the OP subjects and the LP subjects who received questions in the lesson (see Figure 9). The LT subjects who received a non-question lesson generated more qualified questions than the other two groups. To conclude, providing questions in the CBI lesson did not promote students self-questioning skills.

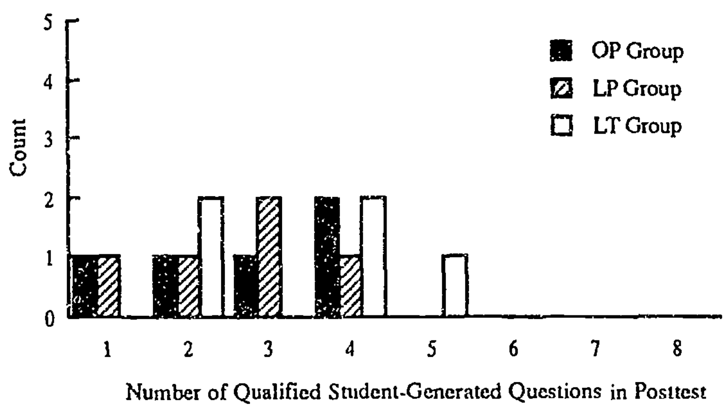

Figure 9. Number of Qualified Student-Generated Questions on Posttest by Groups.

Qualitatively, it seems that students remembered the five main idea questions provided by the lesson such as cause, effects, measurement, detection, and prone-zones of earthquakes. It was found difficult for students to transfer detailed questions specific to earthquakes to production of detailed questions regarding tornadoes. Only few students who knew more about tornadoes generated detailed questions such as "What is in the tornado funnel?" and "Why does the warm and cold air mix cause tornadoes?" In other words, students generated merely main idea questions. If a student has more prior knowledge about a subject matter, then he or she may generate more detailed questions. In this study, however students were not tested on prior knowledge about tornadoes. Upon examining student-generated questions, it was found that many students were concerned with the prediction and prevention of tornadoes to occur, because they believed that such disasters as earthquakes and tornadoes could be predicted and prevented in advance.

CONCLUSION

This pilot study investigated the use of questions in terms of format and sequence in a CBI lesson. The predicted effect of instructional method (i.e., non-linear prequestions) was not significant in any of the analyses possibly due to the small sample size. Some interesting learning effects were found, however.

Although students noted the prequestions, the result of this study did not show the benefit of open accessibility of questions (i.e. non-linear sequence). Two reasons might be offered. One is that this lesson contained too many questions for students to select. Students may have been more able to fully utilize the feature of open accessibility of questions if the number of prequestions for selection had been reduced. It is assumed that one has a fixed amount of cognitive capacity or mental resources. Many options or choices may cause a learner to place extra load demands on his or her cognitive system. As a result, a learner may forego exploring these options or choices. At this point, a learner-controlled lesson seems to be no different from a linear-sequenced lesson or a program-controlled lesson. In fact, most students attempted to make only one or two jumps and then read sequentially rather than to randomly choose questions every single time, although one student with the frequent number of non-linear jumps improved the most from pretest to posttest. Future research could explore the reasons why students selected adjacent questions after a jump and why students preferred resuming the prior sequence.

The outcome of a learner-controlled instruction is also greatly influenced by individual differences. In this study, some subjects were reluctant to freely learn the lesson from the onset; some hesitated to take control at all stages of learning; while some pursued their own unique ways throughout the lesson. Although these individual differences exist, a CBI lesson should motivate learners to maximize the instructional capability of a lesson in the first place. Learners may therefore find a better method to learn than the old method. If this were not to occur, a CBI lesson should also provide an environment where learners feel confident in any way they prefer to learn and which should be equally effective as other methods available in the lesson.

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[2]The learning material was a revision from the joint work created by the author and Shihkuan Shu for a class paper in 1991.

Interdisciplinary Multimedia Learning Using Anchored Instruction

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Abstract

The use of the videotape series, Voyage of the Mimi, was investigated as a vehicle for interdisciplinary "anchored instruction." The study centered around a middle school class of 125 students taught by five teachers. It is the position of this paper that the dramatic videotape series, Voyage of the Mimi, creates an environment for sustained exploration through relevant learning activities. Data was collected using observation, interview, analysis of student products, and pre and post attitude surveys. The surveys were designed to determine whether exposure to the videotape series would improve female attitudes toward math and science. Results from the two-week exercise show no significant attitude improvement. Qualitative information, however, indicates a successful exercise full of mind-expanding activities. The series is popular with both this middle school's students and teachers. Further research is needed in the teachers' evaluation techniques of this type of exercise. This series also appears to be appropriate for those researching inquiry, discovery, and cooperative learning. A surprise was the extent to which this series appears to support student growth in the domain of geography.

Introduction

This paper reports the results of a seventh grade teaching team's two-week interdisciplinary exercise based on a video tape series. The media employed, the Voyage of the Mimi, is a dramatic videotape series developed under the auspices of the Department of Education in 1984; it is distributed by Wings for Learning.

The Mimi package is designed to address math and science. While the tape series does not provide for interactivity or computer control, as most definitions of multimedia would, it does provide for the thematic integration of full motion video, print materials, and computer programs. The series consists of 13, 15-minute segments about a scientific expedition to study Humpback Whales off the Coast of Maine. The expedition's crew provides a tapestry of human interaction. The crew is headed by a female biologist who is awarded a grant to study whales. Among the racially, ethnically, and gender-mixed crew, is a crusty sea captain, his 11 year old grandson, an oceanographer, a hearing impaired research assistant, and two teenagers.

Literature about this highly popular and visible series is limited--especially research reports concerning the its effectiveness. The available information, while anecdotal in nature, generally provides favorable reviews. Mastrolia (1991) states that "... there is enough variety and interest so that any student would become actively involved with learning..." (p. 31). An article in High Technology ("Grade Schoolers", 1985) cites a math teacher in Cambridge, MA who states: "The program is stimulating and practically limitless in its usefulness" (p. 58). The latter article also suggests that the Mimi series causes female students "to view math and science as both fascinating and accessible" (p. 59). Martin (1988) states that the Mimi materials "could create windows of opportunity in which disruption in instructional routines occurred and could be utilized to open a lesson up in positive ways" (p. 6). Not all reviews, however, have been favorable.

In reviewing the Voyage of the Mimi, Postman (1985) states that "media merchants" have created a mindless series, "as if media themselves have no epistemological or political agenda" (p. 154). He undermines a selling point often found in multimedia literature by citing literature which discounts suggestions that learning increases when presented in a dramatic setting. In addition, he questions why children should be studying Humpback Whales, navigation, and map-reading skills. He opines that the subject matter is highly inappropriate. In short, he suggests that children will only have learned that learning is a form of entertainment. Postman's concerns raise some important, fundamental issues concerning epistemology and methodology. Some of his criticisms will be dealt with in later discussion. The paper turns now to a discussion of literature which, in this writer's view, supports Mimi-like applications.

There are several avenues one might explore in finding philosophical, psychological, or epistemological support for a dramatic series like the Mimi. One avenue would be symbol systems and dual channels of communication (Gagné, 1985; Kozma, 1987; Paivio, 1986). Another avenue concerns instructional television and its impact upon education--especially concerning the role that adult models can have on young viewers (Strohmer, 1989). No doubt the latter two avenues are worthy of further discussion, but each deserves separate treatment. This paper suggests that one of the defining values of the Mimi series lies in the use of "situated cognition" or "anchored instruction." Both of the latter are methods designed to provide life-like environments that show students the importance, application, and relevance of the subject domain.

Gardner (1991) and Bigge (1976) remind their readers that before formal schooling, children learn everyday tasks at a prodigious rate--seemingly with ease and enjoyment. After entering formal educational environments, however, many of the same children find learning difficult--if not downright boring and painful. Bigge points out that students often fail to find or understand the relevance of school subjects to everyday life. The Cognition and Technology Group at Vanderbilt (CTGV, 1990) discusses Whitehead's position that instead of relevance, schools promote the learning of inert knowledge. Inert knowledge is defined as that knowledge learned, but often forgotten in appropriate situations.

How does decontextualization affect the learning process? Brown, Collins, and Dugid (1989) contend that students need more than abstract concepts and canned examples. They suggest that learning should be conducted in activity situated in real-life social, cultural, and physical contexts. It might be impractical, however, to take every middle schooler on a converted tuna trawler to study the habits of Humpback Whales. To get around this problem, Brown, Collins, and Dugid suggest a concept termed "legitimate peripheral participation" (p. 40). This concept applies to persons not taking direct part in an activity, yet still learning a great deal from their peripheral position. With a little imagination, this concept could be likened to middle school students viewing the videotape of the Mimi's voyage, then engaging in activities similar to--or congruent with those depicted in the series. Research by the Cognition and Technology Group at Vanderbilt (CTGV, 1990) is a good example of the use of media (videodisc) to "situate" or "anchor" the students within a learning environment.

CTGV used anchored (situated) instruction to develop the Sherlock Project. Their goals were to help develop rich mental models, and to have students "learn to notice and use relevant information to prompt them to actively explore the video and look for clues to historical and geographic accuracy" (p. 4). Videodisc was their media of choice. The authors opined that videodisc "...allows a more veridical representation of events than text; it is dynamic, visual and spatial; and students can more easily form rich mental models of the problem situations" (p. 3). Noteworthy was the suggestion that this environment was especially important for low-achievers and students with little domain knowledge.

CTGV submits that new information learned during meaningful activity is perceived as a tool rather than as inert information. They attempt to attack the inert information problem with video environments that support sustained exploration. According to the authors, this sustained exploration allows views for multiple perspectives and permits opportunities for teacher guided discovery. Their videos contain a large variety of information that allows students with varied backgrounds to find something worthy of contributing to the class. Last, their problem solving macrocontexts allow the students to develop tools that form new, as well as modify old perceptions. This is in contrast to traditional instruction that emphasizes mere facts to be memorized. It is the position of this paper that the dramatic series in the Voyage of the Mimi videotapes also creates an environment for sustained exploration through relevant tool building activities.

Methods

This study was conducted during a two-week Voyage of the Mimi exercise at a middle school in Blacksburg, Virginia. All core classes, throughout the school day, revolved around the Mimi theme. There were 125 seventh grade students taught by a veteran teaching team. The average years of teaching experience for each of four teachers was approximately twenty. There was also a student teacher from Virginia Tech who played an integral role in the execution of the exercise.

Although this study was specifically interested in whether the series supported an exploratory environment, a survey was also designed to see whether the perception and attitudes of female students toward math and science would improve. Results of pre and post exercise attitude questionnaires were analyzed using repeated measures analysis of variance. Observation, evaluation of student products, and pre and post session interviews were also conducted.

It was the impression of this writer that while this teaching team was quite experienced, its individual teachers were more comfortable with a traditional approach to instruction. That is, their approach was more of a behavioral environment based on traditional methodology. In this setting, each teacher served as the expert and source of information. Each relied on behavioral objectives and made a conscientious effort to adhere to the standards of learning outlined in county and state guidelines.

It is important to point out the teachers' epistemological and methodological backgrounds. These teachers were taking somewhat of a risk in using two precious weeks of their spring semester to move into new and uncharted waters. To the observer, the teachers appeared to be excited and optimistic, yet they showed a bit of uncertainty about the upcoming adventure. In addition, the team's planning and coordination time was limited. This only served to heighten the teachers' anxiety.

Mimi literature indicated that there was enough material to support work from two months to a year. This team, however, had only two weeks to devote to the exercise. Obviously, this would be somewhat of an abridged undertaking and some of the published Mimi modules could not be used. One of the team's objectives was to determine whether or not teachers accustomed to using traditional methods could work within an environment said to be supportive of constructivist methodologies. The teachers were also investigating whether the Mimi materials could be effectively integrated into the curriculum.

There was a variety of materials for use. The team had the basic "Overview" manual which followed the video tapes. It offered advise to teachers, making suggestions for in-class activities. It was generic in the sense that it offered suggestions that applied to every discipline. There was also an interdisciplinary guide. The math and science teacher had context-specific modules at their disposal. These will be mentioned shortly.

Daily Events

The day before each new Mimi segment, the team met during a planning period to view the next day's video. The meeting facilitated the coordination of activities and helped preclude duplication of effort. The students spent the first, short, homeroom period viewing the day's Mimi adventure. They then left for their classes, rotating in and out of four classrooms. The paper now discusses each team member's methods and content afforded by the Mimi series.

Math

The math instructor used the Mimi module entitled Maps and Navigation. The teacher followed the manual closely, having the students perform exercises involving, among other things, map making, measurement, distances, latitude/longitude, topographic maps, and triangulation. Math problems included ratios and time-distance problems. The latter supported work the students had been studying in their regular classes. During one exercise, the teacher went outside the text's scenario by taking the students outside the school to estimate distances and determine azimuths (direction in degrees) by use of a compass. Both the teacher and the students were excited about this exercise. The instructor was overheard to say: "Golly, but it went well today--the kids loved it!" One female student remarked: "This was just like in real life! It's something we don't have to learn for a test, then just forget!"

Science

The science instructor used the Mimi module Ecosystems. The students studied food chains, food webs, and scientific methods. In looking at scientific methods, the students compared methods conducted by the Mimi crew with those conducted in the forestry industry. They also had the opportunity to view and comment on some of the Mimi series's 13 videotape "expeditions" to places in which scientific activity was conducted. The students worked on group projects--conducting research in the library, then presenting an end-of-exercise food chain depicted on a poster board. There was also a written exit project for each student.

English

The English classes were divided into those taught by the regular teacher and those taught by the student teacher. The former started the students off by exploring the relationships of the crew members. She had the students keep daily journals--pretending to be an additional crew member. Classroom discussion included the ethics of whaling, as well as how the hunting of whales has changed over the years. They also explored methods of communication for both humans and animals. Last, the students got into writing cinquain and diamante forms of poetry.

The student teacher was fortunate in quickly finding a popular theme. One of the actors depicted in the series was hearing impaired. Once the student teacher found that some of her students were fully versed in sign language, she and the other students commenced to learn the entire alphabet in sign language. Their signing culminated in an entire class taught using signing. The students taught the class--dividing into groups to help one another. The observer was struck with the patience and tenacity of the student teaching groups during this exercise. Toward the end of the Mimi experience, the section was visited by a speech pathologist. She discussed language as well as testing for hearing impairment. The student teacher culminated her exercise by playing "Jeopardy" using Mimi terms and vocabulary.

Social Studies

The social studies teacher had expressed her reservations of such a wide-open approach to the classroom, but was soon struck by the students' interest in various themes offered by the Mimi series. The class conducted research on endangered species; Smithsonian and National Geographic magazines were soon in abundance. Next, the class got into paleontology--evaluating evidence that whales had evolved from land mammals. This led to the review of other evolution--looking for example, at leopards in transitory forms of evolution. Codes were explored; the class deciphered coded written messages and took down messages flashed in Morse code. This class also explored two other major topics. First, the formation of land/water configurations such as deltas, straits, and bays. Second, the influence of Indo-European languages and their various branches.

did the teachers. One teacher remarked that disciplinary problems we

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Results

To this observer, the Mimi exercise was an unqualified success. Postman was right, the students had fun, but so did the teachers. One teacher remarked that disciplinary problems were down and that the students were so involved in the exercise that they were bringing items from home to support the theme. One female student became a local celebrity when she reported on visiting a huge marine museum in California. Others were bringing periodicals such as the National Geographic. Their intent was to share and show off articles concerning whales, fishing, and of course--the Titanic. Place mats from Nantucket were soon gracing the walls along with the Mimi posters. The teacher remarked that the Mimi materials were a wonderful opportunity to go into so many different areas. Instead of being the expert, she became more of a facilitator, coordinator, and mentor in guiding the students to critically analyze the content.

Statistical comparison of the pre and post exercise attitude questionnaires was less striking. The questionnaire was designed to determine whether females' attitudes toward math and science had improved. The post exercise questionnaire was administered two weeks after the series. Of 21 questions using a Likert scale, none showed significant changes in attitude. It may be of interest to note that the beginning attitudes of the females toward math and science were not significantly different than the males. There may be a number of reasons for the lack of difference between genders. First, many of the children in the sample group came from families whose parents are staff or faculty at Virginia Tech; others were the children of professionals from Blacksburg. It seems likely that these students would be college bound and more interested in math and science. The shortness of this exercise may have also contributed to no significant changes in attitudes. Anecdotal written comments from the students, however, were extremely positive. The students were asked whether the next seventh grade class would profit from the Mimi series. Here are some examples of their comments:

- "...it's good for us in all subjects and I especially learned a lot about marine biology, so I think next year's class should have a chance to learn these things too."
- "...it was fun to be learning about all the same things in all classes and makes me get more involved with schoolwork."
- "...I liked how all classes were incorporated with Mimi."
- "...This was a great experience for me. I enjoyed all the work we did, even the homework."
- "...it is educational, shows how important math and science are; it's an interesting way to do it..."
- "...it [helps] students open their eyes to what other areas of science, math, etc. there are."
- "It was different because the Mimi helped us refer the things we learn to real life.
- "I enjoyed a lot of things in this but I think that if anything should stay the same for sure, it should be that the sign language is taught again."
- "I would just like to thank the writers of this program because I had so much fun."

In fairness, there were some negative comments (approximately one percent). In the days of MTV it would be hard to engage every student. There will likely be a small percentage of students whose interests will always be outside the classroom.

In addition to anecdotal information, the students turned in end-of-exercise papers that resembled portfolios. An analysis of these papers showed that the students were wrestling with important concepts. Examples include, but are not limited to: human interaction with the environment--especially concerning endangered species; the social dynamics among the ship's crew members; the nature of variables dealt with by people with physical impairment; paleontology; and geography.

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Discussion

The series truly supports an interdisciplinary approach. One of the unheralded benefits of the series, however, may be in the field of geography. Carstensen and Morrill (1992), in an unpublished paper dealing with a geography project at Virginia Tech, discuss the shortcomings of the nation's students in geography. They cite a need for students to have knowledge of the significance of location, the origins and development of places, and the consequences of the interactions between humans and the natural environment. The knowledge of location and the physical characteristics of places is addressed by them in a module named after the sport of orienteering. They state: "Orientation skills are defined as the ability to determine one's position and the location of distant objects in relation to that position, and the ability to use a compass and map to navigate through an unknown area" (p. 12). They submit that this module "...makes students more aware of the role of geography in their daily spatial behavior" (p.12).

The discussion in the preceding paragraph was introduced to address whether the students in this Mimi exercise were just having fun, or in the best of all worlds, having fun and learning at the same time. In the opinion of this writer, the Mimi materials were adept at directly addressing the types of knowledge discussed by Carstensen and Morrill. The students were learning geography while they were also engaged in the other disciplines. Readers may also wonder about the post exercise opinion of the teaching team that was originally concerned about standards of learning and behavioral objectives. The reader can form his or her own opinion. The team plans to conduct the Mimi exercise during two weeks of the coming fall semester, and the school has purchased the series <u>The Second Voyage of the Mimi</u> for a two week exercise in the spring semester.

During a post-exercise interview, each team member discussed plans for expansion of and further experimentation with his or her methodology in implementing the Mimi series. The math instructor wants to move from a basic map and navigation course to one that incorporates actual orienteering exercises to be held on the school grounds. The other three teachers envision more of a constructivist approach in which cooperative learning plays a greater role. Ability grouping will be a thing of the past during the coming school year, so cooperative activities may be more appropriate. It is this writer's impression that now that the teachers have a first hand experience with the series, each can expand the content or create supplemental activities congruent with the series. This will enable the teachers to create a closer fit between the curriculum and the Mimi series.

Does the dramatic videotape series, <u>Voyage of the Mimi</u>, provide an effective vehicle for instruction? Yes. Within the concept of anchored instruction, it allows the instructor to pursue nearly all disciplines. It also allows the teacher the opportunity to take side trips into interestingly new areas while the students are engaged in learning activities.

One issue dealt with implicitly in this paper was the teachers' methods of evaluation. This is an area that deserves more study in general--not just in the Mimi context. This team's teachers relied on daily observations, participation, homework, projects, and end-of-exercise papers as the basis of evaluation. The latter may sound behavioral in nature, but there were no tests and only a few quizzes. The techniques listed were used more in a constructivist approach. There were more right answers than usual--students received A's on papers that approached the topic from completely different angles.

The Mimi materials provide a very rich opportunity for further research. Measuring the spatial skills of the students who engage in the map and navigation materials is an example. Those engaged in cooperative, inquiry, and discovery learning will also find a fertile environment.

Last, was the expenditure of over $2 million by the Department of Education to produce this series a waste of money? Not at all, it was worth every penny, and more--just ask approximately 125 students and five teachers at this middle school.

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Make It Happen:
Implementing Computer-based Technology in School Systems

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ABSTRACT

The potential of computer-based technology to help improve our current educational system depends on the efforts made by schools to incorporate the technology into daily activities of instruction. The phase during which an innovation is integrated into daily instruction is referred to as implementation. Historically, implementation of computer-based technology in schools (from elementary to college level) has failed either because it has not been properly carried out or the technology has been met with resistance in the schools. This paper examines the problems associated with technology implementation as well as sources of resistance to computer-based technology in school systems. Also discussed are general approaches and specific strategies for ensuring successful implementation of innovations, as put forth in current literature. One strategy, employing the instructional technologist as an implementation mediator (change agent), is given special attention.

INTRODUCTION

Computer technology holds great promise for improving the current educational system in America. Positive changes, however, cannot be accomplished unless the technology is integrated into the regular activities of instruction in schools. While the diffusion of a technology to school systems is a long, arduous process in itself, adoption of an innovation does not guarantee its acceptance or success. Acceptance is achieved when the technology becomes a part of a school's established pattern, that is, when it becomes institutionalized (Levinson, 1990). Success is achieved when the technology becomes more than hardware or software, when it becomes the well-planned systematic arrangement of teaching and learning events accomplished through the use of hardware and software (Fawson & Smellie, 1990).

The phase during which an organization tries to incorporate technology into its daily activities is often referred to as the "implementation phase" (Bishop-Clark & Grant, 1991). Implementation is part of the process of technology diffusion in which an innovation is brought into a new organization to be used by the members of that organization. In the case of educational organizations, the innovation may be new or revised materials, new procedures or approaches to instruction, or the alteration of beliefs (Fullan, 1982). Computer-based technology, the focus of my paper, seems to be all of these things.

I examined two diffusion models to help explain the process of i

MODELS OF DIFFUSION AND IMPLEMENTATION

I examined two diffusion models to help explain the process of implementation. According to Abbott (1967), implementation is the third stage of technology diffusion. It follows the *awareness* stage, during which a dissatisfaction with the status quo arises, and the *search* stage, during which new procedures, materials, etc. are proposed that might solve the dissatisfaction. During implementation, an organization's energies are devoted to integrating into the organizational structure the innovation or innovations upon which they have agreed. Abbott writes that the type of innovation adopted and the extent to which it is implemented depends on the organization's openness to new ideas as well as the rigidity of its rules system. That is, the more open an organization is to new ideas and the less rigid its rules system, the more likely the organization will adopt an innovation and implement it to a great extent.

Knirk and Gustafson (1986) developed a somewhat different model for technology diffusion. In this model individuals or groups usually proceed through the following steps in deciding whether to adopt new materials or processes:

1) **Awareness**	The individual/group becomes aware that a new technology exists.
2) **Interest**	The individual/group develops a curiosity about how the new material/process works and what its benefits may be.
3) **Appraisal**	Individual/group considers the advantages and disadvantages of the technology.
4) **wdoption**	Individual/group decides to make use of the innovation and integrates it into the decision and behavior patterns of the individual or group.

Implementation is not specifically identified, but it is included in the adoption phase of Knirk and Gustafson's model.

Unlike Abbott, these authors believe that, in education, the individual not organizations make the decision to use a new technology. Also, the focus is not so much on a dissatisfaction with the status quo but by educators' curiosity about how an innovation could improve the current system. Knirk and Gustafson do seem to agree with Abbott on a few of the factors which influence the diffusion of innovations in schools or other organizations -- that is, the characteristics of the organization and the characteristics and attitudes of the adopter. In this list of influential factors, Knirk and Gustafson would include the characteristics of the innovation and the adopter's understanding of the innovation.

Besides examining two models of diffusion, I also looked at a model of implementation put forth by Levinson (1990). Levinson breaks down the implementation process into three distinct phases -- planning, installation, and institutionalization. During planning, individuals identify what problems will be solved and design the architecture of the computer-based system (i.e. how the computer functions at the classroom, school, and district levels, as well as how the computer equipment will be linked throughout these levels). The planning phase also includes building coalitions because, according to Levinson, "change needs its alliances for support." The second phase, installation, requires that the school and the technology undergo changes. The role and function of the technology is more clearly defined (or redefined), and teachers learn skills necessary to manage the new technology. Teachers also will assess and redefine their roles in their classrooms because the innovation will change the way instruction has been delivered in the past. The final phase, institutionalization, completes the process of implementation. The aim is to maintain and support the new system as efficiently as possible. Until it becomes a part of the structure of the school system and the daily activities of instruction, it is at risk of failing.

The models described above all have their merits, but none is comprehensive in describing the processes of technology diffusion and implementation in schools. I propose an expanded model which combines the ideas of Abbott, Knirk and Gustafson, and Levinson into a six-stage process. Before I talk about the expanded model, I want to comment on the locus of decision. I have explained that Knirk and Gustafson stated that their approach was based on the idea that individuals, not organizations, make decisions about adopting a new technology, and that Abbott's focus was on the organization's implementing an innovation. My approach flip-flops the researchers' ideas. I believe that, in most cases, organizations (in the form of boards, committees and organizational leaders, each of whom is elected, appointed, formed or hired to make decisions for the organization) will make the decisions about whether or not to adopt a new technology. However, individuals make the decision about whether to implement the new procedure, materials, or belief systems. Organizations can adopt an innovation and either recommend or force its use on the members of the organization, but that does not guarantee its implementation. Individuals are ultimately responsible for the integration and validation of a technology. In schools, the teachers make the decisions concerning implementation of computer-based technology, according to Hativa (1986).

Below are listed the six phases of diffusion with brief explanations:

1. **Awareness** — There is a dissatisfaction with the status quo or a feeling that improvements could be made.

2. **Search** — Individuals within an organization learn of new technologies or innovations that might solve the problem or bring about improvements.

3. **Appraisal** Individuals or groups weigh the advantage and disadvantages of each innovation for their system. If they find one that is suitable, they recommend it to the decision makers.

4. **Adoption** The decision makers decide to adopt a new technology and introduce it into the organization.

5. **Implementation** The technology is integrated into the structure and behavior patterns of the organizations. This involves planning the architecture of the new system, installing the technology, evaluating it, adapting it if necessary, and institutionalizing it.

6. **Continuation** Individuals within the organization and the organization itself support and maintain the new system, adapting it when necessary to meet future changes.

The above model is helpful in understanding how technologies go from the "factory" (designer/developer) to the "customer" (schools and teachers). Also, this model could be expanded to take into account the mind-set of the designer/developer of the innovation, but for the purposes of this paper, this framework is sufficient.

PROBLEMS WITH IMPLEMENTING NEW TECHNOLOGIES IN SCHOOLS

Abbott (1967) writes that the school is a social system whose function is considered in terms of a continuous series of interactions and transactions between it and its supporting environment. To perform its functions, and thus maintain a steady state with its environment, the school receives inputs in the form of personnel and material resources, uses these inputs as sources of energy, and produces (as output to the environment) students who have been subjected to its influence. Thus, schools are undergoing and producing changes everyday.

Change can stabilize an environment, but it also can upset its balance such that adaptation requires major modifications in the structure, behavior, or function of an environment. Change is usually uncertain, often expensive, and almost always time-consuming. Fullan (1982) claims that the source of change in education is not always focused on improving the organization. That is, people may implement change for the wrong reasons (e.g. self-aggrandizement or securing resources the organization could not get any other way). When discussing schools, we often remark that change is a good thing. In many instances, change is good, but in other matters we must recognize that change is not always a positive thing.

Implementing computer-based technology into school systems represents the type of change that upsets social systems like schools. According to Levinson (1990), "if technology-mediated education is to transform our schools, we must change the way we implement change." Not only will schools have to make changes in the delivery of instruction using computers, they also will have to change the ways in which they incorporate computer-based technologies and other innovations into their organizations. Computer-based technology affects the way in which all members of an organization behave -- from the individual who makes the budget decisions to the person responsible for the security of the equipment in schools.

Because computer-based technologies are information technologies -- that is, the material that "runs" computers is information -- they seem to have been more difficult to integrate into schools than perhaps other physical technologies. Information is nonphysical and, therefore, nonhomogeneous, so the applications of information technologies are much less straightforwardly predictable and their net effect is hard to quantify (Aksoy, 1991). Schools lack precise information about the effectiveness of computers in improving instruction. There is no consensus about just how much computers enhance instruction in schools, and given the expense of computer equipment, schools may be reluctant to allocate a larger portion of their resources for computer-based technologies.

Allum (1991) argues that "implementation is not a short-term, one-time event," but rather a continuous process involving long-range planning, continued commitment from teachers and administrators, and a systematic program of evaluation. As well, effective educational change depends more on understanding of what a particular school or teacher needs from an innovation rather than dictating how a school should proceed in utilizing the innovation or evaluating how well an organization masters the innovation. To help ensure the successful implementation of computers in education, the processes of teaching and learning must be considered (Ennals, 1987).

Levinson (1990) identified the following components of effective change in schools attempting to integrate computers into instructional activities: (1) identifying the critical problem to be solved before purchasing new equipment; (2) considering all stakeholders in deciding how the computer-based technology will be used in schools, (3) reaching a consensus about how it will be used; (4) assuming new roles for teachers and administrators, practicing new patterns of behavior, and learning new skills; and (5) actually integrating the computer-based technology into the daily activities of the school organization. Creamer and Creamer (1988) also identified forces that influence change within an institution. (See Appendix A.)

BARRIERS TO IMPLEMENTATION

Given this discussion about the uncertainty and difficulty of change within school systems, one would expect there to be barriers or resistance to the implementation of computer-based technology. Rose (1982) grouped the sources of resistance into four categories: institutional economic barriers, technological barriers, administrative barriers, and educator barriers. These barriers were applied to the current situations in primary and secondary schools, but they also have been observed in institutions of higher education (Glick, 1990).

The institutional economic barriers include a lack of funding to buy and maintain computer equipment and a lack of human and nonhuman resources committed to the implementation of the technology. In a typical school system, almost 90 percent of the budget is taken up by labor, debt service, and other fixed costs, so instructional technology is often seen as a "budgetary frill" (Foshay, 1988). A vicious circle seems to have developed in terms of the financial issue: Schools will not spend money on a technology that is not a part of the organization's structure, and technology will not become a part of the school's structure unless resources are allocated to its integration. Foshay also says that technology often has been brought into schools and then expected to take root and flourish spontaneously. Change cannot take place unless it is managed carefully and supported by those who are managing the change.

There also are technological barriers to the implementation of innovation in schools. First, teachers find it bothersome to adapt or change course content and teaching styles to the technology. If they have methods that work, they do not want to make changes to them. Furthermore, there is no predicting that using the computer will improve what procedures or materials are already in place. A second technological barrier is that instructional technologies are perceived only as tools for teachers, not as integrated alternatives to current instruction. While it is the nature of the computer as a tool that may keep computers in schools, schools will not benefit from computers unless the technology becomes an integral part of the teaching and learning processes (Collins, 1991). Other technological barriers are that the equipment may not be available or accessible to teachers when they wish to use it and that computer technologies may not be perceived as useful in meeting instructional needs or improving instructional delivery.

The human element, in the form of administrators and educators, are also sources of resistance as identified by Rose. Administrators may cause teachers to dislike the new technology because they force the teachers to use it in order to justify the high cost of the equipment. And while administrators advocate the use of computer technology in the classroom, they do not support, appreciate, or reward teachers who use it. Compounding this problem is the fact that many schools have not developed formal procedures for evaluating the results of computer use in their classrooms. The absence of formal formative evaluation procedures makes it difficult for administrators to know how well computers improve instruction, to decide how the computer-based system should be maintained or improved, or to determine who should be rewarded for effectively integrating the computer into the classroom. Lastly, institutional leaders are failing to lead their schools during the crucial implementation phase. Unless the administrators champion the implementation of computer technology and make it a priority during budget planning, schools will not benefit from the power of computer technology to improve instruction.

The final source of resistance to innovation, according to Rose, is that created by educators. First, educators may be unaware of new technologies or they do not care to learn about them. It may be that they know about them but do not understand how to use them. Teachers may perceive the computer as a threat to their jobs. They are concerned that computers will replace them or that computers will force them to give up their control over learning and instruction. And even if they are willing to try a new instructional approach, they may become disillusioned with the notion of using the alternative method because they do not receive support for their efforts. Teachers also worry about the ability of the equipment and software to perform properly during instruction -- the failure of the equipment being a potentially embarrassing situation. Finally, educators do not have the time to design and develop quality computer-based instruction that meets their specific needs. A small piece of courseware can take many hours to develop -- time teachers do not have to spare.

Gross, Giacquinta, and Bernstein (1970) claim that most researchers attribute the success or failure of planned organizational change to the organization's openness or resistance to change, respectively. They studied a school attempting to implement a major innovation to which members had an initial positive orientation and found that this school also encountered barriers to implementation. These barriers are listed as follows:

1) Lack of clarity on the part of organizational members about the innovation and what is expected in terms of implementation

2) Lack of the capabilities necessary to carry out the innovation on the part of the members

3) Lack of tools or equipment to carry out the innovation

4) Incompatibility of the existing organizational conditions with the implementation of the innovation

5) Permission and incentives not given to subordinates to carry out implementation

Implementation is difficult even when schools open their arms to innovations like computer-based technology.

STRATEGIES FOR FACILITATING IMPLEMENTATION

A number of authors have proposed strategies or guidelines for overcoming resistance to innovations in schools (Rose, 1982; Foshay, 1988; Dalton, 1989; Fawson & Smellie, 1990;

Glick, 1990; Levinson, 1990; Persky, 1990; Bishop-Clark & Grant, 1991). Some of the general guidelines are as follows:

- Build cooperative computer-based learning environments
- Develop integrated software that supports routine curriculum objectives
- Provide teacher training in the use of innovations
- Let the individual teacher decide whether or not to use the innovation
- Define new roles for teachers (facilitator, developer, and manager)
- Increase the monetary and personnel resources available for change
- Reward and support the users of nontraditional instructional approaches
- Develop procedures for evaluating the effectiveness of instructional technologies
- Engage an instructional technologist (teacher or outside consultant) as a change agent, someone who assists in the implementation process

A more general approach to the successful application of educational technologies in schools is put forth by Foshay (1988). Instructional technology (in this case, computer-based technology) should be defined as a systematic and comprehensive methodology rather than as hardware or software. Schools and instructional technologists/change agents must develop strategies for introducing technologies into schools as part of a comprehensive instructional improvement effort. Computers should no longer be isolated from other innovative efforts to improve the educational system.

Foshay also states that instructional technology should be applied in "fertile ground," organizations that are committed to implementing computers into the school system as well as the financial means to do so. These schools are models for those who do not have a clear commitment or plan for technology implementation in their system.

I would add to this general approach the recommendation for building a consensus among organizational members about how to implement the technology in that particular school (Levinson, 1990; Allum, 1991). Also, instructional technologists as change agents must do what Tessmer and Harris (1990) call an "environmental analysis" -- the analysis of the physical and instructional characteristics of product use in order to describe how the instruction will be employed in the real world. All the strategies for facilitating implementation must be carried out not only by teachers and school administrators but also by the educational technologists who wish to bring new innovations to school systems.

THE INSTRUCTIONAL TECHNOLOGIST AS CHANGE AGENT

When change happens, people respond to it by adapting to it, ignoring it, or making use of it. In order for schools to benefit from large-scale changes like computer-based instruction, they must carefully manage the processes of implementation and continuation. "School systems need reliable assistance in the processes of integration, assessment, and public relation contact), his/her role as "change agent" may be the most important in relation to schools. The basic role of a change agent is to determine strategies that will result in the adoption, acceptance, and integration of a new educational technology (Knirk & Gustafson, 1986). Change agents often are third parties outside the school organization who can provide technical and implementation expertise without having direct control or power over the intended users (Bishop-Clark & Grant, 1991). Although the IT is somewhat limited in the number of implementation strategies he/she can choose in a particular setting, the IT may have a greater chance of success than a teacher or administrator because the technologist is less of a threat.

Dalton (1989) suggests that instructional technologists are in a unique position to manage the process of change within school systems. "What distinguishes educational technology as a discipline is the systematic or scientific methodology that we apply to practical problem in education. We analyze, design, develop, and evaluate solutions." He adds that the most significant role of the change agent is to act as an interface between the adopters of an innovation and those individuals with a vested interest in seeing change occur. However, the most frequent mistake made by ITs as change agents is that they fail to examine their solutions to educational problems in light of the needs of the intended implementors: teachers (Dalton, 1989). We must remember that teachers ultimately make the decision about whether or not an educational innovation will be implemented. Change agents must keep teachers in mind at all times when designing strategies for the implementation of computer-based technologies in schools.

Knirk and Gustafson (1986) have identified a list of skills that are positively correlated with effective change agents:

- Is client- and need-centered rather than material- or innovation-centered
- Is somewhat more educated than the client
- Is perceived as knowledgeable and competent by the client
- Is open to information from a variety of sources
- Works hard to communicate information about the technology to intended users
- Seeks, empathizes with, and gets the support of leaders in the adopting organization

Miles, Saxl, and Lieberman (1988) also developed a list of 18 skills that are key for effective change agents. Among the key skills are relating simply and directly to others, developing a nurturant, supportive relationship with the client, facilitating team work, orchestrating the implementation process, and resolving or improving situations where incompatible interests are in play. (For a complete list, see Appendix B.)

The skills mentioned above make it easier for instructional technologists to effect change within the educational settings in which they are based. The skills also help the technologist in carrying out the following tasks of implementation mediation, as identified by Bishop-Clark and Grant (1991): (1) understanding the sources of resistance to innovation within an organization; (2) educating and communicating with teachers about the new technology and about the implementation process; (3) encouraging positive attitudes toward technology; (4) introducing change that is consistent with the social and educational environment of the school; (5) supporting and encouraging the champions in schools, those who actively and enthusiastically promote a technology.

CONCLUSION

Because there is little need to develop a product or technology that will not be used, understanding the process of technology implementation becomes very important for schools and for instructional technologists acting as change agents in those schools. It is also important to recognize that change is not always good for schools, despite all the current problems in our educational system. The basic approach to implementing change in schools should be a focus on the needs and desires of the implementors and intended users of new technologies or materials. Schools should recognize and take advantage of the potential of instructional technologists to implement change effectively. In turn, the instructional technologist must recognize and confront the possible barriers to implementation as well as determine strategies to encourage the integration of educational technologies into the daily activities of schools.

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APPENDIX A

CREAMER & CREAMER'S KEY CONDITIONS FOR CHANGE

Variable	Condition
Circumstances	The presence of a uniform perception of a need for change
Value compatibility	The project and its plan for implementation are seen as useful and harmonious with other procedures
Idea comprehensibility	The project goals and ways to implement them are articulated clearly
Practicality	Adequate personnel and resources are sustained throughout the planning and implementation of the project
Top-level support	Top-level leadership exhibits sustained commitment to the project
Championship	A clearly definable project champion serves as an influential advocate empowered with the responsibility to implement project goals
Leadership	A clearly identifiable project leader maintains commitment and support throughout the planning and early implementation of the project
Advantage probability	Outcomes of the project are apparent and perceived to address significant institutional concerns
Strategies	A distinction is maintained between the process of conceptualizing the fundamental focus of the project and the process

APPENDIX B

MILES, SAXL, & LIEBERMAN'S KEY SKILLS FOR CHANGE AGENTS

Skill	Description
Interpersonal ease	Relating simply and directly to others
Group functioning	Able to facilitate teamwork
Training/Doing workshops	Directs instruction; teaches adults in systematic way
Educational general/ master teacher	Has wide educational experience; able to impart skills to others
Educational content	Has knowledge of school subject matter
Administrative/ organizational	Defines and structures work, activities, and time
Initiative-taking	Starts or pushes activities; moves directly toward action
Trust/rapport-building	Develops a sense of safety, openness, and reduced threat on the part of clients; good relationship-building abilities
Support	Provides nurturant relationships with and among clients
Confrontation	Able to express negative information; can challenge what works and what does not without generating a negative effect
Conflict mediation	Resolves or improves situations where multiple incompatible interests are in play
Collaboration	Creates relationships where influence is mutually shared
Confidence-building	Strengthens clients' sense of self-efficacy and belief in self
Diagnosing individual's problems	Forms a valid picture of the needs and problems of an individual teacher or administrator as a basis for action
Diagnosing organization's problems	Forms a valid picture of the needs and problems of a school as an organization (including its culture) as a basis for action
Managing/controlling	Orchestrates the change process; coordinates activities, time, and people; directly influences others
Resource-bringing	Locates and provides information, material, practices and equipment that is useful to the client
Demonstration	Can demonstrate the desired new behavior while in meetings and in the classroom

Selected Abstracts for the

Special Interest Group for Emerging Technologies (ETSIG)

Designing Computer-Supported Intentional Learning Environments
Joanna C. Dunlap and R. Scott Grabinger, University of Colorado

Computer-supported intentional learning environments (CSILE's) provide students with a forum for subject matter/content area exploration based on individual needs and interests. Using a CSILE as an instructional tool, designers and teachers enable students to take responsibility for and control of their learning goals and processes. CSILEs provide for student-directed knowledge base creation through collaborative involvement utilizing higher order questioning, elaboration, productive/constructive commenting, and learning process management skills. Before student contributions are added to a CSILE system, CSILE is simply a computer-based shell. Designers must consider five main issues:

- -What is the nature of the subject matter/content that will be entered by the students during knowledge base creation?
- -How will students want to express their contributions to the knowledge base (e.g., textually, graphically, audibly)?
- -How will students want to retrieve the knowledge contained in the database?
- -What is the appropriate level of control to incorporate into the structure of the shell (e.g., linking capabilities available)?
- -How will teachers/instructors want to incorporate CSILE's into the curricula, and how should they be incorporated?

This presentation demonstrated how session participants can create computer-supported intentional learning environments.

Electronic Performance Support Systems Demonstrated to Reduce Cholesterol Among Users!
Robert C. Fratini, AT&T National Product Training Center

Electronic performance support systems (EPSS) have burst on to the human performance scene within the past several years. As with such previous "revolutionary" concepts as computer-based training, the vanguard espousing the development of EPSS tend to claims of new paradigms and the utter bankruptcy of the performance technology which preceded EPSS.

Exactly how revolutionary are EPSS? Are we better off forgetting everything that we ever learned about the design of user documentation and interactive instruction or are EPSS just the latest tool in a performance technologist's toolkit? In what situations can EPSS be developed cost effectively given today's technology? And what are realistic expectations of what EPSS can and cannot do to enhance human performance?

The presentation examines EPSS in the context of an overall human performance support system which consists of multiple components, each addressing different aspects in the enabling of performance. To the extent that EPSS do represent a new paradigm, performance technologists must be capable of shifting their perspectives to incorporate elements of EPSS where appropriate.

Evaluating Mindtools in Schools

David H. Jonassen, University of Colorado

Mindtools are computer application tools, such as database management systems, spread sheets, semantic networking programs, hypertext, expert systems, and microworlds, such as Logo and Bubble Dialog that may be used by students to analyze content domains across the curricula as well as reflect their own knowledge structures which engage them in cognitive learning strategies. 140 junior high school students spent four months during the spring building content databases in Works, creating semantic networks using Learning Tool, and creating expert systems rule bases in Primex.

No significant differences in gains on the critical thinking test were found, however, the treatment period was shorter than desired. Fluid intelligence predicted performance on all scales. Both student and teacher reactions to the project were very enthusiastic.

Exploration and Experience with Second Generation Authoring

Paul J. Magelli, Software to Educate People, Inc.

This session will begin by reviewing the problems and requirements for second generation authoring systems. The development of courseware with the current generation of authoring technology is slow and produces courseware that is difficult and expensive to manage and maintain. These systems collapse the learning dimensions of instructional material - such as its organization and instructional strategy - and forces the instructional developer to develop courseware as a sequence of *frames*.

This talk will focus on an exploration of second generation authoring technology in commercial courseware development and the experience gained with it. This technology offers the ability to capture knowledge in a knowledge base and supports the automatic construction and reconfiguration of courseware with different content, organization, instructional strategy, and media. It also supports the reuse of previously captured knowledge and the ability to easily and quickly re-target instructional material. The talk will present the experience gained including a reduction in courseware development time, maintenance time and improved courseware quality. The presentation will also look at the challenges ahead for this new technology.

Building Sophisticated Learning Software in Multimedia

John E. Whitaker, Arthur Andersen & Co., Societe Coopertive

Andersen Consulting, working in cooperation with Northwestern University's Institute for the Learning Sciences created the Business Practices Course (BPC). BPC simulates a client engagement through 15 modules at Perrin Printing & Publishing, a case company. Using over 180 minutes of audio and video segments stored on CD-ROM, the learner conducts interview with PP&P personnel, receives phone calls, reviews memos from Andersen Consulting supervisors, and even attend meetings with PP&P upper management. As with actual client engagements, the course allows for multiple solutions to most activities.

The 40-hour BPC replaces approximately 65 hours of self-study and 40 hours of instructor-led training. Over 3,500 Andersen Consulting personnel worldwide will complete BPC each year. Estimated cost savings are about 8 million dollars per year which is comprised of housing, tuition, travel and training reduction costs.

This session provides participants with valuable insight into developing/converting courses into a highly interactive self-study format utilizing multimedia. Through a short lecture and demonstration, the participants will gain a first hand look at the development of this complex CBT project.

A Computer-Based Simulation of Planned Change

Michael Yacci, Rochester Institute of Technology

The Simulation of Planned Change is a computer simulation that allows a student to experience the effects of various change strategies in a social system. The simulation is specifically based on the ideas and models of change described by Rogers, Havelock, and Zaltman and Duncan. In this simulation, the student is asked to make a series of decisions regarding innovation and change; the computer then dynamically reacts to students choices.

The Macintosh-based simulation is framed as an interactive game in which a single learner interacts with the computer. The learner plays the role of the Minister of Diffusion in a fictional country which is under financial pressure to modernize its industrial base. The modernization options, the strategies used to implement these options, and the results of these decisions are the essence of the game.

This presentation outlines the final version of the simulation and also discusses the process by which it was created. Finally, the instructional uses for the simulation will be discussed.

Selected Formal Papers from the

Special Interest Group for Emerging Technologies (ETSIG)

Advisor Development Life Cycle

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Abstract - A development life cycle pertaining to intelligent advisor systems is presented. Its main attribute is to be user oriented. That means the better set of tactics for recalling concepts, principles, and rules pertaining to a complex transfer task is first identified. After, decisions about physical implementation are taken. Technical aspects do not have any influence on the strategy of intervention. Extracts of MUSIC documentation, a musical composition intelligent advisor, illustrate each phase of the development life cycle.

Introduction

An intelligent advisor system is "an adaptive system aiming at intervening when the user of any given software performs transfer tasks" (Boulet, 1992). A transfer task "consists of principles (or guidelines) that an expert uses to generate the appropriate performance for any given situation. It also consists of secondary content, such as concepts and information" (Leshin et al., 1992). Designing and developing an intelligent advisor system, claiming to be able to help a user performing a transfer task, is a very complex undertaking. It is to plan a help that surrounds an individual, aiming at furthering the transfer of several knowledge previously learned.

To design such a surrounding, the best set of tactics for presenting to software users concepts, principles, and rules, being part of a complex transfer task, must be identified. This set of tactics aims at favoring the emergence of the best solution. To favor it, this instructional technology assists both the thinking process of an individual facing a complex problem, the planning process of the appropriate solution, the process of carrying out the plan, and the process of validating the solution. While the advisor is helping, it collects data to be able to adapt the content of its help transactions to the user, and to propose a relevant remedial help.

An intelligent advisor system is a technology to be used after initial learning of concepts, principles, and rules. An intelligent advisor does not aim at replacing the formal teaching; it addresses the transfer of knowledge. A development life cycle that considers requirements for this particular instructional technology from a user standpoint is described.

Description of the steps

Step 1. Describing the strategy of intervention

1.1 Stating the aim of the advisor

What the advisor will bring to the user is defined: MUSIC aims at individualizing feedback when a grade 9 high school student performs musical creation activities described in the Québec Ministry of Education music curriculum (Ministère de l'Éducation, 1981, 1983).

1.2 Characterizing the target users

The target users of MUSIC are grade 9 high school students with weak to satisfactory knowledge of the musical language elements listed in the Quebec Ministry of Education's music curriculum, and little to no experience transferring it.

1.3 Describing the help transactions

An advisor is designed to help someone: MUSIC does a human teacher cannot do, i.e., performing concurrently several tasks. There are thirty learners, and the lesson lasts fifty minutes. It is impossible for a single teacher to give concurrently fast, individualized, and detailed explanations and feedbacks on each learner's composition, and to recall prerequisites; MUSIC does.

1.4 Describing the main characteristics of the course of interventions

While the user composes, and in accordance with his or her request, MUSIC answers questions, comments on the user's composition, creates its own compositions, and comments on them.

1.5 Describing how the advisor adapts itself to the user

There are several possibilities. Examples are presented in the following. The advisor can engage the user in a dialogue; according to the user's feedback, it will modify the content of its next interventions. It can be decided to grade the user. She or he can select among levels displayed, or a grading test can be used. Inferring the user knowledge level is another possibility. The nature of requests can be analyzed. That corresponds to answer to the following question: Do the user requests refer to prerequisite knowledge? The Elaboration theory (Reigeluth,1987; Reigeluth et al., 1983) can facilitate the identification of prerequisite knowledge to a complex transfer task. Prerequisite knowledge being identified, it is possible to link user requests to a level within a hierarchy; this level can after be used to determine the user one. Another way is to produce a list of systematic errors with their causes; models coming from the field of measurement and evaluation are useful. A user's question (or a set) can be related to a particular error. One can decide to divide the domain in regard of prerequisite knowledge, and to link systematic errors to the corresponding performance objective. The user knowledge level can also be inferred using the frequency of requests for help, or errors, or both, relatively to a same topic. The main problem is to define the norm: how many requests or errors are necessary to infer that it is enough. MUSIC provides individualized feedback and help by considering student's requests and his or her composition. MUSIC refers to prerequisite knowledge (i.e., rules issued from tonal system, and from the musical composition processes (such as augmentation, diminution, question-answer, repetition)), when answering the student's requests, commenting on the student's composition, composing its own melody, and commenting on it.

1.6 Overall characteristics of the subject of interventions

Examples of questions to be answered are: Will the advisor comment on the problem solving process, or the results? The objective stated in the Quebec Ministry of Education music curriculum (1981, 1983) is not to learn the right way to solve the problem of composing a melody.

Consequently, MUSIC will solely comment on results, i.e., the melody composed. The main objective being to transfer the knowledge of musical language elements, MUSIC outlines prerequisite knowledge within each intervention.

1.7 Overall characteristics of vocabulary of presentation

As an advisor aims at helping a user while performing a transfer task, the short term memory is the main concern; means to allow the user to recall prerequisite knowledge are planned. Examples are: using demonstrations, examples, generalities, index, maps, pictures, or procedures. Leshin's and al. (1992) design strategies and tactics can be referred to. MUSIC does three types of interventions: 1- explanations requested by a student in regard of musical language elements, 2- comments on compositions made up by the advisor, 3- comments on the student's composition. Explanations present either a generality, or a statement of principle or rule; when suitable, an example is displayed. Melodies composed by MUSIC are in accordance with the musical composition process currently used: for example, the composition of a G Major melody, eight bars, using the question-answer process, time signature being $\frac{4}{4}$, range of the melody of an octave. Comments on the student's composition, or on its own, is done taking into account the way the musical language elements are used.

1.8 Interface

The interface is described: natural language, menu driven, buttons, keywords, etc. MUSIC's interface is a mixed one. Buttons and menus allow the selection of a particular option. Keywords refers to a given explanation. Natural language is used to comment on a composition. Comments are pre-stored sentences having variables. Content of those variables is adjusted considering the characteristics of the composition. Mechanisms related to gender and number are installed.

At the next step, designers focus on strategy and means to acquire knowledge. It is instructional design oriented so, they don't make any a priori choice about encoding the knowledge in the advisor data structure as for "black box" (e.g. issue-based tutoring, Burton, et al., 1982), and "glass box model" (e.g. knowledge-engineering techniques, Clancey, 1982) approaches.

Step 2. Describing the knowledge acquisition strategy

2.1 Boundary of the domain

Means to delimit the domain are described. That corresponds to analyze and characterize the transfer task.

2.2 To identify problems

Means to identify problems an individual may have, when he or she performs a complex transfer task X, while using an application software Y, are selected and described. To identify the knowledge usually not mastered, a standardized test can be used. The proportion of target users that the advisor will fail to help because some of their questions are not part of the test can be estimated. Then, the number and cost of errors that users could make despite the investment in the technology can be estimated. It can be decided to analyze how a representative sample of target users performs the transfer task. The performance can be observed, or shooted. These users state their questions out load, designers list them. Because irrelevant variables can affect the environment, it must be rigorously surrounded. The proportion of users the advisor will fail to help will be estimated, using values such as users not represented in the sample; the cost of the advisor's failure, utility of the advisor, etc. will be estimated too. It can be decided to perform a simulation and an analysis of protocol. Means ensuring the sample actually covers the variety of future users must be planned. Means ensuring the (subjective) process of linking a request for help to a category will be objectively done have to be planned. To avoid a too large lost of information (simplification of the reality), there must be an appropriate number of categories. Here again, proportion of users that are not represented in the sample, reliability and validity of the case study with error associated, etc. will be used to estimate the proportion of future users that will not be helped by the advisor (because their questions were not collected so, the advisor is not able to answer); the linked risk, i.e., they make mistakes, will be estimated.

2.3 To identify sources to write interventions

Means to write content of interventions the advisor does, when an individual performing a complex transfer task X, while using an application software Y, makes a request for help or mistake, are then selected and described. There are several possibilities: specialized manuals, course syllabi from academic or professional sector, content of courses given in the academic or professional sector. Will courses be observed, or shooted? Will experts doing the task and expressing out load how they perform the complex task be observed, or shooted? Will a simulation of the advisor be setted and followed by an analysis of protocol allowing the identification of experts' answers when facing a user's request? In any case, cautions mentioned before in regard of the users' requests for help identification and categorization are relevant. Those mentioned in regard of calculating values to be used to estimate the margin of error of the advisor (i.e., what proportion of users the advisor will fail to help) are also relevant. Decisions on how data collected in regard of explanations given by experts will be processed must be taken. Analysis of these data must allow to identify explanations that really helped the user to perform the complex transfer task. Then, the proportion of users that will not be helped even if the advisor is able to answer their precise question will be estimated. Risk of errors users can make with cost related will be estimated too.

To determine what will be the content of interventions, it can be decided to refer to a certain form recommended by researchers. Those researchers recommend it after having done several rigorously controlled experiments involving several samples; these experiments were done to identify how to facilitate the mastery of a particular capacity described by an action verb. As example, we mention instructional tactics proposed by Leshin, et al. (1992) in regard of each type of capacity they define. The use of those principles or tactics can contribute to minimize the margin of error. Moreover, the values necessary to estimate the utility and the risk of failure can be found in the literature related. The following comes from MUSIC documentation.

Objectives stated in the high school music curriculum relate to a spiral curriculum. To make easier the delimitation of the domain, the Manhattanville Music Curriculum Program (s.d.) will be consulted.

Previous step documents mention that access to prerequisites, and to links between them, will be ensured by outlining keywords within each explanation. We recommand that a network be elaborated in order to illustrate what concepts, principles, and rules are referred to, when a particular explanation is displayed.

MUSIC has to be able to comment on each student's composition. It also has to be able to compose a melody, and to comment on it. In regard of rules to analyze or compose a melody, it is recommended to define determinant elements: those that must be enforced, and those that can be used. An example of mandatory determinant element (as far as the question-answer musical composition process is concerned) is: the number of bars of the answer must be equal to the question one. The following is an example of determinant element that can be used: the relation between the question and the answer can be parallel, semi-parallel, or contrasting. To write i erventions related to prerequisites, it is recommended to refer to the Québec Ministry of Education's documentation, the Manhattanville Music Curriculum Program, and specialized books. To identify determinant elements, it is recommended to have musical composition activities performed on paper by students. Music teachers and professional composers will then comment on these melodies. Weaknesses will be listed; it will also provide many samples of comments done by experts to help each student making progress. It is also recommended to refer to specialized books addressing the topic of musical composition to list the determinant elements. These elements being used, the advisor will be able to compose, and to comment either on its own composition, or on the student's one.

2.4 To set out the knowledge acquisition method

Having identified sources of knowledge and means, steps of the corresponding knowledge acquisition method are then detailed. Note tha' ·he method is not a generic one.

The following summarizes the knowledge acquisition method proposed for MUSIC.

1. Identification of the prerequisites
2. Specialized books analysis (Musical language in general)
3. Synthesis in view of writing a tentative content
4. Links between prerequisite knowledge
5. Students' compositions, and music teachers and professional composers' comments analysis
6. Specialized books analysis (Musical composition)
7. Synthesis to list determinant elements and identify comments related
8. Sequencing the activities in accordance with the spiral curriculum

To summarize, at this step, sources that will be used to delimit the domain are identified. Then, means to collect knowledge (problems, and interventions) are selected. Means to assess quality of this knowledge are proposed: characteristics of the sample, means of control when categorizing, usefulness of explanations, etc. Means to evaluate margin of error of the advisor are also selected. Doing so, it makes easier to evaluate if it is worth to invest in this particular technology.Step 3. Description of the content, the architecture, and the strategy of implementation in the environment

3.1 To analyze sources of knowledge

Sources of knowledge identified at the previous step are analyzed in accordance with the knowledge acquisition method.

3.2 To write the content of interventions

Each intervention is written in accordance with the knowledge acquisition method. If there are persons that will write any part (think about an automatic collecting of real cases, or an automatic collecting of exercises), its structure will be carefully detailed. Doing so, the style will be kept unvarying.

3.3 To produce the architecture of the advisor

The container being considered, the advisor structure is outlined, without taking any physical aspects into account. Global characteristics of the advisor are illustrated and documented. The main components are identified. The identification of these main components brings about the identification of the main modules, and of links between them.

To elaborate models of data and treatments, conventional techniques such as structured analysis for treatments (data flow diagrams), and conceptual database modelling for data (entity-relationship diagram), or object oriented analysis can be used.

3.4 To document the architecture

While producing the architecture, analysts have to document it using a data dictionnary.

3.5 To describe the strategy of implementation in the environment

Works done focused on one aspect of the problem, being the transmission of the knowledge in a help context. Modelling tasks currently done focus on another aspect, being to find the best technological solution for the transmission of knowledge in regard of this particular context. Simultaneously, works related to the problem of implementing an instructional technology in the environment begin.

The strategy of implementation of the advisor in its environment is defined to make sure that all the target users will always have all the information they need, no matter changes occurred within the organization. An example is an employee that quits; it is not sure that the information transmitted in order to prepare the environment to the installation of any given instructional technology, i.e. aim, type of help, limits, etc., will be available to the new person hired. To be sure that everybody always have all the information needed to use the advisor, or always have an easy and quick access to that information, whatever changes occur in the organization, means to have a detailed plan of communication for all advisor life long. It also means that someone must be permanently and actually affected to the management of the post implementation.

Step 4. Description of the physical implementation

4.1 To convert logical models into physical models

At the previous step, designers did logical modelling. They now have to convert it into a physical model. It can be decided to prototype.The following is an example of reason behind the decision to prototype a part of MUSIC: "Domain experts elaborated at the previous step, a first version of explanations. ... The prototype being developed, content and form of explanations changed. At first, domain experts wrote a quite literary content. ... using the prototype, they realized that this definition was not very helpful. In the same way, the prototype was used by a sample of future students ...: it was asked to each student to state in his or her own words what was the meaning of the explanation displayed." (Boulet, 1992).

4.2 To validate the content of interventions

Prototypes allow testing parts with the target users before the whole advisor be programmed. Adjustments are easier and cheaper than later.

4.3 To program

Program the advisor is the point at which application programs are written or purchased.

4.4 To test the programs

To test the programs, methods proposed in the literature are used.

4.5 To implement the advisor

Programs are run, the different files are interfaced, and the human-interface is setted.

Functioning of the advisor

As illustrated at figure 1, when a student calls the advisor, he or she can select the process of composition.

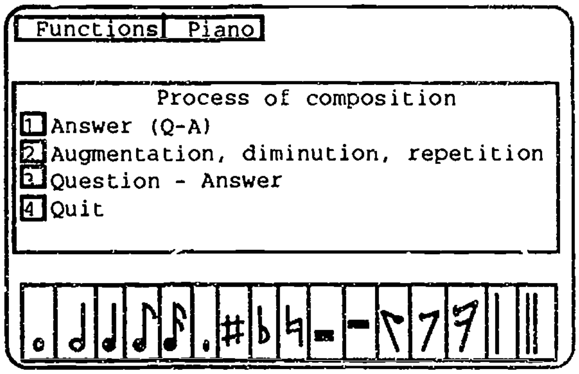

FIG 1 The main menu.

Figure 2 illustrates a student asking an explanation about the accidental concept. Some words are outlined. If the student selects one of them, he or she will have the explanation related.

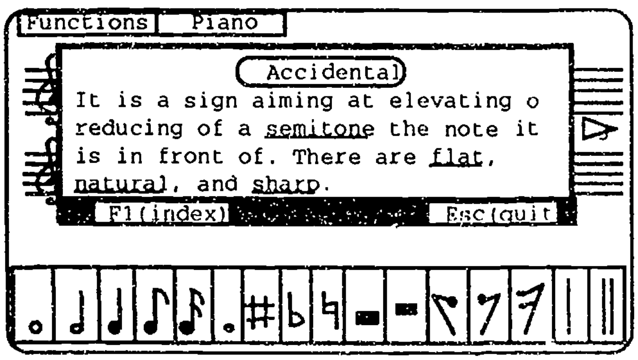

FIG 2 Answering to a student's request.

Figure 3 illustrates the result of a melody analysis.

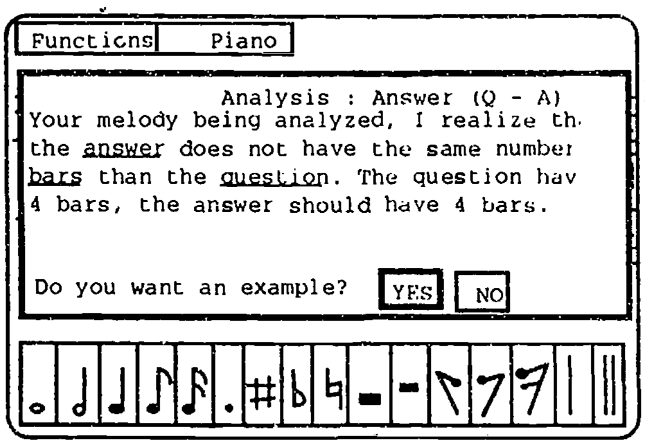

FIG 3 Analyzing a melody.

Conclusion

The life cycle is user oriented. That means designers don't have in mind any a priori technical solution such as "To use Hypercard", "To develop a natural language interface", or "To use an interactive videodisc system"; that also means they don't make any a priori choice about encoding the knowledge in the advisor data structure. The first three steps of the development life cycle emphasize on the creative thinking process related to the identification of all the details of the strategy of intervention, the user being considered. Time and again, the focus is on how the intelligent advisor will help the user that performs a complex transfer task. The system analysis and models associated come after.

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Cognitive Maps Before and After Using a Knowledge Construction Environment

Joanna C. Dunlap
R. Scott Grabinger

Abstract

Discovering the effectiveness of collaborative learning environments using recall measures is a fairly basic task. However, examining the effect of those environments on thought processes is much more difficult because it involves inferential methods. One of these methods is the use of maps representing the perceived relationships between several pairs of concepts associated with a specific topic using pathfinder or multidimensional scaling techniques. This study examined the effect of working within a computer supported learning environment on the participants' knowledge structures. The findings indicated that after working with the learning environment the participants' knowledge structures became more complex and sophisticated.

Introduction

In today's complex and uncertain environment, simply knowing how to use tools for gathering information is not enough to remain competitive. Industry specialists are reporting fervently that people at every organizational level must now be highly creative and flexible problem solvers — an ability based on knowledge construction skills and not simply information gathering skills. Even members of the so-called "blue collar" workforce are now required to demonstrate an advanced level of problem solving skill in order to attain and retain employment (e.g., employees working on computerized/robotic assembly lines need to be able to troubleshoot problems involving highly technical and advanced machinery which requires the ability to flexibly use past experience and knowledge to address new problems). Consequently, learning to think critically and to analyze and synthesize information (construct knowledge) to solve technical, social, economic, political, and scientific problems is crucial to a modern, competitive society. New technologies involving multimedia and hypermedia applications have increased our ability to create learning environments that help teach people to achieve these goals.

However, in our increasingly diverse society , it is more and more difficult to give people the individual attention they need to develop the necessary critical thinking and problem solving skills. Learning these skills is no longer something that can take place in an isolated setting — such as within one course or a six-week time frame. Instead, reasoning and problem solving skill development must be an integrated part of an interdisciplinary program of study — a program or environment that places students in situations where they can practice solving problems in a constructive and collaborative manner.

One new educational strategy that addresses the above problem is the use of knowledge construction environments (KCEs). One kind of knowledge construction environment is the computer-supported intentional learning environments (CSILEs) designed to support intentional learning (Scardamalia, Bereiter, et al., 1989; Scardamalia and Bereiter, 1991). Through their work with CSILEs in educational settings, Scardamalia and Bereiter found that through the development and support of a collective zone of proximal development (cooperative knowledge building) there is potential for students to move toward higher levels of control over their zone of proximal development. In other words, successful student participation in a knowledge construction environment, such as a CSILE, can help students become more responsible for the process of learning, including becoming more creative and flexible problem solvers.

How does a knowledge construction environment work? What kinds of activities do students engage in? The following is a description of the process of intentional learning promoted in a CSILE setting:

- After being presented with a content area for investigation (by the instructor or collaboratively through group process), students individually determine what they want to know about the content area through the development of low level (factual) questions and high level (wonderment, content synthesis) questions.

- After question development, students construct an action plan specifying what their goals are (e.g., answers to their questions developed during the previous stage) and a plan, including a timetable, for gathering the necessary information and completing appropriate projects to answer their questions.

- After gathering information and completing learning activities, students have constructed new meaning (knowledge) from the information. These answers are placed, using text and graphics, in a networked computer program. Then the students review each other's answers to see if the questions have been answered sufficiently. As a result, students may be required to gather more information, rework their synthesis of information, or simply rewrite/represent (all answers are not necessarily presented in written form due to the possible use of graphics, digitized voice, video, etc.) their answers for clarity or specificity.

- Finally, students must formally add their constructed knowledge to a collective database that the students are building together. This process includes developing appropriate links to other information already existing in the database so that other students may be able to access the new information. Although this is a final step, students are responsible for maintaining and updating the database throughout the lifecycle of the database.

- For support throughout the learning process students engage in collaborative commenting which provides students with constructive feedback from peers (as well as the instructor) during question development, goal and plan construction, information gathering and synthesis, and answer reporting to the collective database.

To apply Scardamalia and Bereiter's study on CSILEs, a computer–supported intentional learning environment was used to teach advanced HyperTalk® programming techniques (involving high–level reasoning and problem–solving skills) and CSILE concepts in an advanced hypermedia/ multimedia class. As part of the class requirements, students created their own CSILE programs within HyperCard® (this taught the HyperTalk programming techniques) and worked collaboratively within their CSILE to learn knowledge construction environment concepts.

The use of a CSILE to teach about knowledge construction environments came about as a reaction to student progress. Because of the complexity and richness of the material, students were having trouble understanding CSILE concepts through the conventional process of learning through class discussion and reading. As a reaction to this problem, it was proposed that an understanding of CSILE and all its inherent complexity could be more easily reached if students actually participated in a CSILE.

This, of course, led to another problem. How could we measure the effect of this strategy? We were interested in seeing whether participation in a knowledge construction environment helped students develop richer and more complex knowledge structures about CSILE. To examine the students' knowledge structures, a concept map generating program, KNOT-Mac, was used to generate representations of the students' maps. Students generated two sets of concept maps: one set was created before actual CSILE development began and a second set was created after CSILE development and in–class participation was completed. The maps were then compared to each other as well as to an expert's concept map. It was our hypothesis was that students would develop a deeper, more expert-like understanding of the CSILE concepts by seeing how a CSILE works firsthand. In other words, it was assumed that the second map generated by the class would more closely resemble the expert's map than the first student map would.

Method

Participants
Participants were 14 students in a graduate course entitled Hypermedia and Multimedia Learning Environments. Students included seven men and seven women. They ranged in age from 29 to 45. About half were public school teachers and the others were working in training and development. Participation in this study was part of the students' class participation requirement.

Concepts
Seventeen CSILE concepts (see Table 1) were used in individual map construction. The concepts were selected through a three step process:

1. Students generated a list of concepts that they believed were important to understanding CSILE.

2. Two experts edited the student concepts and added some of their own creating a list of about 20 concepts.

3. two experts practiced making comparisons with the concepts. From that practice they compiled a list of 17 concepts for the concept map exercises.

Table 1
CSILE Concepts Used in Paired–Comparison Test

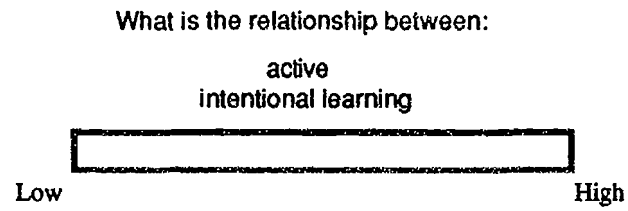
active	intentional learning
boring	interesting
collaboration	knowledge construction
commenting	low level learning
control of learning	lower order questioning
goals/plans	passive
high level learning	student
higher order questioning	student initiative
	teacher

It should be noted that when the list of terms key to the overall concept of CSILE were developed, reference to computers or other media were purposely excluded. Computers and media are simply tools that help make the environment more efficient, but are not necessary elements of a knowledge construction environment.

Procedure
Students were first exposed to knowledge construction environments and CSILEs in particular through assigned readings. Following the assigned readings, two class discussions were held focusing on CSILEs and intentional learning. After the class discussions, students generated their first concept map.

Students generated their maps during class time using the Knowledge Network Organizing Tool for the Macintosh (KNOT–Mac). KNOT–
Mac gathers data through a paired–comparison process. The program presents students with two concept terms at a time in which they rated on a continuum scale from "not related" to "very related" (see Figure 1). Each concept mapping exercise took approximately 15 to 20 minutes and resulted in a graphic representation that could be compared to other students' and experts' knowledge structures (see Figure 2).

Figure 1
Rating System Used to Match Concepts



Students generated their first set of maps after reading two articles about CSILEs (the two articles referenced at the beginning of this paper) and in-class discussions of those articles. The second set of maps, done at the end of the semester, reflects the knowledge structures of the class after working with CSILEs in class (specifically focusing on learning environments as an instructional strategy).

After students generated both sets of maps, the individual student maps for each set were averaged creating one collective map for each set (after class discussions and at the end of the semester). The collective maps were used for data results.

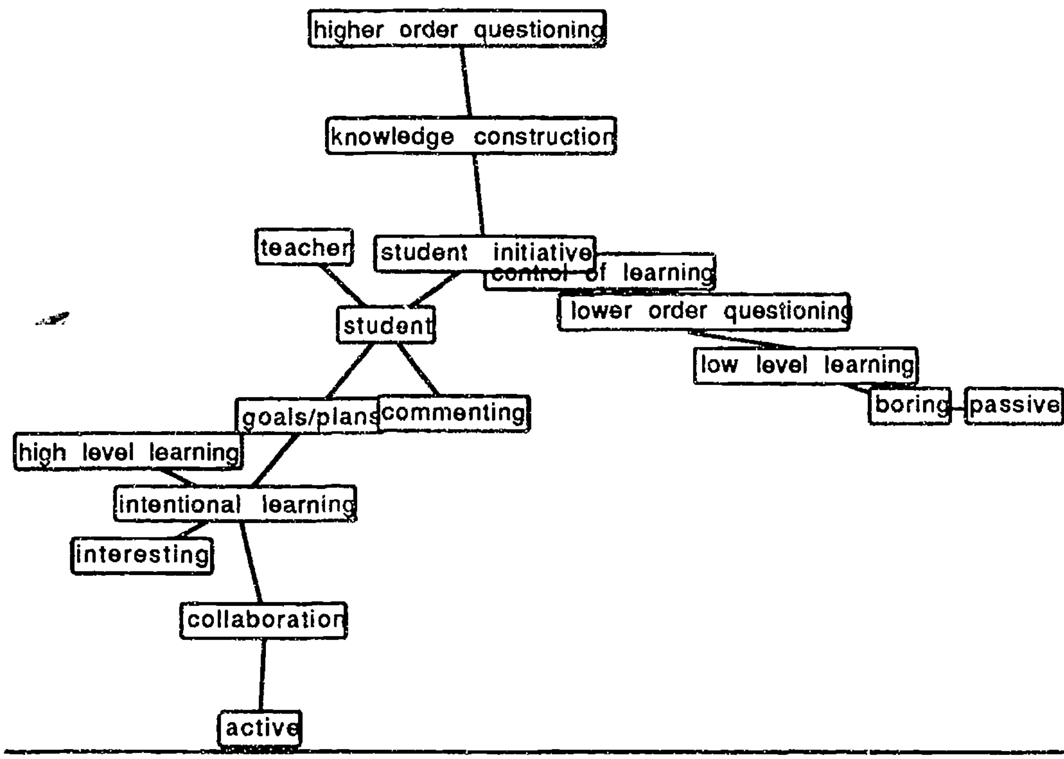
Finally, an expert map was created. The expert map was created through a collaborative concept rating session with two knowledge construction environment experts. A collaborative strategy was used because there were not enough experts to create a collective or averaged map. Both experts examined each pair concept terms presented during a KNOT-Mac session identical to the sessions students participated in and discussed the extent of the relationship between the concepts and then selected a mutually agreed upon value.

Results

Results of the concept map analysis are based on a visual comparison and interpretation of the first map (Figure 2) with the second (Figure 3) and each session with the expert map (Figure 4).

Expert Observations

Figure 2
Expert's Map



1. Intentional learning forms the most central concept with seven direct connections (see Table 2): control of learning, collaboration, teacher, goals/plans, high level learning, higher order questioning, and interesting. These are the main attributes, as judged by experts, related to intentional learning and knowledge construction environments.

2. The concept "active" provides a link to a second cluster of terms: lower order questioning, low level learning, boring, and passive. This indicates that activity is the basis of learning, whether high level or low level. However, the concept "interesting" is not linked with the low level cluster, but with the intentional learning cluster. "Interesting" is an adjective that describes and places a value on high level learning.

3. A third cluster of terms is related to the student. "Commenting" is within the province of student activity. "Control of learning" provides the link between intentional learning and the student because the main objective of intentional learning is to enable students to take more control over their learning.

4. The term "knowledge construction" also provides a set of connections that lead to the construction of knowledge structures: active, higher order questioning, and high level learning. "Knowledge

construction" is also at the top of the map, all paths lead to knowledge construction, the goal of intentional learning.

Overall, the experts' map shows more of a web–like structure than either of the class' maps.

Table 2
Connections in the Experts' Map

active	3
boring	2
collaboration	1
commenting	1
control of learning	2
goals/plans	1
high level learning	2
higher order questioning	2
intentional learning	7
interesting	2
knowledge construction	3
low level learning	2
lower order questioning	2
passive	1
student	3
student initiative	1
teacher	1

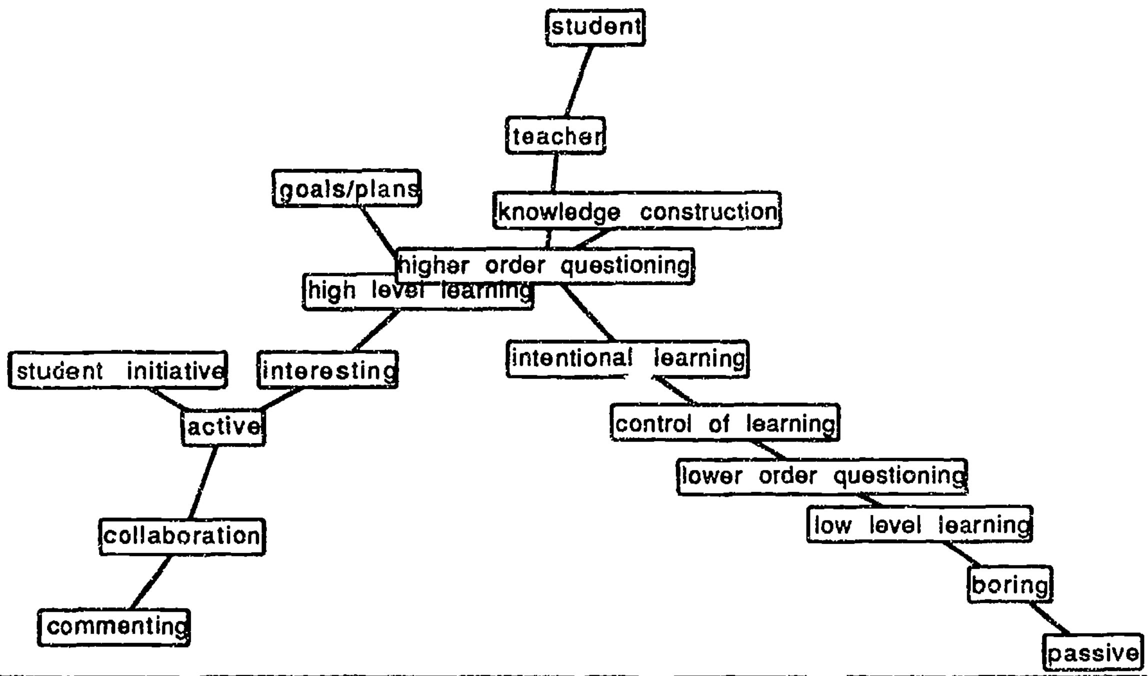
Class Observations: First Map

In general, the first class map, generated after reading two articles and two class discussions, does not show any "mistakes," but it does shows a lack of sophisticated understanding of the concepts and how they interrelate. This unsophisticated understanding is most apparent in the lack of any central focusing concept, such as intentional learning in the experts' map and in the linearity of most of the relationships.

1. The most connected concept in the class' first map is higher order questioning (see Table 3). Questioning was one of the most discussed concepts in the Scardamalia and Bereiter articles so, it seems logical that they would focus on this concept.

2. The class was composed of mostly teachers. This is reflected in the knowledge construction" – "teacher" – "student" path. This infers that the student constructs knowledge through the teacher. This indicates a lack of understanding of the purpose of knowledge construction environments and intentional learning in turning control of learning over to the student.

Figure 2
First Map Produced by Class



3. "Intentional learning," the most central concept of the experts, was related to "higher order questioning" and "control of learning," but did not form the basis of the class' first map.

4. The concepts of "commenting" and "collaboration" were related to "active," but there was no direct connection to "intentional learning." This indicates that these concepts were understood but the relationship to intentional learning was not complete.

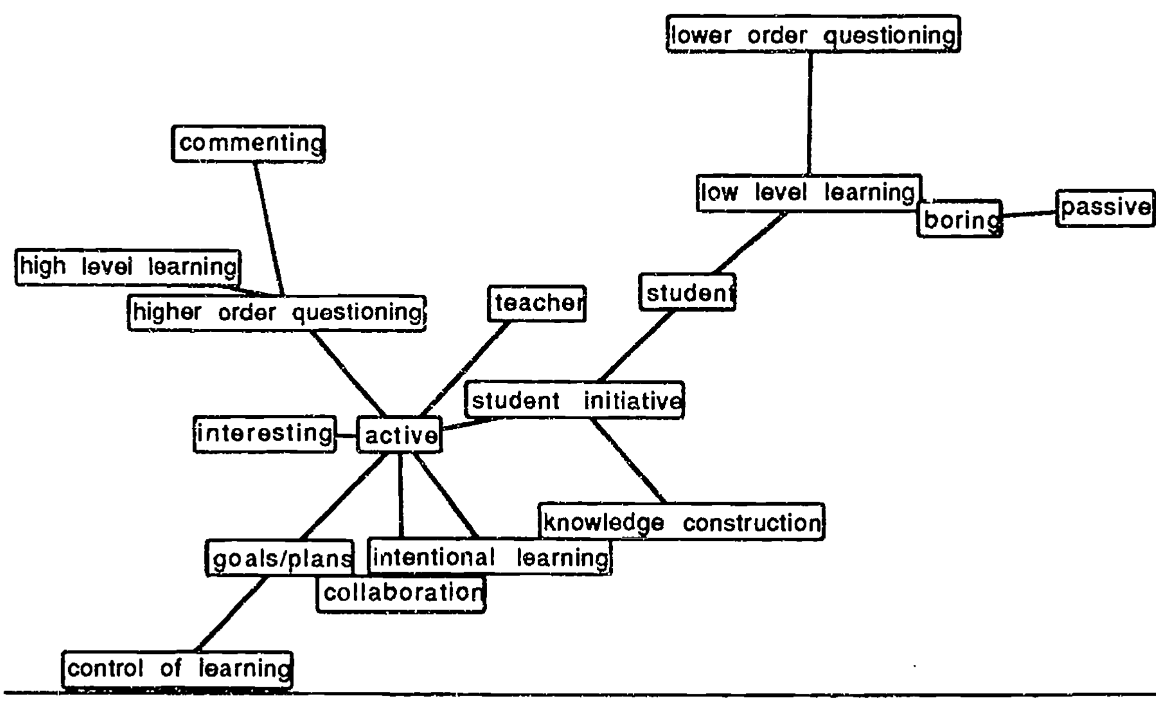
All–in–all, the first class map shows an understanding of the concepts as individual terms, but it shows a lack of depth and lack of understanding about how the concepts interrelate. For example, all kinds of questioning lead to knowledge construction, but in the class' first map "knowledge construction" is associated only with "higher order questioning."

Table 3
Connections in the Class' First Map

active	3
boring	2
collaboration	2
commenting	1
control of learning	2
goals/plans	1
high level learning	3
higher order questioning	4
intentional learning	2
interesting	2
knowledge construction	1
low level learning	2
lower order questioning	2
passive	1
student	1
student initiative	1
teacher	2

Class Observations: Second Map

Figure 4
Second Map Produced by Class



1. The word "active" forms a central focus point for the concept relationships. Active has seven direct connections (see Table 4): student initiative, intentional learning, collaboration, goals/plans, interesting, higher order questioning, and teacher. The concepts connected to "active" are the main attributes of learning environments and intentional learning. The word "active" is central because this reflects the students' point of views and experience. They were active in questioning and collaborating and developing goals and plans. Whereas the experts place intentional learning as the central concept because it is the basis of the knowledge construction strategy.

2. The word "commenting" shows a change in conceptualization. In the second map it is related to "higher order questioning." This demonstrates a more sophisticated understanding of commenting, because it is an integral part of the questioning strategy in a CSILE.

3. The cluster related to "low level learning" shows a slight change from the first map also. In the first map, the class simply associated those concepts together in a long chain. In the second map, the students refined their definitions, associating "lower order questioning" with "low level learning," but separating "boring" and "passive." This indicates a greater understanding of the questioning process, that lower order questions lead to low level learning but are not necessarily boring or passive.

4. Another difference between the first and second maps is the position of "control of learning." In the second map, control of learning is related to goals/plans, again demonstrating a more refined understanding of the meaning of control of learning.

5. The second map still reflects some immaturity. For example, "knowledge construction" is related to "student initiative," but to nothing else that leads to knowledge construction, such as higher order questioning, collaboration, or intentional learning.

In sum, the class' second map is less linear than the first. It shows that after working with CSILEs, the class has a better idea of the interrelationships among the concepts and a deeper understanding of the topic of intentional learning. They have formed a more sophisticated knowledge structure of the concept.

Table 4
Connections in the Class' Second Map

active	7
boring	2
collaboration	1
commenting	1
control of learning	1
goals/plans	2
high level learning	1
higher order questioning	3
intentional learning	1
interesting	1
knowledge construction	1
low level learning	3
lower order questioning	1
passive	1
student	2
student initiative	3
teacher	1

Conclusion

Discovering the effectiveness of collaborative learning environments using recall measures is a fairly basic task. However, examining the effect of those environments on thought processes is much more difficult because it involves inferential methods. One of these methods is the use of maps representing the perceived relationships between several pairs of concepts associated with a specific topic using pathfinder or multidimensional scaling techniques. This study examined the effect of working within a computer supported learning environment on the participants' knowledge structures. The findings indicated that after working with the learning environment the participants' knowledge structures became more complex and sophisticated.

These results must be utilized carefully, for the basic findings are dependent upon observation and visual analysis instead of probability levels. Reasons for the changes in the knowledge structure are speculations based on observations rather than on testing data. However, the differences among the three maps compared are striking. The next step, then, is to utilize additional measures to see if the complex visual representation of the knowledge structure can be associated with performance in real-world tasks. For example: does a complex knowledge structure mean that a person may be able to use the knowledge represented in a more flexible and sophisticated way? Further information is also needed to explain the difference between the expert's map and the complex learner's map. Why is it that the learners had a different focus point in their map? The use of the maps to identify learner progress in creating knowledge structures seems to provide a promising new way of evaluating the effectiveness of instructional techniques.

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KNOT–Mac: Knowledge Network Organizing Tool for the Mac
Interlink, Inc., P.O. Box 4086 UPB, Las Cruces, NM 88003-4086

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Selected Abstracts for the

Special Interest Group for Health and Medical Education (HESIG)

HESIG

Using Multimedia to Provide Information About Childhood Cancer to Elementary Grades

Ida Flynn, University of Pittsburgh

This showcase will allow users to access information about childhood cancer from a multimedia interactive information retrieval system designed and developed for elementary grade students.

This videodisc contains 30 minutes of selected segments from the special taped developed by Family Communications and the American Cancer Society; its format is visual and audio intensive. The computer's hard-disk contains a factual database related to specific childhood cancers and their treatment information on support groups and a list of children's books available in local public libraries. The interface between the two databases gives users control in retrieving discrete chunks of information, from either database, based on their current needs. Specific search paths can take users from one database to the other via existing links created in the interface and activated by mouse clicks. Users may look at the same segment, from either storage medium, as often as needed. They may jump back to a previous segment or forward to a new one within a matter of seconds.

It is hoped that viewers will be interested in evaluating the retrieval system and volunteer their ideas and suggestions on its design and contents.

Computer-Assisted Learning - Tools vs. Appliances

John A. Mack, XR Data Systems

Since the initial excitement generated in the 1960's by the potential for computer usage in education, virtually all computer-assisted learning materials have been produced by content experts for use by individual learners. Although the person-hour cost of an hour of courseware had remained remarkably constant, computer technology has changed dramatically. Thousands of computers have become millions, and they are nearly as accessible to end-users as paper and pencil.

Although hypertext, personal information, or text base management programs may be useful for organizing knowledge, it does not follow that they would be particularly useful as tools for learning; an important characteristic of educational software is that it is intended to put something into the memory of the **learner** (not just into the memory of the computer). The high person-hour cost of courseware suggests that, in order to be useful, authoring tools for learners are likely to be quite different from authoring tools for teachers.

A package of programs (X-CAR) will be described which supports computer usage by an individual learner with an arbitrary, self-defined, and evolving knowledge base to:

-manage that knowledge base,
-produce courseware appropriate to that knowledge base, and
-manage the use of that courseware to achieve self-established goals of proficiency.

Student Access to Hospital Information Systems: Problems and Approaches
Cynthia M. Mascara and Ramona Nelson, University of Pittsburgh Medical Center

Students in health care disciplines learn to care for patients through contact with actual clients. Like all health professionals, they use the patient's medical record. The introduction of computerized patient records is limiting their access to vital patient information.

The University of Pittsburgh Medical Center and the University of Pittsburgh School of Nursing piloted a project providing fifty-five nursing students with access to the hospital information system (HIS). The major issues and potential approaches to providing student access were grouped into five areas. These include:

1) **Level of Access** - Students may be given the same access as professionals or a more restricted access.
2) **Student Instruction** - Instruction may be provided by hospital employees or school instructors.
3) **Teaching Approach** - Lecture, demonstration, hands-on experience, self-learning techniques or a combination may be used.
4) **Data Security** - Generic student access or personal access codes may be used.
5) **Evaluation** - Techniques for evaluating student learning and benefits of access must be developed.

This project demonstrated that cooperative planning and careful evaluation of issues and potential solutions is imperative when providing short-term student access to automated patient data. This pilot has been instrumental in planning HIS access as a routine component of health care at UPMC.

Clinical Nursing Experience in Labor and Delivery Via Interactive Video
Dee McGonigle, Pennsylvania State University

Interactive video can augment, enhance, and even replace clinical nursing education depending upon the learner's needs. The clinical area of labor and delivery is an educational challenge; providing students with clinical experience is difficult. The time spent in labor and delivery is limited and the variety of births observed is not predictable. The presenters, are nursing researchers who obtained grant monies and developed an independent learning module in which all of the nursing students receive the same labor and delivery clinical experiences via interactive video. This learning modality is applicable to generic students, returning registered nurses seeking baccalaureate degrees, graduate nursing students, and nurses currently working or seeking positions in this clinical setting. Utilizing this technological learning modality will enhance the students' experiences and ultimately improve professional practice and client care. This presentation will review the grant guidelines and proposal. The pilot program design will be explored with a focus on the targeted research areas. A video presentation of the pilot program will be assessed and the evaluation procedures reviewed.

Selected Formal Papers from the

Special Interest Group for Health and Medical Education (HESIG)

Faculty-Student Teams Develop CBL Software

Anthony J. Frisby, Ph.D.
Rodney B. Murray, Ph.D.
Thomas Jefferson University

Abstract

The Summer Computer Fellowship Program (SCFP) was established by Jefferson Medical College in 1984. The primary objective of the fellowship is to provide an opportunity for faculty and students to learn about the use of computers in medical education and to produce computer programs that could be used by future students as part of the curriculum. Competition for the fellowship program is open to any medical student upon completion of their freshman year.

Faculty preceptors who have submitted proposals for educational computer projects (also accepted on a competitive basis) are then paired with a fellow. The teams spend the next ten weeks working on computer based learning (CBL) programs. The Office of Academic Computing (OAC) provides guidance in instructional design and educational principles, as well as programming assistance.

The development of effective, attractive, and high quality instructional programming, is a time consuming and difficult undertaking. The SCFP students work hard to develop instructional programs that meet the needs of Jefferson's medical students. During the past eight years the SCFP has produced a wide variety of programs, many of which have become a significant part of the curriculum. The SCFP continues to provide CBL for medical and allied health students.

Summer Computer Fellowship Program

The SCFP was established at Jefferson Medical College in 1984 to give faculty and students an opportunity to learn about the use of computers in medical education and to produce computer programs that could be used by future students as part of the medical curriculum. Medical students who have completed their first year are eligible to apply for the fellowship and are selected on a competitive basis.

Faculty members interested in participating and developing a CBL project submit proposals to the OAC which reviews and selects them based on several criteria. Among those criteria are: feasibility (is this a project the fellowship can accomplish); usefulness (are the end users likely to use the program); and need (has a program already been produced that would likely fit this need). Fellows are then paired with faculty preceptors and the resulting teams work together for ten weeks.

In the past, the students have provided much of the computer expertise and performed the bulk of the design and programming of the CBL projects. Recently though, more of the faculty preceptors have been returning to the SCFP to produce additional programs or to enhance a previous version.

With each successive year, the amount of personal experience in computing has increased among the participating faculty members. This increase, along with the significant improvements in authoring tools and peripheral devices have permitted the development of several marketable programs.

Since 1984, thirty-three faculty and sixty students have participated in the SCFP. Forty-six different projects have been worked on of which 19 are in use at this time. Twelve (36%) of the faculty have participated more than once. A listing of programs or research areas appears in Appendix A.

There are a number of factors that affect the current use of those programs developed. First, not all the teams had the goal of developing a software application. In other instances, the program was never finished. Failure to complete a program was usually because the student ran out of time and couldn't finish it during the school year, or the faculty member no longer was interested in it (or moved to another institution).

Process

The SCFP runs for approximately 10 weeks, meeting as a group regularly. In that time we introduce the students to the fundamentals of instructional design, provide an orientation to computers (if necessary), and teach an authoring language, programming language, presentation or research tool. With these skills the students and preceptors work on their projects, the OAC providing technical assistance and equipment resources. Periodically during the 10 week program students will demonstrate their programs to the whole group to critique and share ideas.

Realizing that 10 weeks is a very short time to develop a viable piece of CBL, we've structured the program to optimize the time available. The first two weeks are formally structured, providing lectures and materials on instructional design and tutoring on an authoring (or other) language. Students are expected to spend at least eight hours a day working on their projects. Starting with the third week, we meet twice a week to discuss any problems, concerns, and new insights.

Conclusion

This year, 1992, marked the eighth anniversary of the computer fellowship program. After each summer, a short evaluation has been conducted to assess the overall feeling regarding the SCFP. Both faculty and students strongly agree that the SCFP is a useful and enjoyable experience. They agreed that the program helped increase their knowledge of computers and their use in medicine. Most agreed that they had produced a useful program.

The support and positive feedback have encouraged us to pursue continued funding for the program. Jefferson remains committed to the computer fellowship program and the important role computers play in education, practice and research.

Appendix A

Summer Fellowship Program Projects

1984

Q&A Respiratory Histology
Tutorial on Abnormal Karotypes
Disease Model for Patient Simulator
Database of Review Questions in Biochemistry
Self-Study Guide for Computer Novices
Translate Case Study (basic to pilot)
Tutorial/Simulation on Pediatric Poisoning

1985

Multiple Choice Anatomy Review
Diagnostic Database for Expert System
Patient Simulation Authoring System
Videodisc Control Programs
Review Questions on Carbohydrate Metabolism
Health Screening Tutorial/Simulation
Tutorial on Sensitivity, Selectivity and Predictive Value of Lab Tests

1986

Muscle Attachment Tutorial
Tutorial - Adult Immunization
Tutorial - Respirator Mechanics
Continuation of Tutorial on Lab Tests
Tutorial - Facial Dysmorphism
Natural Language Q&A in Gross Anatomy
Tutorial - Computerized Medical Record
Authoring Program for Videodisc Programs

1987

Case Simulation for Emergency Medicine
Patient Management Problem: Alcoholism
Explore use of Video in Teaching Microbiology
Tutorial & Cases on Neurology
Authoring Program for Videodisc Quiz
Automated Pediatric Physical Exam Entry

1988

Tutorials: Interview Substance Abuser
Histology Tutorials
Clinical simulations OB/GYN
Spinal Injury
Promoting Health in Medical Practice
Tutorial/Reference in Psychological Development
Electrical properties of cell membranes

1989

Diagnosing Substance Abuse
Pathology of Inflammation
CAI-V Histology Tutorial and Quiz
Geriatric Curriculum Project
The Gross Project
Cardiac Pathology
Child & Adolescent Behavior Eval.

1990

Antibiotics Guide (3 modules, 3 students & 3 faculty)
The Gross Project
Histology Tutorials

1991

Histology Quiz Maker
Diagnostic Problems in Child Development
Pathology Quiz Bank
The Gross Project
Diabetic Patient Education
Skeletal Muscle Contraction
MECCA
Microbiology Guide Notes

1992

The Gross Project/A.D.A.M.
Simulations in Microbiology
Q&A Pathology
Q&A Histology
Tutorial - pH
Intudcution to Ophthalmology

GUIDELINES FOR DESIGNING EFFECTIVE AND HEALTHY LEARNING ENVIRONMENTS FOR INTERACTIVE TECHNOLOGIES

Michael Weisberg, National Library of Medicine

ABSTRACT

Many of the findings from ergonomics research on visual display workstations are relevant to the design of interactive learning stations. This paper briefly reviews ergonomics research on visual display workstations; specifically, (1) potential health hazards from electromagnetic radiation; (2) musculoskeletal disorders; (3) vision complaints; and (4) psychosocial stresses. Based on this review, guidelines on how to design an ergonomically correct workstation and learning environment are presented. These guidelines seek to balance human performance with learner satisfaction and well-being.

1

INTRODUCTION

Technological advances in recent years have led to the prevalence of computer and other electronic technologies in the everyday lives of people-at play, at work, in the home and in school (Forester, 1989; Fox, 1989; Postman, 1992). Recent technology innovations include the "Personal Digital Assistant" (Linderholm, 1992) and the inchoate fields of cyberspace (Gibson, 1984; Benedikt, 1992) and virtual reality (Rhiengold, 1991). As technologies insinuate themselves into work, entertainment and learning environments, the interests of broadcasting, publishing, and computer industries intersect and become the focal point for a variety of interactive systems (Brand, 1988). These systems may include visual display monitors, microcomputers, laser discs, various optical disk formats and a plethora of peripherals (Frenkel, 1989). As these technologies become more widely used certain problems are emerging. These problems range from the slightly humorous (the images of frustrated consumers attempting to program a video cassette player to record their favorite television program) to the very serious, e.g., (potential health hazards from electromagnetic fields emitted by visual display devices, and the physical and psychological stress of spending long hours working or studying at computer workstations).

Much research addressing the potential and real problems associated with the design and use of visual display workstations has been conducted. The majority of research has focused on the productivity and health of workers who use visual display workstations: (NIOSH, 1991; Sauter, 1991; EPA, 1990; Klemmmer, 1989; Kilbom, 1988; Zenz, 1975). Numerous guidelines for the design of effective and safe workstations have emerged from this research: IEEE, Spectrum: Special Workstations Guide (1991); NIOSH Publication on Video Display Terminals (1991); Computer Workplace Ergonomics (Gross and Hassel 1991); Herman Miller Research and Design (1991); American National Standard for Human Factors Engineering of Visual Terminal Workstations (1988); Boeing Aerospace Company (1984); Human Factors of Workstations with Visual Displays, (IBM, 1984); and Design of Visual Display Products-Workstation Ergonomics, (IBM, 1988). A somewhat lesser, although substantial, amount has been written about the real or potential problems associated with the design and use of technology in the home (Miles, 1988; Norman, 1988; Bass, 1991). Very little, however, has been written about problems, either potential or real, associated with using visual display technologies designed for use in learning environments (Spangenberg, 1975; Yeaman, 1983, 1984, 1986).

Learning environments, of course, differ from the workplace environment. In the learnplace environment, the measure of productivity is not a unit of work but rather the accomplishment of an educational objective, usually demonstrable in knowledge or performance. The design and implementation of the learning environment is an important factor in achieving educational objectives. Interactive technologies are an important segment of the learning environment; they include the full range of optical formats (laser videodiscs, CD-ROM, CD-ROM XA, CD-I, CD-TV, and DVI) and microcomputers and peripherals that are currently available. Also included are those technologies that are on the horizon and those that can be reasonably anticipated for the near future, such as multimedia systems.

The learnplace environment for interactive technologies has many similarities with the workplace environment for visual display workstations. Among these similarities are such dynamics as: (1) viewing a visual display monitor; (2) using a mechanical device (keyboard, mouse, trackball) or a touch screen monitor; (3) sitting for long periods in awkward positions while interacting with devices and furniture configurations; and (4) performing under stress. Many of the findings from ergonomics research on visual display workstations are relevant to the design of interactive learning stations.

The paradigm and hypotheses guiding research on the effective design and use of visual display workstation technologies were derived from the principles of ergonomics. Ergonomics is an interdisciplinary science that addresses human performance and well-being in relation to the job (task), the equipment, and the environment (Gross and Hassel, 1991). Ergonomics embraces three major concerns: (1) safety and health; (2) comfort and well-being; and (3) productivity and efficiency (Berns and Claridge 1990). The scientific disciplines involved in ergonomics fall under three general headings: (a) engineering and physical sciences; (b) biological sciences; and (c) behavioral sciences, including psychology (Zenz, 1975). These disciplines define the domain for research on ergonomics.

AN ERGONOMIC MODEL

A useful conceptual framework for operationalizing this domain is found in Human Factors, Ergonomics and Usability, (Baker, 1989). Baker describes a "model of work" proposed by IBM (1982) and Baker (1984) that explores the work environment by delineating the relationships among: (a) the individual user; (b) the tools; (c) the workstation; and (d) the job to be performed. With the substitution of "learner" for "user" and "learning/performance" for "job to be performed", this model is easily adaptable to the learnplace. Figure 1. illustrates the model with the proposed substitutions.

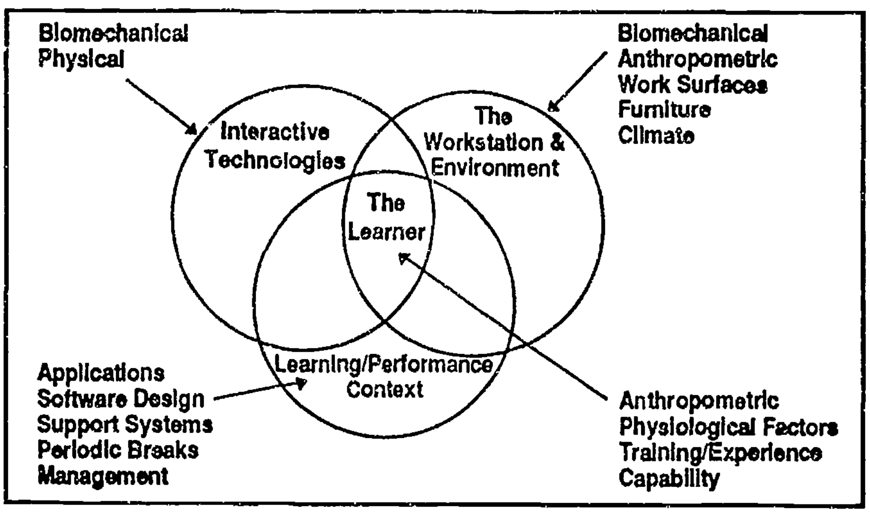

Figure 1.

The model addresses human performance, satisfaction and well-being in relation to the task, the technology and the environment. It suggests interrelationships among the major variables and provides an ergonomic framework for defining and investigating the extent of these relationships.

Much of the recent research on the ergonomic aspects of work with visual display workstations explores the relationships among the major variables as suggested by the IBM (1982) and Baker (1984) model. The lion's share of the research examines the potential health hazards to users from exposure to electromagnetic radiation emitted by visual display terminals. Since 1977, NIOSH alone has conducted thirty-six health hazard evaluations and published seventy-two scientific articles (Sauter, 1990). Other studies examine the effects of video display terminal work on the musculoskeletal and vision systems, and on the general stress level of workers (Arndt, 1984).

The remainder of this paper will review briefly the recent ergonomics research on visual display workstations. Research areas will include: (1) potential health hazards from electromagnetic radiation; (2) musculoskeletal disorders; (3) vision complaints; and (4) psychosocial stresses. Based on this review, guidelines on how to design an ergonomically correct workstation and learning environment will be suggested with the goal of preventing potential health problems and optimizing human performance. These guidelines will seek to balance human performance with learner satisfaction and well-being. The guidelines will enable health professionals to design learning workstations free from such computer workplace problems as musculoskeletal disorders, blurred vision, fatigue, headaches, and the potentially dangerous, extremely low frequency magnetic fields (ELF).

VISUAL DISPLAY TERMINAL HAZARDS

A dichotomy of opinion exists today on the subject of potential health hazards from video display terminals (VDTs). One set of opinions, represented by the public, is informed by popular literature. The other, represented by the scientific community, is informed by epidemiological studies. This makes for an interesting dilemma--the public is worried although the preponderance of scientific evidence indicates no conclusive evidence of harmful health effects from VDTs.

Public concern over the potential health hazards of electromagnetic radiation emitted by visual display terminals was aroused by the publication of several articles in popular magazines and newspapers: (Brodeur, 1990; Borrell, 1990; Infoworld, 1990; San Jose Mercury, 1990; Washington Post, 1990). Some of these articles had very provocative titles: Is Your Computer Killing You, (Borrell) and The Magnetic Field Menace, (Brodeur). These articles drew attention to possible health hazards from very low-frequency (VLF) and extremely low-frequency (ELF) electromagnetic fields emitted by visual display terminals. Magnetic fields, or more specifically, magnetic flux densities historically have been measured with a unit called the milligauss (1 milligauss(mg)= .001Gauss(g) (Feero, 1991). Electrical engineers and physicists use the Tesla as a unit of international standard (Feero, 1991). One

Tesla is equivalent to 10,000 Gauss or 10,000,000 milligauss. The Tesla is used in technical journals and the milligauss unit is used in information for the general public.

Public articles also focused on the concern of European countries, particularly Sweden, with the development of guidelines for radiation emissions from VDTs. It was noted that in 1986 Sweden developed guidelines for VLF magnetic emissions (defined as frequencies between 2kHz and 400kHz, in cycles per second, and that these had been amended in 1990 to include guidelines for ELF magnetic fields (defined as 5Hz to 2kHz to an intensity of no more than 2.5mg at one-half a meter from the monitor)(O'Connor, 1991). This vigilance in Sweden spurred concern in the United States.

Scientific research indicates that video display terminals cause four types of electrical and magnetic fields: (1) an electrostatic field associated with high voltage applied to the internal surface of the cathode screen; (2) a magnetic field of extremely low- frequency generated by the vertical scanning coil; (3) a low- frequency magnetic field generated by the horizontal scanning coil; and (4) a low-frequency electrical field generated by the high voltage flyback transformer (Laliberte, 1987; Marha, 1986). This results in VLF and ELF emissions from the back and sides of monitors. These emissions, therefore, have been the focal point of concern and research.

The National Institute for Occupational Safety and Health (Murray, 1991) reports three specific health problems that are generally attributed to operators' exposure to radiation emitted from VDTs: (1) cataracts; (2) reproductive problems; and (3) facial skin rashes. Both animal and human studies demonstrate that the aforementioned health problems can result from exposure to a high level of radiation similar to the type emitted by VDTs (NIOSH 1991). However, dozens of radiation surveys conducted by NIOSH and independent groups such as Bell Laboratories, Duke University School of Medicine and the University of Washington have not shown any scientific evidence that the occurrence of cataracts, birth defects, miscarriages, or skin rashes is related to radiation exposure from VDTs (NIOSH, 1991). In the final report of An Investigation of Electrical and Magnetic Field and Operator Exposure Produced by VDTs: NIOSH VDT Epidemiology Study by Robert Tell and Associates, it was reported that typical personnel exposures to electric and magnetic fields are: (1) relatively low; (2) within a relatively confined range of magnitudes; (3) not highly dissimilar to exposures commonly encountered from radios and other devices routinely found in the home or workplace; and (4) generally substantially less than any electromagnetic field exposure limits developed for radiation protection purposes by organizations within the United States and many other countries.

NIOSH (Murray, 1991) also addressed the issues of whether malfunctioning VDTs, aging VDTs and the presence of multiple terminals cause increased radiation and therefore poses more danger. It was found that: (1) malfunctions would make a VDT unusable; (2) exposure does not seem to increase as terminals become older; and (3) multiple terminals do not increase exposure.

Charles Reis (1991) tried to put the issue in perspective in an article entitled, Video Display Terminal Hazards: The Other Side of the Controversy. His article was a balanced attempt to review both popular press articles and epidemiological studies conducted by industry, academia, and government agencies. Reis concludes that it is an almost impossible task to draw a sound conclusion on the VDT hazard issue and suggests more research on the long term effects of exposure to VDTs. This is both sensible and prudent. Further research is necessary to determine the long term effects on users from exposure to visual display monitors. Long term studies make sense since children and people of all ages are being introduced to technology and are certain to be exposed to visual display monitors over the long term. This is not to say that liquid crystal displays and other display technologies, which emit no radiation, could not at some future time replace standard cathode-ray tube type monitors and end the dilemma.

The scientific community also supports research on the long term effects of exposure to VDTs. NIOSH supports long term research predicated on the need to accurately measure the levels of radiation exposure for users and to compare these levels to existing occupational exposure standards and to the threshold for biological effects available from epidemiological studies (Murray, 1991).

The question becomes, what should users do until there is definitive scientific evidence that visual display terminals do not pose a long term health hazard. Preventive measures offer a logical solution. The Swedish guidelines, which are also recommended by the Institute of Electrical and Electronics Engineers, Inc., are a good general reference point. Recent studies of some commercial monitors found that field strength diminishes with distance and that it is generally below 1 milligauss at 76 cm from the monitors front and 122 cm from its sides and back (Spectrum, 1991). This finding is consistent with information reported in the Brodour (1990) article appearing in MACWORLD. Taken together, these findings suggest that the user is exposed to ELF levels of less than 1 milligauss when sitting 29 inches from the front of the display and 4 feet from the sides or back of the display. And since an office partition will not shield users from ELF emissions, workspaces should be designed so that no one in an adjoining area is within 4 feet of the sides or back of a monitor in someone else's work area (Spectrum, 1991).

It should be noted that there have been some false claims that anti-glare screens reduce low level magnetic fields. When properly grounded, anti-glare screens reduce electrical emissions but they do not significantly reduce low-level magnetic fields (Branscum, 1990). Magnetic field elimination or reduction through shielding requires use of high permeability materials (Laliberte, 1987). According to Laliberte, shielding against magnetic fields has been obtained by adding a semi-transparent, high permeability filter to the screen. Some monitor manufacturers have resorted to various shielding or cancellation techniques for reducing magnetic emissions. Although these efforts are represented by only a few large companies (IBM and SuperMac), an after market appears to be developing (O'Conner, 1991) and a recent advertisement in Monitor Radiation News (Vol. 1., 1991). This development has the ironic effect of perpetuating concern about radiation while simultaneously providing preventive measures.

MUSCULOSKELETAL DISORDERS IN A VISUAL DISPLAY ENVIRONMENT

Musculoskeletal disorders represent a complex phenomenon. Within the context of computer work environments, the individual disorders themselves are complex and represent a wide array of conditions that are commonly referred to as cumulative trauma disorders (CTDs) or repetitive strain injuries (RSIs). Research shows that computer work and the design of the workstation can interact to amplify the risks of musculoskeletal disorders such as carpal tunnel syndrome and other cumulative trauma disorders. Statistics on organizations where computers and keyboards are essential for productivity illustrate increasing numbers of carpal tunnel syndrome and repetitive stress injuries in both the United States and the United Kingdom (Mallory and Bradford, 1989; Hill, 1989). This reportedly has led some companies to spend millions of dollars on medical treatment, ergonomically correct equipment, training and legal expenses (Minter, 1989).

Because of the complexity of these disorders, however, and the methodological limitations of the studies investigating them, their etiology cannot be attributed solely to the visual display workstation environment (Sauter, et. al., 1991). Herman Miller Research and Design (1991) corroborate the complex nature of CTDs by organizing risk factors into three general groups: (1) ergonomic stresses; (2) psychosocial stresses; and (3) physiological predispositions. The dynamic interrelationships among these factors is brought home again by a recent report by NIOSH (Swaboda, 1992) showing that psychological factors such as job insecurity, work demands and electronic monitoring contribute to musculoskeletal disorders among VDT users even when preventive ergonomic measures are implemented. Etiology is further complicated by chronic pain syndromes (Kusack, 1990). Therefore, caution must be used in attributing the causes of such injuries. Nevertheless, adequate research evidence exists to justify a systematic examination of the ergonomic aspects of work environments in which mechanical input devices, such as keyboards (QWERTY), mice and trackballs are in use. Each of these devices forces users to make repetitive, small movements that over time can cause RSIs (Hurty, 1992).

A major comprehensive study of workstation design and musculoskeletal discomfort within the context of a visual display terminal data entry task was conducted by Sauter and others (1991). The primary objective of this study was to clarify the contribution of workplace ergonomic factors to musculoskeletal problems among VDT users. The study objective had special significance given statistical evidence pointing to the increased incidence of musculoskeletal disabilities among VDT workers in the United States (Eisen and LeGrande, 1989; Pasternak, 1989; NIOSH, 1990). Study methodology attempted to overcome limitations of previous studies which led to discrepant findings of the association of ergonomic factors and musculoskeletal problems. Emphasis was placed on: (1) objective assessment of work postures; (2) reclassification of continuous data on working conditions and discomfort into categorical variables for analysis; (3) use of multivariate statistical techniques; and (4) adjusting for biodemographic factors.

The study findings provide support for the emerging data on outbreaks of musculoskeletal disorders among VDT users that point to the vulnerability of upper extremities--the hand and the wrist in particular. The authors concluded that the study findings: (1) served to reduce the uncertainty regarding the contribution of ergonomic factors to the etiology of musculoskeletal problems; (2) suggested workstation configurations that will minimize these problems; and (3) improved the definition of the regional pattern of musculoskeletal problems among VDT users. Among the suggestions for environment and workstation design were: (1) low placement of the keyboard; (2) avoidance of low compressible seats to prevent leg discomfort; (3) preference for an erect sitting posture and backrest height adjustments; and (4) physical exercise during work and frequent rest breaks.

Most of the general information articles citing musculoskeletal disorders in VDT workstation environments focus on carpal tunnel; however, other musculoskeletal problems are also associated with VDT workstations. A comprehensive list would include such disorders as tendinitis, tenosynovitis, trigger finger, gamekeeper's thumb, Guyon's canal syndrome, epicondylitis, cubital tunnel syndrome, low back pain, and others (Herman Miller, Inc. 1991). What these disorders appear to have in common is a work environment characterized by: (1) awkward positions; (2) localized pressure; (3) holding a static position without movement; (4) excessive use of force or strength; and (5) repetition without rest breaks (Herman Miller Research and Design, 1991).

Several studies cited in Herman Miller (1991), associate awkward wrist positions with CTDs. Users of keyboards, computer mice and trackballs are susceptible to awkward wrist positions. Keyboard computing-related CTDs are the result of pressure changes in the carpal tunnel caused by many repetitive movements made while the wrist is vertically deviated outside of neutral range-either in a position of flexion (bent such that the palm is lower than the wrist joint), or extension (bent such that the palm is higher than the wrist joint) (Marras and Schoenmarken, 1991). In this case the major postural risk factors are wrist extension/flexion and the acceleration of extension/flexion hand movements (Proformix-Research Update #002, 1991).

To minimize this risk and practice safe keyboarding, it is universally recommended that wrists be properly supported in a neutral position with minimal flexion and extension. Alternatives to the flat keyboard might also provide a solution. Several alternative keyboards split the keys into left-hand and right-hand groups, aiming them inward to reduce bent wrists. Others crack the keyboard in half, creating a tent shape eliminating the forearm rotation required for standard keyboards. Unfortunately, these alternatives are presently prototypes and are not available (Buesen, 1984; Hobday, 1988; Zipp, 1981).

Mice and trackball devices are beginning to attract the attention of ergonomists. Since these devices involve small, repetitive movements that have a cumulative effect, they also are looked upon as a source of repetitive strain injuries. Given their recent introduction compared to the computer keyboard, however, there is scant ergonomic information (Whitefield, 1989; Herman Miller, 1991; Hurty, 1991). Because many mouse users rest their forearms on their work surface and move the mouse around through wrist movements they create a side-to-side bending of the wrists which can potentially cause CTDs. In the case of the trackball, the role of the thumb is an important consideration. The thumb's limited freedom of movement is well suited for side-to-side grasping actions but makes it a poor choice for controlling up-and-down or circular motions (Hurty, 1991). Touch screens also deserve attention. Touch screens are appealing input devices for a number of reasons: (1) users point directly at an object; (2) they require little or no training; (3) they are faster than other pointing devices; and (4) no extra work surface is required. The down side to touch screens involves arm fatigue, callouses on fingers with heavy use, smudges, optical interference and increased glare.

With all these devices, as well as with the keyboard, it is important to address the broader issue of overall workstation design to ensure prevention of musculoskeletal injuries. In as much as musculoskeletal injuries are influenced by workstation design and the interrelationships among psychological stresses and physiological predispositions, it is crucial that studies on etiology be implemented as controlled experiments. These studies should have valid experimental methodologies and should be followed-up by case control and prospective studies performed on ergonomic interventions in actual work settings (Sauter, 1991).

Lab and field studies should also be developed to provide practical data on specific ways in which preferred individual adjustments of workstations differ from the recommended standards. Some recent studies have shown that individuals prefer adjustments that differ from the standards (Jaschinski, 1988; Sauter, 1991). Standards are not meant to be monolithic. Professional ergonomists and users should work together towards the goal of developing equipment and workstations that allow the user maximum flexibility to customize the configuration.

VISUAL DISPLAY TERMINALS AND VISION COMPLAINTS

In a recent survey conducted by the American Optometric Association, eyestrain, headaches, and blurred vision were ranked as the top three vision complaints associated with the use of VDTs (Sheedy, 1992). Visual fatigue and double vision have been reported by other surveys. Studies are divided, however, on the issue of whether VDT use directly causes increased visual problems.

Research distinguishes between visual causative factors (specific diagnosable visual disorders that an individual has) and environmental causative factors (specific factors in the design of the VDT, the workstation and the environment) (Sheedy and Parsons, 1990). It must be noted also, that an individual's visual problems may be due to a single cause or a combination of causes. Since it is duly noted that: (a) individual predispositions have an effect on visual problems; (b) problems can have one or more causes; and (c) separating out predispositions from environmental factors is a daunting prospect, it will suffice to simply delineate some of the environmental factors that are amenable to change and that may influence vision complaints.

The major environmental problem involves lighting. Florescent overhead lighting is the norm in most offices. This results in 100-150 ft. candles of illumination on desk surfaces. This level greatly exceeds the 18-46 ft. candles recommended by the ANSI Standard (1988). Because desk and reference documents are significantly brighter than the VDT screen, adaptation problems may occur as the result of the users having to move their eyes back and forth from brightly lit documents to the screen. Another source of eye discomfort is glare off the screen caused by bright lights in peripheral vision (either from florescent lights or bright outside light). These problems can be alleviated by turning off some overhead lights, drawing blinds or shades or moving the VDT, perhaps recessing it so that it is lower than the desk surface. Reflections on the screen can also interfere with resolution and contrast. Glass anti-reflection screens are a good solution and are preferred over mesh screens. VDTs with dark characters on white background provide better resolution. A screen refresh rate of at least 60 Hz (German health regulations require 70 Hz) is preferred. A lower refresh rate creates screen flicker which may cause eyestrain and headaches. For optimal viewing of the screen, the screen height should be adjusted to 10-20^0 below the user's eyes. This range appears to alleviate neck and back ache as well as dry irritated eyes and contact lens difficulties because of decreased blinking (Sheedy, 1992).

Adult learners working with VDTs are faced with a special problem. The loss of eye focusing that invariably accompanies advancing age (presbyopia) requires special prescription lenses for the adult population (Sheedy, 1992). In the Sheedy (1992) survey, thirty percent of all VDT patients received prescriptions for bifocals and nineteen percent for trifocals. Bifocal and trifocal users may experience neck and back problems in addition to vision complaints as they attempt to accommodate two or three visual focal points. The author can attest to this special difficulty, having word processed this paper while wearing trifocals.

The American Optometric Association estimates that among the seventy million eye exams a year, ten million patients obtain eye exams because of problems with VDTs (Sheedy 1992). Thirty-seven percent of these complaints are attributed to environmental visual factors such as lighting, poor screen resolution and glare. Neck and back ache are also reported with these vision complaints due to high VDT placement.

VISUAL DISPLAY TERMINALS AND PSYCHOSOCIAL STRESSES

The recent NIOSH study (Swoboda, 1992) linking job stress to VDT physical injuries reinforces the ergonomic perspective of the dynamic interplay among the worker, the job, the workstation, and the environment. As reported in the Washington Post (July 21, 1992) the NIOSH study was conducted at the request of US West, Inc. and the Communications Workers of America Union. The study reported that musculoskeletal disorders occurred among VDT workers even in situations where ergonomic precautions where implemented by employers to protect them. Even when preventive workstation designs were implemented, psychosocial factors apparently influenced the development of musculoskeletal injuries. This finding has caused leaders at US West to view management's treatment of workers as equally important to an injury free environment as the equipment and the workstation.

Earlier studies (Sauter, 1981; Smith, 1983; Arndt, 1984; Sauter, 1984) reported on the general stress levels caused by the introduction of automated technology in the office; specifically, the visual display terminal. These studies did not look for the effect of psychosocial (organizational or social environment) stresses on physical complaints of VDT users. Like the previous subjects discussed, it is difficult to demonstrate a cause and effect relationship from the research. However, it is informative to review the results of a major ergonomic intervention study conducted at Federal Express Company.

A report of this ergonomic intervention was presented as a case study by Allen Westin in Promoting Health and Productivity in the Computerized Office: Models of Successful Ergonomic Interventions (1990). By 1983, Federal Express had 8000 VDTs in use throughout the organization. Federal Express's Director of Human Resources Analysis established the proactive view that the issue of VDT use was not a narrow ergonomics issue involving only equipment and workstations. He expanded ergonomics to include job design, work-group relations, employee education and manager training. Through surveys and interviews, management staff discovered that employees perceived a direct relationship between job stress, VDT work, and their health. With this information, Federal Express developed a "corporate ergonomic standard" to ensure the health and well-being of those whose work environment involved video display terminal use. In 1990, Federal Express had 52,300 VDTs and an additional 3000-4000 stand-alone PCs.

The pay off from this forward-looking approach has been no reported cases of repetitive strain injury at Federal Express despite their intensive and extensive VDT use. There have been fewer than six stress related claims by VDT users filed under worker compensation in the past five years. The model implemented at Federal Express should be reviewed by other companies or groups as a potential approach for preventing psychosocial stresses from contributing to the development of musculoskeletal disorders among VDT users.

Other ergonomic interventions have reported similar positive results (Sauter, et al. 1990). Ergonomics in these interventions was broadly defined, as in the Federal Express case, to include: (1) equipment and workstation design; (2) job design; (3) work-group relations; and (4) education of employees and training of staff. The interventions reported show a matrix of effects suggesting significant health and productivity gains from the effective application of ergonomics in the VDT workplace. These studies also demonstrate dramatic productivity increases in the range of twenty percent resulting from ergonomic improvements in the design of job, and the workplace. A concomitant increase in worker satisfaction and a decrease in somatic complaints were also reported. Absenteeism, turnover, sick leave and compensation claims were also in decline.

CONCLUSION

New interactive technologies present a challenge and an opportunity for designers of learning environments. This paper has touched upon several of the major variables that influence the design of safe and effective visual display learning environments. An ergonomic model was presented as an organizing concept for defining the domain of ergonomic variables relevant to the study of learning environments. Research on ergonomics in the workplace was reviewed with the goal of deriving relevant guidelines for designing learning environments for interactive technologies. Based on this review, and the perusal of major documents from science and industry on ergonomic standards and specifications, a set of guidelines was presented. It is hoped that these guidelines will be useful to health science educators and administrators.

The application of ergonomics is a complex process that requires careful management. To ensure that standards and guidelines drawn from human factors and anthropometric data are safe and effective for individuals, they must be validated through prospective demonstrations and case studies in "real life" learning environments.

GUIDELINES FOR AN ERGONOMICALLY DESIGNED WORKSTATION

General Workstation Specifications

- o Worksurface depth and width--a minimum depth of 30 inches and width of 48 inches--surface space must allow for efficient organization of documents, papers and other materials relevant to the learning task

- o Worksurface height--if adjustable, between 25.5 and 29.5 inches for effective use of keyboard and mouse--if not adjustable, 28.3 inches as a compromise--option of the keyboard tray below the work surface which places hands and wrists in a wrist neutral position

- o Surfaces should have bullnose edges to avoid sharp corners

- o The keying surface between 23 inches and 28.5 inches from the floor with detachable keyboard--top surface of the "home row" of keys no higher than 2-2.5 inches above worksurface--to allow elbows at 90^0 and arms and hands parallel to the floor--keyboard where thumb joints are located--wrist rests are helpful

- o A mouse and writing platform that are positioned within the primary reach zone and will give hand/wrist support during use

- o Research findings on carpal tunnel suggest options of- an adjustable keyboard tray below the work surface which places hands and wrists in a "wrist neutral" position or the Tony Keyboard that is hinged in the middle reducing pressure on the median nerve

- Interactive and multimedia equipment requires additional space for peripherals such as modems; CD-ROM drives; laser videodiscs; second monitor; and printers--a plan for how equipment will be used will determine space requirements--options include stacking on surface or additional adjacent, above or below moveable surfaces

Visual Display

- Distance between learner's eyes and visual display should be between 18-28 inches to provide preventive measures against the potential hazards from extremely low frequency electromagnetic emissions (ELF)--Swedish National Board for Measurement and Testing g: ʻdelines (MPR-2) and IEEE recommendations--restrict ELF magnetic fields (5Hz-2kHz) to an intensity of no more than 2.5mg (milligauss) at half a meter (19.7 inches) from the monitor

- Acceptable viewing angles range from 0-60^0 from the top of the screen to the home row of the keyboard--preferred viewing angle is somewhere between 10-20^0 below the horizontal--display should be located so that the individual's normal line of vision falls in the upper half of the display

- Monitor should have independent height and angle tilt and swivel adjustments--Glass anti-glare screens are preferred over mesh screens--special glare control screen filters are available to reduce static electricity

- Monitors should be placed at 90^0 angle to windows and never directly in front of windows

- Display should be "flicker free"--refresh rate of at least 60Hz and higher are preferred (German standard is 72Hz)

- Non-interlaced monitors are preferred over interlaced

- Keep monitors clean

Seating (Cited primarily from ANSI/HSF 100-1988)

- Seat height--consensus not available on optimal seat height--ANSI/HSF 100-1988 calls for seat height adjustment of 16 to 20.5 inches--Herman Miller et. al., show that 40% of subjects set their chairs at 20.25 inches or higher--difference points up need for adjustable chair

- Seat depth should be between 15 and 17 inches--it is recommended that seats have a "waterfall" contour just behind the user's knee and underside of the thigh to avoid excessive pressure in this area

- Seat width minimum is set at 18.2 inches

- Seat pan angle when user has feet flat on floor must ensure angle between upper and lower leg of between 60 and 100^0

- Seat pan and pan angle should range from 90 to 105^0

- A seat back rest and lumbar support should be provided--no specific guidelines given

Acoustics, Lighting and General Environment

- Acoustic panels are required for workstations in addition to acoustically treated ceilings--goal is to balance sound from background and adjacent sources

- Ambient or background noise (white noise) is desirable at a level that does not interfere with task performance (between 40-55dba)

- Illuminance sources should be designed and located to minimize glare--illuminance measured in the range of 200 lux to 500 lux on the work area is sufficient

- Task or local lighting may be needed for reading documents or passive light-absorbing displays with inadequate luminance-task lights with batwing lenses provide sufficient light and minimize glare

- A combination of indirect -overhead, natural and task lighting is preferable

- For close-up work light should be directed sideways onto documents to avoid producing glare on monitor--helps prevent eye fatigue and headaches

- Florescent glare can be reduced by replacing plastic prism coverings with grids that break up the light pattern

- Color scheme should be neutral and pleasing to the eye

- Proper ventilation requires about two air exchanges per hour-temperature and humidity should be kept constant with temperature range from 68 to 75^0 F

Multiple Group Learning Workstations

- o Learning stations should be configured so that no individual comes within 48 inches of the side or back of a monitor--corner arrangement prevents extremely low-frequency (ELF) problems--when users face each other, check distance from back of monitor to opposite user
- o Power supply under a raised floor with 4-plex grounded outlets every five feet
- o Information on electrical requirements (watts) per computer and peripheral type should be calculated based on required configurations--information is available in technical specifications from manufacturers
- o Cables, wires, and electrical cords should be channeled with a wire management system built into the workstation panels
- o Separate air conditioning for workstation area with circuits separate from other areas and no mechanical devices
- o For small group work-- a viewing area adjacent to workstations equipped with wall screen and multiscan video projection system for accommodating different monitor scanning rates
- o Small group area convertible into break area with tables and comfortable chairs for relaxation, stretching and change of activities

Psychosocial Harmony Through Training and Exercise

- o Teachers should receive orientation and training with regard to their perceptions of how the technology will be used and their expectations of the learners' behaviors--these expectations should be clearly communicated to the learners and the learners should have an opportunity to acknowledge them
- o Learners should receive proper orientation and training with regard to what behaviors are expected of them in this environment and in addition, they must receive specific instructions on how to operate all equipment and on how to effectively customize the adjustable features of their environment
- o Adequate opportunities should be given for rest breaks and exercise--in addition to brief exercises for flexibility, stretching and strength development, vision aerobics software is available for depth perception, focusing skills, frequent blinking and relaxation exercises

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Selected Abstracts for the

Special Interest Group for Home Economics Education (HOMEC)

Development of an Interactive Multimedia System Presenting Food Safety to Navajo Audiences

Jeanne Gleason, New Mexico State University

Walk in Beauty, Walk in Danger is a touch screen interactive multimedia system presenting safe food storage and handling practices to members of the Navajo Nation. Each system includes a Macintosh computer, customized laserdisc taped on the Navajo Reservation, and computer graphics.

Communications research indicates the users ability to control the pace of the presentation is particularly appropriate for Navajos whose communications style incorporates pauses or silence uncharacteristic of English speakers and who are reluctant to talk with those who are not close acquaintances.

This presentation will cover:
--artistic designs for Navajo audiences,
--impacts of Navajo customs and spiritual beliefs,
--pacing and design of video clips,
--use of Navajo and English audio,
--menu designs and user options,
--information design for varied audiences,
--installation and maintenance logistics, and
--formative and summative evaluation.

The presenter will also cover how to deal with an advisory committee and target audience 400 miles away, and incorporate students into the development process.

Development is funded by the W.K. Kellogg Foundation, the United States Department of Agriculture, and the New Mexico Cooperative Extension Service. Topics covered include safe food storage and food handling, home butchering, cleanliness with limited water, use of commodity foods, and food safety at tribal gatherings.

Selected Formal Papers from the

Special Interest Group for Home Economics Education (HOMEC)

CAD: AN EXPRESSIVE PARTNER, A CHALLENGE, A VIOLIN!

Stephanie A. Clemons, M.S., Colorado State University
Lisa Waxman, Florida State University
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Abstract

The first purpose of this paper is to describe three specific assignments which use CAD to document the design process or use CAD as a design tool throughout the design process. The second purpose is to address common challenges design educators may face as they begin, or continue, to integrate CAD into their curriculum. Care was taken to represent three different design programs across the nation, as well as various computer platforms and software techniques.

Introduction

Throughout time, people have felt the need to express and share their ideas. The advent of the printing press greatly expanded people's ability to share their thoughts, yet the technology of the press remained secondary to the expression of ideas. Today, computers in general, and computer aided design (CAD) systems specifically, seem to dominate as a technical device rather than as a tool for expression. There is a widespread stereotype of computers as machines with which people can only form an analytical, rule-based relationship (Turkle, 1991). Recognizing the computer's second nature as an expressive medium is important for design educators especially since CAD systems have become incorporated into areas typically dominated by designers. CAD systems, with the new graphic software, offers educators an opportunity to assist the students in developing a more subjective, rather than objective, relationship with computers.

The role of CAD, as a technical device, has been fostered in interior design because frequently the initial users of this technology have been technicians, not designers. In many work settings, designers typically created and the technicians entered the results into the CAD system. Computer instruction also fostered this role. Often the goal was to teach systems, platforms, software--hence the technology--rather than teach design applications using the computer as a tool. Our language of "tools" typically revolves around the "best" system, the most "efficient" system, the most "user friendly" system. Current textbooks are written as a self-paced tutorials where the student is given step-by-step instructions on replicating a provided design solution (McLain-Kark, 1991; Wohlers, 1991). For computers to become a design tool, they must be incorporated into the design process with students producing their own ideas.

Background

CAD has become an integral part of interior design education (McLain-Kark and Rawls, 1988). Research has shown there is a relationship between familiarity with CAD and fluency of ideas (Eshelman & Villegas, 1990). Interior design programs are struggling with the integration of CAD into design studios (Inman, et al, 1990). The general use of the computer, as a design tool, is starting to be used in the design process in sophomore studio classes (Jones, 1991). Results from a survey of practitioners revealed that interior designers strongly believe that students should have CAD instruction prior to graduation (Clemons & McCullough, 1989). Educators have responded to this challenge. Research indicates that almost 90 percent of the interior design programs with IDEC members are offering optional or required courses on CAD. In addition, interior design faculty are providing this instruction (Clemons, 1991). The 1990's could be called the "second generation" of computers in design education with CAD no longer used solely as a technical device, but incorporated into studios (ACADIA, 1986). With this ever-changing technology, new problems are cropping up to challenge the time, patience, and skills of the design educator.

Purpose

The goals of this paper are twofold. The first purpose is to describe how three specific interior design projects are being used to document the design process or use CAD as a design tool throughout the design process. The second purpose is to address common challenges design educators may face as they begin, or continue, to integrate CAD into their curriculum. Care was taken to represent three different design programs across the nation, as well as various computer platforms and software techniques.

Design Process

The objectives of the first project, an introductory assignment, was to give students a chance to design a two-dimensional project using CAD as an expressive tool. Each student designed one of the following: entryway/door facade, fireplace/mantel design, piece of furniture, custom area rug, or custom fabric design. Two alternatives to their design were then presented. The process of developing a second design, by modifying the first, encouraged students to explore various possibilities. Many times the second designs were stronger than the first. Seeking out design solutions was simplified with the use of CAD. Students easily made changes and the habit of looking for further solutions enhanced their problem solving skills. These skills carried over into more advanced CAD projects, as well as other studio classes.

The second project was an assignment for a resort hotel design (IFDA Student Competition, 1991). The objectives of this project were to have students develop a comprehensive image package based on an individual concept. The project program included designing a logo, signage package, hotel amenities with logo, uniforms and table place settings including dishes, flatware and linens. Students gained experience using an electronic garment library, electronic color, as well as graphics and word processing programs. The project was very successful in designing and applying an image to a variety of objects. The development and manipulation of color resulted in more refined color schemes on the computer and more accurately rendered color off of the computer. Two of the students were regional competition winners and one received a national honorable mention.

The third project sought to document the design process using a CAD system. Students were given a design problem and were instructed to document their design process by using the "make slide and view slide" command within AutoCAD software. The generated computer slides record the process as the student's design solution evolved. A script file, or mini program, which nests the slides together in an animated documentation is then created. Other possible applications of the script file might be to record all of the students drawings in an individual "animated portfolio" or record student work completed in a semester or year for marketing and accreditation purposes.

Common Challenges

The second goal of this paper is to address common challenges interior design educators may face as they begin, or continue, to integrate CAD into their curriculum. Educators may have to cope with the reliance on computer technicians, providing lab hours for students, working with administrators on behalf of the CAD program, modifying teaching techniques, and educating peers. These hints should be of interest to educators who wish to avoid the areas of stress, frustration and time consuming activities possible with the further implementation of CAD. Discussion of these common difficulties may make other educators aware their problems are not isolated to their class, program or school and will offer possible solutions.

Reliance on a Technician

Historically, manual tools such as the T-square, drafting table and pencil were tools to teach drafting, space planning and communication skills to the student. Today, few educators consider themselves "computer experts" with the capabilities to solve problems inherent to CAD systems. A dependency on the technical expertise of computer technicians is adding a new dimension to developing and teaching courses in which the computer is a tool. Establishing course goals and creating an environment for learning requires foresight and, many times, compromise. Time conflicts, communication, and awareness of each other's responsibilities are challenges for both the educator and the technician to address.

Lab Hours

Rarely do design programs have money to establish and maintain a CAD lab for their exclusive use. Typically, the labs are shared areas between programs, departments and colleges. Because the expense of the lab needs to be justified, the classroom is used for multiple courses. The result is few available hours for students to complete their homework assignments. Solutions some universities have incorporated are combination locks placed on the lab doors for students to use or have provided keys that students are allowed to check out overnight. Others have expanded existing lab hours through departmental donations of student workstudy hours or graduate student hours, to extend the operation of the lab.

Continuing Education

Software and hardware technologies are advanced continuously on a yearly basis. If the design program can afford to purchase available updates, educators are teaching CAD with new software and hardware each year. Who teaches the teacher? Continuing education courses are taught at community colleges. Correspondence courses are available. However, too often, the educator sits with their "nose in the manual" to stay one step ahead of the student. Remaining current on software and hardware is time consuming and somewhat frustrating for the design educator.

Support from Administration

The ability of administrators, deans, department heads and coordinators to operate a computer are variable. Some advocate and encourage design educators to learn the newest technology (Inman, et al, 1990). Some administrators have never used a keyboard, deeming it the secretary's territory. Educating administrators on CAD's unique problems and capabilities can prove to be both a joy and a headache. Unless the education of administrators is handled properly and support is provided, they can become a major stumbling block in the acquisition of hardware, software, and technical assistance for teaching CAD.

Teaching Techniques

Many students take independent study courses on CAD that propel them ahead of the educator's knowledge. A new paradigm for teaching and managing is developing on the business and education horizons. The new paradigm is based on the premise that the "heroic" form of leadership is obsolete, and that "developmental" leadership is the more appropriate model for the future (Tubbs, 1989). CAD classes can be a prime place to practice developmental teaching where the teacher is not the "end all" but acts as a facilitator of the students' learning process. Student mentors in the class can assist in the facilitation and remove some of the minute-to-minute demands students may place on the instructor. This type of teaching style can encourage "design team" skills and assist the student in individual problem solving.

Attitudes of Peers

Many times the educator teaching CAD is the assigned "computer expert" on the interior design staff. They act as a catalyst in spreading information on computer capabilities to other members. Occasionally there is resistance to change from peers. Educators teaching CAD find themselves with unique problems inherent to technology and without the emotional or pragmatic support from peers.

For those individuals, it is critical to develop networks with educators at other schools or with technical support people around campus.

Summary

In summary, CAD systems as a tool should be presented to students as a paintbrush or a violin in which a cultural design can be developed and expressed; rather than a tool like a hammer or chisel, that roughs out the work. By developing assignments where the student is involved in the total design process, a more subjective, enjoyable relationship can be engendered for the student.

Practicing designers are expecting interior design graduates to have skills utilizing the CAD system. Historically, educators have relied on their own skills to teaching drafting and design. With the implementation of CAD, new pitfalls are developing on the educators' horizon. By addressing common challenges, other educators may avoid the areas of stress, frustration, isolation and time consuming activities possible with the implementation of CAD. Solutions are available.

CAD hardware, software and peripheral equipment is changing on a yearly basis. It is difficult for instructors to stay abreast of the new technological advancements. Likewise, it will be a challenge for the students, upon graduation, to remain current on CAD. To support the "learning to learn" premise, projects appropriate for computerization need to be identified within existing course content. It is vital that projects adapted for computer instruction allow for design decision making and not be step-by-step replications of a provided solution. It is the opinion of the authors that teaching students how to use CAD during the design process will have a more lasting effect on the student's education than how to replicate a completed design solution.

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EFFECTS OF PRESENTATION TECHNIQUES
ON CAD WORKSHOP PARTICIPANTS' ATTITUDES

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Abstract

This research investigated whether attitudes, opinions, and behavior held by practicing interior designers toward CAD differed depending on the exposure to a hands-on versus a lecture-style teaching technique. Differences between pre- and post-test for the lecture-style group were found significant for five of the six variables studied. One day hands-on CAD workshops for those just learning to operate CAD were not significant in changing participants' attitudes or opinions. The learning curve may be too difficult for a one-time exposure. However, overall attitudes toward CAD remained positive for both groups.

Introduction

Computer usage is quite common in interior design firms today. Research shows that many benefits can be gained from the installation of a computer aided design (CAD) system (Berghauser, 1986; McLain-Kark, 1986). Favorable attitudes of practicing interior designers toward CAD usage have been shown to be related to the exposure or experience the designer had had with CAD. Past research supports the assumption that educating designers about CAD systems will facilitate a more rapid adoption of the tool into the design field (Clemons & McCullough, 1989).

Eshelman and Villegas (1990) performed a pilot study to test the hypothesis that designers will experience an increase in fluency of ideas as they become more familiar with a new tool--CAD. Their hypothesis was confirmed by the results. From a list of extraneous variables that could have affected the positive correlation between familiarity with CAD and fluency of different ideas, the attitude of the participants toward learning CAD appeared to be the most influential.

The purpose of this research was to investigate (1) whether attitudes and opinions held by practicing interior designers toward CAD differed when exposed to a hands-on versus a lecture-style teaching technique and (2) if their behavior toward CAD usage had modified one year after attending the workshop. A pre- and post-test design was used to assess the results of a hands-on versus lecture-style workshop on designers' attitudes, opinions, and behavior. Results of the study will help evaluate pedagogical techniques used in educating present and future professionals about CAD as a design tool.

Methodology

Sample

The sample was drawn from a mailing list of associate and professional members of the American Society of Interior Designers (ASID) and the Institute of Business Designers (IBD) in Colorado and Wyoming. Industry Foundation (IF) members, educators and press were excluded from the mailing list. Of the 349 designers identified within Wyoming and Colorado, 94 (27 percent) returned a postcard indicating they had never used a CAD system and therefore were qualified to attend. Fifty-two practicing designers ultimately participated in the workshops.

Of the participants, 61 percent were associate members and 39 percent were professional members of ASID or IBD. Seventy-eight percent were female; 55 percent were over 35 years of age. All had completed college or comparable design school training and 57 percent had ten or fewer years of design experience. Most (72 percent) of the designers worked in small design firms with the same percentage of firms having two or fewer staff designers. Sixty percent indicated that their work was at least 50 percent contract design.

Workshops

In May 1989, three complimentary workshops, each one day in length, were presented. Two groups, 19 designers each, participated in a hands-on workshop during which AutoCAD software was used by each participant. One group of 14 designers participated in a lecture-style workshop during which CAD's advantages and disadvantages were presented with demonstrations, lectures, slides and reading material (N=52). Designers were not notified of workshop differences. The registration material identified three different workshop dates. Designers then self-selected the most convenient time to participate in a workshop.

The pre-test was administered at the workshops to all attending designers before presentation of any material on CAD. A post-test was sent one week later and again one year later to assess changes in the variables studied. Results presented in this paper are based on the post-test scores obtained from questionnaires returned one week later except for the variable measuring behavioral changes. The same questions were asked in the pre- and post-tests, with the exception of the designer's background information which was obtained only in the pre-test. The results cannot be generalized beyond this sample but do give some guides for teachers, researchers, and users of CAD.

Variables

Attitude Toward CAD (see Table 1) was measured by asking respondents to check from a list of 12 adjectives, the three which best described their current attitude toward CAD. Seven adjectives represented positive attitudes; five, negative (see Table 2). Each respondent's score could range from +3 (three positive adjectives chosen) to -3 (three negative adjectives chosen. *Present State of Mind Toward CAD* was also assessed by having respondents select three adjectives. Respondents chose those from a list of 17 (seven positive, ten negative) which best described their present state of mind toward CAD (see Table 3). Scoring again could range from a +3 to -3.

The variable referred to on Table 1 as *Rationale for Implementing CAD* consisted of the sum of participants' responses to 14 statements, each providing a possible explanation as to why respondents might not learn to incorporate CAD into their careers or possible problems with its implementation. With responses to each statement ranging on a five-point scale from strongly agree to strongly disagree, a mean variable score was obtained with a score of 5 representing a strong rationale to learn or implement CAD and a score of 1 indicating a strong rationale not to learn or implement CAD.

The subject's *Familiarity with CAD* systems was assessed by asking one question to which participants checked their response as being very familiar (coded as 5) to not familiar (coded as 1) with CAD. Using a scale from five (favorable) to one (not favorable), the designer's *Feelings Toward CAD* were sought by asking each to respond to the statement, "In general, my feelings toward the use of CAD systems in the interior design field is." Responses to the question, "If you were to look for a new job, a firm that used a CAD system would be:" ranged from very important (5) to not important (1) and measured the variable, *CAD's Importance in New Job.*

Advantages of CAD Training asked respondents to check, from a list of eight possible advantages of training on a CAD system for their career, all that they perceived as possible advantages. Scores ranged from 0, if none were checked, to 8. *Behavior Concerning CAD Systems* consisted of five statements from which respondents chose the one best representing their level of knowledge, exposure, or use of CAD.

Findings

Table 1 presents the results of t-tests to determine if mean scores were significantly different following the workshop for hands-on and lecture-style groups. The designers' attitudes toward CAD were positive both before and after the workshops and were not significantly changed by the type of exposure they had had to CAD's abilities. The most frequently indicated adjectives (Table 2) used to describe attitudes toward CAD before and after the workshops were "advantageous," "impressive," and "exciting" with over 60 percent of the respondents checking these adjectives during both time period. No one, either pre- or post-workshop, checked "useless" to represent their current attitude. The largest percentage point change from pre- to post-workshop was that for the adjective "overwhelming," with 29 percent checking this adjective after the workshops compared with 15 percent prior to the workshops.

The mean score of the lecture-style group for the present state of mind toward CAD variable increased significantly in a positive direction from the pre- to the post-test (Table 1). Only one adjective, "untrained," in the pre-test and two adjectives, "untrained" and "favorable," in the post-test had 50 percent or more respondents checking them (see Table 3). However, the same three adjectives--"untrained," "eager," and "favorable"--had the highest percentages of respondents checking them

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during both tests. The largest percentage point change for this variable was from 38 percent of the respondents checking "favorable" before the workshops to 60 percent after the workshops. Respondents were less likely to consider themselves "untrained" (from 68 percent to 50 percent) or "uneducated" (from 30 percent to 13.5 percent) after the workshops; however, fewer stated that they were "eager," and more designers stated that they were "hesitant" after attending their workshop.

The rationale of the lecture-style group for learning or implementing CAD was significantly stronger after the workshop than before; the mean score for the hands-on group remained the same as before the workshop (see Table 1). Twice as many (31 percent) of the participants agreed with the statement, "My career keeps me too busy to learn how to use CAD," after the workshops than before (15 percent).

A key finding was that both the hands-on and the lecture-style groups were significantly more familiar with CAD after the workshops than before. Nevertheless, with mean scores below the mid-point of the familiarity scale, workshop participants realized that they still had more to learn before being completely familiar with CAD.

Feelings about CAD were highly favorable before and after the workshop. Perhaps individuals feeling negatively would not commit themselves to attending a workshop. The mean score of the lecture-style group increased significantly after the workshop. Likewise, the lecture-style group's perception of the importance of CAD in a new job increased significantly following the workshop whereas the hands-on group's perception did not.

As Table 4 indicates, chi square analysis showed a significant difference in the behavior of workshop participants in regard to CAD after the workshops. One year later, each of the 50 percent of participants who initially lacked information about how CAD systems worked had gained some understanding of how CAD worked or had thought about a system for home/work use. After the workshops, 23 percent had thought seriously about obtaining a CAD system, had gotten one, or had decided against it compared with only 6 percent prior to the workshop.

The opinions of participants about the advantages of CAD education for enhancing careers were sought. As noted in Table 5, the possible advantages which were cited by the highest percentages of respondents prior to and after the workshops were: trained for future needs, versatility and credibility within your job, improved communications skills to work with CAD operators, and increased speed at your job. With the exception of increased speed at your job, each statement was cited by a higher percentage of respondents as a possible advantage after the workshops than before. However, the difference was significant only for job security. Over twice as many (44 percent) thought job security was a possible advantage after attending the workshop than prior to it (21 percent).

Discussion

Interior designers occasionally express a reluctance to adopt CAD into their design firms. Today, and in the past, it is common to use lecture-style pedagogical techniques when educating professional designers and educators about CAD systems. Trade shows, professional/education workshops, continuing education credits (CEU's) and in-house training seminars are just a few of the areas where lecture-styles or "show and tell" demonstrations typically take place. This study was conducted with the assumption that designers, given an opportunity for one day to personally operate CAD would experience positive attitude and opinion modifications toward CAD usage. The results did not support that assumption. However, the variable assessing the participating designers' behaviors one year later indicated some positive changes.

The pre- to post-test results reveal that some participants were increasingly overwhelmed by their exposure to CAD. An explanation may be that many times CAD is presented to designers by professional computer personnel as a "magic show." Previously rehearsed demos are typically presented to the designer smoothly and perhaps, unrealistically. Little information is offered concerning the necessary learning curve required to develop design proficiency with a CAD system. Designers assume from the CAD presentations that CAD can be learned quickly and that little time will be sacrificed from their work day. Perhaps their somewhat overwhelmed "state of mind" was a result of the realistic snapshot, offered by this workshop, of the time that must be invested to competently operate a CAD system. Yet despite feeling increasingly overwhelmed, the designers still believed CAD was "advantageous" (70 percent), "impressive" (73 percent), and "exciting" (64 percent) to learn. In addition, the pre-post test results revealed that the participants were more favorable (38 to 60 percent) toward CAD usage. Results revealed that the percentage of participants' indicating that job security would be one advantage of CAD education doubled from pre- to post-test.

Significant differences between pre- and post-test for the lecture-style group were found for five of the six variables presented in Table 1. All of the changes were positive. Only one variable was significantly changed for the hands-on group. It is the opinion of the researchers that those actually operating the CAD systems were exposed to the learning curve required for CAD proficiency.

Summary

This research sought to investigate whether attitudes and opinions held by practicing interior designers toward CAD differed depending on the exposure to a hands-on versus a lecture-style pedagogy. The majority of the sample was female, had completed their college education and was practicing at least 50 percent contract design in small firms. Significant differences in variable scores between the pre- and post-tests occurred primarily for the lecture-style group which only saw demonstrations; they did not operate a CAD system. They felt a stronger reason to learn or implement CAD after the workshop and believed CAD to be more important than did the hands-on group in a new job. One day hands-on CAD workshops for those just learning to operate CAD were not significant in changing participant's attitudes or opinions. The learning curve may be too difficult for a one-time exposure.

However, overall attitudes toward CAD remained positive for the hands-on and lecture-style group and both groups realized that knowing CAD would significantly increase their job security.

Future Areas of Research

One area of further research would be to randomly select a sample of practicing designers who have not operated a CAD system and offer a three- to five-day CAD workshop to assess designers' attitudes, opinions, and behavior modifications in relation to their exposure to CAD. Also, the current study should be replicated with a larger sample to gain further insight into the effects of presentation methodology.

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Table 1 Mean Scores on Key Variables Prior to and Following a CAD Workshop for Respondents in Hands On (n = 38) and Lecture Groups (n = 14)

	Variables	Pre Workshop	Post Workshop	t-Score
1.	Attitude toward CAD			
	Hands On	2.1	2.0	.20
	Lecture	1.7	1.8	-.27
2.	State of Mind toward CAD			
	Hands On	-0.21	0.13	.89
	Lecture	-0.29	0.93	-2.72*
3.	Rationale for Implementing CAD			
	Hands On	3.3	3.3	.15
	Lecture	3.2	3.6	-3.70**
4.	Familiarity with CAD			
	Hands On	1.7	2.5	-5.92***
	Lecture	1.7	2.8	-4.17***
5.	Feelings about CAD			
	Hands On	4.1	4.2	-1.48
	Lecture	3.9	4.4	-3.31**
6.	Importance of CAD in New Job			
	Hands On	3.3	3.2	.32
	Lecture	3.0	3.6	-3.23**

* p < .05
** p < .01
*** p < .001

Table 2 Percentages of Respondents Checking Adjectives as Representative of Current Attitude Toward CAD Systems (n = 52)

Adjective	Pre	Post	Difference in % Points
advantageous	77.4	69.2	-8.2
impressive	67.9	73.1	5.2
exciting	60.4	63.5	3.1
amazing	22.6	15.4	-7.2
foreign	15.1	1.9	-13.2
overwhelming	15.1	28.8	13.7
powerful	11.3	17.3	6
affordable	7.5	9.6	2.1
unbelievable	5.7	5.8	0.1
ugly	1.9	0	1.9
useless	0	0	-
unapplicable	0	5.8	5.8
other	9.4	3.8	-5.6

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Table 3 Percentages of Respondents Checking Adjectives as Representative of Present State of Mind Toward CAD Systems (n = 52)

Adjective	Pre	Post	Difference in % Points
untrained	67.9	50	-17.9
eager	41.5	26.9	-14.6
favorable	37.7	59.6	21.9
excited	30.2	25	-5.2
uneducated	30.2	13.5	-16.7
agreeable	20.8	19.2	-1.6
intimidated	15.1	7.7	-7.4
anxious	13.2	9.6	-3.6
hesitant	13.2	25	11.8
confident	11.3	15.4	4.1
reluctant	7.5	7.7	0.2
incompetent	5.7	7.7	2.0
fearful	3.8	0	-3.8
neutral	3.8	1.9	-1.9
unaware	1.9	1.9	0
educated	0	5.8	5.8
sold	0	7.7	7.7
other	0	1.9	1.9

Table 4 Percentages of Respondents Indicating a Particular Behavior Concerning CAD Systems Prior to and Following a CAD Workshop (n = 52)

Question	Pre	Post
I have heard of CAD systems but really do not know how they work.	50	0
I have been exposed to some information about CAD systems and have some understanding of how it works.	44.2	76.9
I have seriously thought about getting a CAD system for my home/work.	5.8	15.4
I have a CAD system for my home/work.	0	1.9
I have decided against a CAD system for my home/work.	0	5.8

Chi square = 36.8
df = 4
p < .001

Table 5 Percentages of Respondents Prior to and Following a CAD Workshop Perceiving Each Factor as a Possible Advantage of CAD Training for Their Career (n = 52)

Factor		Pre Workshop	Post Workshop
1.	Trained for future needs	81	85
2.	Versatility and credibility within your job	73	83
3.	Improved communications skills to work with CAD operators	52	65
4.	Increased speed at your job	73	64
5.	Easier to find a better job in the market	44	60
6.	Better salary	40	56
7.	Job security	21	44*
8.	No real advantage at this moment	4	12

Chi square = 5.29
df = 1
*p < .05

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INTEGRATING CONTROVERSY SKILLS INTO COMPUTER CONFERENCING: PARAMETERS FOR INSTRUCTIONAL MODEL BUILDING

by

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ABSTRACT

An experiment in problem-solving was conducted in which one group of students used computer conferencing and another, class discussion groups while attempting to solve a legal problem in a course in consumer law. Student success rates for solving the assigned problem were similar. Based upon data collected, four parameters were identified as critical to integrating computer conferencing as an instructional strategy. These are: (1) precise problem definition; (2) intensive preliminary training; (3) pacing student inputs/outputs; and (4) redistributing class time. The role of the classroom instructor was perceived as entirely different by members of each group.

One of the most adventurous types of conferencing becoming more readily available to academicians is what may be labeled as <u>many-to-many interactive communication by</u> means of a computer. This interactive learning strategy enables an individual as part of a large group of users to keyboard messages at personal computers located at varying on-campus and off-campus locations. These comments may be filed centrally by means of a host-mainframe, thus enabling individuals to share ideas openly in a public forum. By adopting such an interactive strategy, individuals are capable of entering into dialogue with others while eliminating the barriers of time and space.

Alex Cruz (1992) of American Airlines Decision Technologies describes computer conferencing as a mechanism that enables individuals to communicate with one or more people through a computer that is connected to a network of other computers. Edward Yarrish (1992) describes computer conferencing as being somewhat different from electronic mail. Whereas electronic mail customarily results in private communication between two individuals, computer conferencing adds the dimension of continual public exchanges of ideas through asychronous meetings. In this regard, Yarrish categorizes computer conferencing as different time/different place technology in contrasting it to same time/same place learning environments typical of the more traditional classroom discussions found in today's educational institutions.

Experiment Conducted

An instructional experiment was conducted for the purpose of comparing student perspectives when utilizing traditional classroom discussion or computer conferencing as an interactive learning mechanism when debating a legal controversy. The focus of learning was upon having undergraduates apply prior learnings while thinking critically when recommending a public policy related to product safety in the marketplace.

During the experiment in a consumer law course, 48 undergraduates were divided into two learning groups with a control group of 24 students utilizing traditional class discussions and an experimental group of 24 students participating in a computer conference. Each group was given the identical charge of selecting and defending an alternative for solving what was presented as a product liability crisis in the marketplace. Members of the experimental group accessed personal computers using CONVENE software marketed by IBM for use on the IBM3090-E mainframe. Positions taken by the experimental group were forwarded by email to the instructor. For the control group, positions were presented in written format.

Data was collected by means of questionnaires completed at the conclusion of the 2-week experiment. Using a 5-point rating scale where a 5 rating indicated a strong agreement with a statement provided and 1, strong disagreement, students indicated their perceptions as to specified aspects of the instructional strategy to which they were subjected.

Findings of Study

The findings indicate that undergraduates in both the control and experimental group perceive similar occurrences in terms of degree of helpfulness, risk taking, maneuvering, dealing with large number of comments, determining significance of comments made, and the degree of difficulty in formulating final positions (Table 1). However, there was a significant difference in the perceptions of students between the control and experimental group as to the role undertaken by the instructor during the actual debate.

Delivery of education through computer communication alters the relationship between the instructor, student, and the course content. Unlike traditional classroom instruction in which the educator generally leads in discussion, prompts responses, and paces the class, computer conferencing is more student-centered with less instructor involvement. The mean score of 2.875000 on the part of the experimental group indicates that students generally disagreed with the statement that they found it necessary to rely upon the classroom instructor for leadership and direction. However, the mean score of 3.625000 reveals that students in the control group were more in agreement with the need to seek and get instructor support.

Table 1
MEAN SCORES AND PROBABILITIES OF STUDENT PERCEPTIONS
OF OCCURRENCES BY STUDENT GROUP

Occurrence	Mean Exp. Grp	Mean Control Grp	T-Score	Prob.
Others influenced my thinking	3.708333	3.833333	-0.595	.55
Comments generally repetitive	3.500000	3.296667	0.7468	.45
Difficult to keep track of comments	3.166667	2.875000	1.0579	.20
Like to take risk expressing myself	3.083333	3.125000	-0.1259	.90
Used readings identified by others	3.541667	3.416667	0.4248	.67
Necessary to meet outside of class	2.666667	3.125000	-1.5235	.13
Was candid when interacting	3.416667	3.333333	0.2851	.77
Difficult to make comments	3.083333	2.625000	1.4728	.14
Easy to interpret sign. of comments	3.625000	4.125000	-1.6262	.11
Willingness to share ideas	3.916667	3.750000	0.7938	.43
Relied upon Inst. for Guidance	2.875000	3.625000	-2.0180	.05**
Computer Conf/ Disc. Helpful	3.750000	4.00000	-1.0000	.32

**Significance at .05 level of confidence

The findings also indicated that both the control (mean score of 4.00000) and experimental (mean score of 3.75000) groups found their instructional strategy (whether traditional class discussion or computer conferencing) to be helpful for gaining data and support for defining their own position in terms of the legal controversy under debate. Both groups appeared to be candid with their remarks and also agreed that they did not find it necessary to meet with others outside of class for getting assistance in arriving at a position (Table 1).

Parameters for Instructional Model Building

Several qualitative findings are worthy of note in terms of conducting students through computer conferencing activities. Since both the control and experimental groups generally succeeded in defining and defending a position that was documented for credibility, it appears that group-oriented learning has considerable merit. However, the role of the instructor may be characterized as somewhat different for that of computer conferencing. In this regard, four parameters were identified which may be identified as significant when structuring a computer conference with the purpose of generating input and exchange of dialogue among all the participants.

1. Structuring the Problem-Solving Situation. The problem utilized as a focus of study should be quite specific and one in which much has been written in the literature. By focusing upon an existing controversy, students are able to relate findings to their own welfare, which is important to giving credibility to the process. Therefore, guidelines as to labeling comments with communicative titles, generating ideas within specified comment lengths, and documenting thoughts through references to current literature are most critical toward bringing order to what could easily become chaotic in terms of information overload (that is, rambling comments that never seem to end). Structuring comments within strict limits reduces the length of time students are keyboarding, reading, and recalling prior exchanges.

2. Student Preparation. The technical idiosyncrasies associated with maneuvering within a computer conference have a tendency to misdirect the student's attention to the task at hand. Therefore, it is suggested that students require "substantial" prior practice in accessing, maneuvering, and organizing thoughts through electronic dialogue. Because of the technical nature of computers, computing support staff must be readily available to assist users through the "pitfalls" of computing (especially editing sequences). In this experiment, students were required to complete a three-hour, one-week training period followed by a "practice controversy" in which each participant entered into dialogue by initiating ideas and reacting to comments of others.

3. Pacing Student Involvement. In order to assure that students did not wait until the last minute to participate in the conference, specific deadlines were established by which comments had to be entered/responded to throughout the 2-week experiment. A minimum requirement of 6 comments per week was established--two per day reflecting traditional class meetings--in order to convey the importance of helping others along a continual paradigm. In addition, the length of comments was restricted to no more than 2 computer screens. It should be noted that a vast majority of students met the minimum criteria for participations over the debate conducted during the experiment.

4. Redistributing Class Time. Undergraduates participating in the computer conference were excused from traditional class meeting over the two-week period. However, 6 classes were held with the control group using a class discussion format whereas those in the

computer conference were required to enter two comments per class day but within a time frame of 6 a.m. to 12 midnight. Therefore, each group did not interact with one another and the computer conference was considered a substitute for class meetings.

Significance of Experiment

It is worthy to note that with computer conferencing, the classroom instructor has an additional responsibility of providing a learning structure that enables students to work out a problem, search for strategies on their own, and evaluate their solutions. The computer conference enables the teacher to fulfill the role as an observant with the primary focus upon having student adapt individual thinking processes for analyzing and synthesizing thoughts into a logical conclusion. The role assumed by the instructor may be described as being alert for misinterpretations on the part of participants and immediately correcting them to allow participants to proceed without unnecessary delays or distractions.

During a computer conference, each participant finds himself/herself in a role of having to participate. Such an occurrence is not necessarily true in the traditional classroom discussion. In face-to-face exchanges, some students may have little opportunity to participate. Personality appears to become less important in computer conferencing than in traditional classroom debating processes.

The findings of the experiment give credibility to the argument that students should be rewarded for posing new alternatives, for changing their positions when the evidence is substantial, and for arriving at an informed decision reflecting advanced problem-solving skills. Therefore, the learning process itself becomes the focus of attention--and not necessarily any one particular solution to a controversy.

If computer conferencing is adopted, the result is a redistribution of class time in that student involvement moves from that of primarily interacting in a controlled classroom environment to that of a campus perspective whereby library resources and computing capabilities are integrated into a learning network. Therefore, in this respect, it is the promoting and managing of controversy constructively that requires students to think out their ideas thoroughly, to gather additional information when circumstances suggest a need, and to sequence prior learnings into a logical order for final presentation. In this regard, computer conferencing has considerable merit as a learning strategy.

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Selected Abstracts for the

Special Interest Group for HyperMedia (HYPERSIG)

Teaching with HyperCard: An Innovative Case Study
Bryan R. Cole, Texas A&M University

This presentation outlined the conceptualization, development and implementation of the configuration of a course, "Higher Education Law" utilizing HyperCard programming on the Macintosh computer. The presentation sought (1) to expand participant understanding and thinking about the improvement of teaching and learning through the utilization of HyperCard as an instructional delivery system, (2) to share with session participants lessons learned from the development of an idea into a computer-based instructional delivery system, and (3) to provide session participants with an opportunity to interact directly on issues impacting upon the utilization of HyperCard in an on-line instructional environment. Emphasizing pedagogical rather than technical considerations, the presentation outlined the course methodology utilizing a HyperCard database of over 1300 case briefs which serve as an on-line retrieval system that effectively represents the case law of higher education administration. Cases can be retrieved from the database using three different indexes (1) case name, (2) subject, and (3) topic. Accordingly, the database can be utilized in conjunction with a Macintosh computer, overhead projector, and an overhead projector LCD projection panel to provide real time access during class instruction to this complex and comprehensive database. This methodology has now been utilized in three graduate courses. The presentation, therefore, also included evaluation and recommendations as a result of the pilot period and offered suggestions to others who may want to utilize HyperCard to direct support of course offerings. The session included a demonstration of the database and how it is used in the course.

Simulating the Reasoning Process with Causal Modeling Techniques
Joanna C. Dunlap and David H. Jonassen, University of Colorado

Instructional computer-based simulations, through the presentation of realistic scenarios in situated settings, attempt to provide learners with environments in which they can safely practice using their skills and knowledge to solve problems and make decisions. One of the problems with using a simulation as an instructional strategy is that it can often be difficult to realistically represent the complexity that is part of actual "real world" decision making and problem solving; decision-making and problem solving often happen under a veil of uncertainty in which there are many possible reasons for and causes of each event/problem and just as many possible solutions for, answers to, or effects of each event/problem. Using causal modeling techniques (statistical techniques that facilitate the speculation of causal linkages among correlations), instructional designers are able to provide simulated learning environments that enable learners to practice being problem solvers and decision makers under uncertainty.

Causal modeling theory was used as a basis for structuring a learning environment for medical students in the area of transfusion medicine problem solving and decision making that simulates the reasoning process involved in addressing complex clinical situations.

This presentation demonstrated how instructional simulations can be structured using causal modeling techniques.

The Media Mix

Stephen W. Harmon, The University of Houston - Clear Lake;
Thomas C. Reeves, The University of Georgia

Everybody's talking about multimedia, but nobody seems to be doing anything about it. This session presents a panel of experts in interactive multimedia, discussing some of the "why's" "why nots" and "how-comes" of multimedia project development. Speaking from experience garnered in business and industry, the military, and university settings, the panelists will present their views of managing multimedia projects, discuss special problems in creating multimedia applications and will answer questions from the floor (and from members of the audience!)

A wide variety of project management concepts have gained popularity recently,mm and many of them have made their way into instructional settings as well. Panelists will discuss Total Quality Management (TQM), rapid prototyping, traditional ISD, and other approaches to creating effective multimedia projects. Panelists will discuss case studies of projects already completed and currently underway.

An Examination of Novice Linking in Hypermedia Environments

Steve W. Harmon, University of Houston - Clear Lake

The goal of this study was to evaluate how novice users of hypermedia systems carried out the task of linking nodes of information in a relatively unfamiliar content area. The hypermedia system was designed to present the nodes as separate topics with no pre-imposed structure and no suggestion of relationships between topics. Data was collected through observation, interview, link capture, pre-treatment survey, post-treatment questionnaire and a post-treatment individual differences measurement test. Eight different types of links were identified by the subjects.

The first two of these are similar and opposite links, used when nodes were either alike or opposed. The third link type is causal, resulting when one node was the result of another node. The fourth link type is sequential, identified when one node occurred chronologically before or after another. The fifth link type is associative, describing links where one node explicitly mentioned another. The sixth link type is exemplary, used for links between nodes that illustrated each other exemplary. The seventh link type is componential, used when one node was a part of another one. The eighth link type is accidental, used when subjects made a mistake when linking two nodes. This session fully describes the study, and discusses its results and implications.

Cognitive Flexibility, Epistemic Beliefs, and Hypertext Learning Environments: Research into the Transfer of Complex Knowledge

Michael J. Jacobson, The University of Illinois at Urbana-Champaign

The utilization of hypertext and hypermedia systems for instructional purposes continues to receive considerable attention. Although research is starting to document the instructional efficacy of learning environments based on hypertextual technologies, a number of psychological and educational dimensions associated with the instructional uses of these systems remain to be explored. In an earlier hypertext study, Jacobson and Spiro (1991) found significant knowledge transfer outcomes associated with hypertext design elements that were explicitly based on a recent theory of learning, *cognitive flexibility theory*. This presentation discusses a follow-up study examining different degrees of learner control over a cognitive flexibility hypertext procedure that provides conceptual and case "criss-crossings" of hypertext nodes to demonstrate structural knowledge interrelationships. It is anticipated that epistemic beliefs about the nature of learning and metacognitive factors related to the learner's control of the hypertext exploration paths will interact with the ability of the students to learn and to transfer their knowledge after using the experimental hypertext materials. The implications of this study will be discussed in terms of design issues for hypertext learning environments and cognitive factors associated with knowledge acquisition and transfer.

Conceptual and Methodological Problems in Hypermedia Research

David H. Jonassen, University of Colorado

In order to yield coherent research that can guide the design of hypermedia systems for learning, a systematic research agenda must be implemented to investigate the following issues (these are the issues, I claim, that most affect learning from hypermedia):

- Appropriateness of hypermedia applications and the implications for meaningful learning resulting from them
    - Information retrieval hypertexts
    - Complex, constructivistic learning environments
    - Collaborative knowledge construction
- Assumptions of hypermedia for learning
    - Learner control
    - Meaningful purpose or goal for learning
- Design and procedural issues
    - User functionality in the interface
    - Intellectual functionality in the structure and facilities
    - User literacy
    - Relationship of functionality to learning goal
- Evaluating outcomes from hypermedia use
    - Process outcomes from hypermedia use
    - Learning outcomes
        - Relevance
        - Depth of processing
        - Relationship to process outcomes

Collaborative Knowledge Construction in an Argument-Based Hypertext
David H. Jonassen, University of Colorado

Computer supported intentional learning environments (CSILEs) provide students with a forum for subject matter/content area exploration based upon individual, self-determined needs and interests (Scardmalia et al, 1989; Scardmalia & Bereiter, 1991). This presentation describes a hypertext shell to facilitate argumentation of issues in an advanced knowledge seminar. Individuals were required to attach *issue* links to these content nodes. To each issue node, personal *position* and alternative model links can be automatically created to reference nodes described by those links. To each of these position nodes, *argument* nodes and links can be created. The outcomes of imposing this type of formal argument structure onto the collaborative construction of a class text include more elaborate class discussions and better argued class papers.

The Application of Research-Based Instructional Design Principles in Developing a Hypermedia-Assisted-Instructional Courseware for Second Language Learning
Min Liu, West Virginia University

The nonlinear, associative, flexible and efficient characteristics of hypermedia have excited many educators. Due to these obvious advantages, hypermedia is becoming a popular tool for courseware development. However, hypermedia has its limitations such as disorientation, cognitive overload and "too much" learner control. To develop a quality hypermedia-based courseware, efforts must be made to take care of these inherent limitations. Research has shown that a knowledge of instructional design theories and principles is critical for designing effective CAI.

This presentation intends to discuss ten research-based instructional design principles that are most relevant to design courseware using hypermedia and how these principles can be used to maximize the potential of hypermedia as well as to overcome its limitations. It will also discuss the author's experience of implementing these principles in developing a semantic-network-based hypermedia courseware for second language learning.

Information Seeking - A Fundamental Learning Activity
Carol B. MacKnight, University of Massachusetts

Searching for information in documents is an activity that is carried out by all of us, first as students and then as employees. We search dictionaries, encyclopedias, textbooks, manuals, and the like for a solution to a problem. A first step in any learning process is satisfying our informational need, that is, seeking information that answers a question, solves a problem, or helps us to comprehend. The importance of this task is highlighted by Kirsch and Guthrie (1984) who found that adults in the workplace spend more time on reading to locate information than reading for any other purpose.

How students search electronic documents and how effective they are in this process is the subject of our study. We wanted to know which navigation tools student would choose for a particular task, how effectively and efficiently they used the navigational/structural aids to locate the information, what types of errors were made, and where parts of the hypertext system need improvement or redesign.

After a brief introduction to the system, sixteen undergraduate students searched a hypertext version of the **Publication Manual of the American Psychological Association** (APA Manual), which consisted of seven chapters and over 1,000 cards, for answers to six questions.

Students were encouraged to work as quickly as possible and asked to write their answers on paper. The total time spent answering a question was recorded from the moment the students pressed a navigation button signifying the beginning of the search process and ended with student signalling the beginning of the writing process. Student's choices of navigation tools and their path through the material were computer recorded. A comparison was made between the best path and the path chosen by the student. Other comparisons and analyses were made with tentative results showing that there were no significant differences in time required to search an electronic document and time spent searching a paper document.

A Course Design for Going Beyond HyperTalk

Rose M. Marra, AT&T Bell Labs; R. Scott Grabinger, University of Colorado

Instructional Technology curricula often stop at the Hyper Talk level. Although this provides much functionality and satisfies many learners, there is a class of problems the HyperTalk language cannot address.

For example, gaining direct access to certain parts of the hardware is not possible with HyperTalk. In addition, other operations such as sorting large stacks and doing complex linking operations are cumbersome to perform within HyperTalk.

If students wish to be completely proficient in using HyperCard/HyperTalk to create educational solutions of any scale, a way *beyond* these limitations must be available. As HyperTalk does not offer an internal solution, one must look outside of HyperTalk.

This session will present a course design for teaching students to use *"C"*, or another high-level programming language such as *Pascal*, to write commands external to, but accessible from within HyperTalk scripts. HyperTalk provides a means to access these externally written commands and functions; or as HyperTalk refers to them, *XCMDs and XFNCTs*. Implementing these *XCMDs and XFNCTs* in a high-level language provides the functionality not available in HyperTalk.

Wildlife Wonders: Validating a Prototype for Multidisciplinary Education for Middle School

Gayle M. Munson and Eric E. Smith, University of Northern Colorado

The goal of Wildlife Wonders is to teach students to creatively solve problems and to appreciate the world around them. This is accomplished by putting creative tools in the hands of students while presenting information about the natural world. Problems to be solved are presented by the teacher or generated by the students. The problem might be "create a fable about a whale" or "do a report comparing whaling in the last century with today." The student then has a resource to begin exploring the issue. With guidance from the teacher, the student learns to solve the problem and create and present the solution. To be successful, the student must combine problem solving with research with content with writing and other disciplines. The process of combining the approaches leads to more excitement and the development of "multidisciplinary eyes" needed to reach solutions to real-world problems.

This presentation discusses the design of the material and the results of a validation study conducted in the Laboratory School at the University of Northern Colorado. The Wildlife Wonders project is the first piece of the Taliesin Project vision to be completed and validated. The Taliesin Project (Smith & Westhoff, 1992) is aimed at creating a multidisciplinary learning/teaching environment and attitude.

Hypermedia Development Issues: Validated Guidelines and Research Needs

Gayle M. Munson, Tom Lightner, and Eric E. Smith, University of Northern Colorado

Practitioners involved in developing hypermedia education environments are currently producing their systems in a standardless world, producing more uncertainty for students, end users, and novice developers. Different developers may use different interface standards compounding the confusion. There are contrasting opinions about which navigational scheme to use when, such as icons, menus, or maps, to best mediate content learning in specific situations, leaving the user without familiar direction. Screens are frequently designed without convention as to information density and placement of text, graphics, and controls, resulting in student focus on interface rather than content. Designers may be unfamiliar with different methods for structuring information. They may devise a product using a hierarchical structure when node-linked is more appropriate. Or they might use either structure type without adequately preparing the user to follow the information.

A comprehensive set of guidelines for developers, for students, and other users is needed. Currently there are many recommendations in areas such as information structures, screen design, navigational schemes, and the use of icons, but little substantiated evidence collected regarding those recommendations. This presentation examines each of these issues and the relevant empirical research to date surrounding each issue. The presentation also highlights areas deserving more study.

Effectiveness of Interactive Video on Tennis Skill Analysis

Gayle M. Munson and Eric E. Smith, University of Northern Colorado

The purposes of this study were: (a) to develop a computer-based interactive video instruction system for tennis skill analysis for preservice physical education teachers, (b) to determine the effectiveness of the computer-based interactive video instruction system on preservice physical education teachers' psychomotor skill analysis ability, on preservice physical education teachers' cognitive skill analysis ability, and on preservice physical education teachers' motor skill performance. Twenty-one undergraduate physical education majors enrolled in an analysis of movement course in tennis at the University of Northern Colorado participated. The 11 subjects in the experimental group received instruction on the tennis skill analysis using the interactive videodisc. The 10 subjects in the control group received conventional instruction from the investigator.

The pre- and post-test control group design was implemented to determine effects of the treatment from pre- to post-test. The data were collected using three types of instrumentation: (a) written cognitive skill analysis test, (b) tennis skill performance test, and (c) psychomotor skill analysis test using the videodisc. An analysis of covariance (ANCOVA) determined no significant difference between the groups' cognitive knowledge of tennis skill analysis, psychomotor skill analysis competency, or tennis skill performance. An analysis of variance (ANOVA) determined significant improvement form pre- to post-test for both groups on all three dependent measures. These results suggest that the use of interactive video-based instruction for psychomotor skill analysis has great potential for physical education teacher training.

Evaluating Hypermedia Environments: Insights from the Perseus Project

Delia Neuman, University of Maryland

Perseus is a multimedia, interactive library of fifth-century Greek history, literature, art, architecture, geography, and culture. Created by a team of classicists at various universities and headquartered at Harvard, Perseus has been under development for approximately five years, with major support from the Annenberg/CPB Project and additional funding from Apple Computer and the National Endowment for the Arts.

The Perseus Evaluation Team of Gary Marchionini and Delia Neuman (University of Maryland) and Kenny Morrell (St. Olaf College) have used both qualitative and quantitative methods to conduct an ongoing formative evaluation of the emerging Perseus materials. Observations, interviews, and various kinds of document analysis have been conducted at the project's primary evaluation sites -- Bowdoin College, Harvard University, University of Maryland, and St. Olaf College -- while questionnaires have been the primary data collection strategy at approximately 25 beta sites.

Results to date have indicated a mechanical advantage for Perseus, the existence of some qualitative differences in students' learning with Perseus, a variety of insights about system performance, a need for both physical and conceptual infrastructures to enhance the value of Perseus, and a concern for managing the cognitive overloads students experience with the system.

Building Blocks - A Literacy Program

Laurie Rosenthal, Teachers College/Columbia University

Intergenerational literacy centers are places where computers can profitably be used to improve learning by at-risk populations. Consequently, there is a need for software specifically designed to capitalize on the unique learning situations present in these settings.

Building Blocks, a HyperCard based hypermedia program, meets this need by integrating educational ideas with cognitivist theory to improve users' skills, as well as increase their knowledge. Intergenerational dyads, consisting of a preschooler and an adult, work on activities that promote cooperative learning, while providing children with positive adult role models, and adults with experiences that develop a sense of empowerment.

Building Blocks consists of several stacks including a storybook, and an alphabet. Constructivist ideas, branching, rich graphics, animation, sound, and a whole language approach to reading/writing are used in structuring activities, and to make information interesting and meaningful. A direct object manipulation user interface makes the program engaging and highly interactive, and serves to stimulate discussion and question asking. Preliminary tests show Building Blocks is easy to use, holds user interest, and increases user knowledge.

Developmental Formative Research on Interactive Materials

Erik Strommen, Children's Television Workshop; Barbara Flagg, Multimedia Research; Patricia R. Garretson, IBM Corporation; Henry Olds, Bolt, Beranek & Newman

Developmental formative research is the evaluation of education materials, especially technology-based materials, for children conducted during the development process. The goal is to ensure that the design and content of educational technology applications are appropriate to the intended learner population. The present panel will report on a wide variety of formative research projects conducted to address different aspects of educational technology use in different settings, and an open discussion of issues in formative evaluation will follow.

Selected Formal Papers from the

Special Interest Group for HyperMedia (HYPERSIG)

A Strategy for Updating Large Hypertext Systems

John M. Jackson
Office of Medical Education
University of Virginia

Abstract

While many sophisticated authoring systems exist for creation of hypertext programs, no authoring tools are available that reliably and automatically revise manually created hypertext links when program contents are revised. For large hypertext programs, this can mean manually re-creating thousands of hypertext links each time the contents are updated. This article presents a technique for automatically reestablishing any number of hypertext links after a program's contents have been revised. The technique does not require any hidden codes and authors may use word processors to revise program contents. The technique may be used with many hypertext authoring systems.

Introduction

Although the concepts and theory of hypertext have been around for several decades (Bush, 1945; Nelson, 1987), commercial authoring systems did not become available until the mid 1980's. Since then, software tools have proliferated, first on mini and mainframes, then spreading onto microcomputer platforms. Today hypertext designers have many tools to choose from according to the needs of their projects. As hypertext software has evolved, so has the research guiding the structure and interface design of hypertext documents (Conklin, 1987; Shneiderman, Kreitzber, & Berk, 1991). While there is still much to be learned about the appropriate structure of hypertext, we are developing a good understanding of how to build documents that are easy to use and navigate through.

Hypertext research has also expanded into the automatic conversion of documents into hypertext form. Commercial packages take several approaches to build links automatically. Some use an index or key word list and build links to all occurrences of those terms (Riner, 1991). Others use lexical, statistical, and syntactical analysis as well as underlying semantics to intelligently build links between related concepts (Rearick, 1991; Salton, 1989). These approaches look at the meanings of words, how words are used, and how often they are used to analyze the content. Hypertext links are then build automatically to tie together related topics and concepts.

Another class of automatic conversion tools uses the Standard Generalized Markup Language (SGML) to automatically construct hypertext links. SGML is a meta-language that has grown out of the publishing industry that defines the structure, relationships, and hierarchy of a document through a tagging system. SGML is commonly used in mini and mainframe publishing systems, but encouraged by ISO 8879 that defines and standardizes SGML's characteristics, SGML is now being incorporated into some microcomputer software (Goldfarb, 1986). While SGML is primarily intended to simplify the printed publishing process, hypertext tools can use embedded SGML tags to analyze document structure and quickly build links without resorting to complex and sometimes unreliable syntactical analysis (Staff, 1991). Unfortunately few microcomputer based word processors can create SGML tagged text, though a few utilities are available to convert word processed files into SGML format.

Automatic text-to-hypertext conversion software is useful for developing reference systems, technical documentation, or other hypertext applications that allow the user to freely navigate through material. Automatic conversion to hypertext is usually not applicable to computer based instruction (CBI) that guides the learner through a structured learning experience. Typically the CBI author would not be satisfied with a hypertext document that simply cross referenced every occurrence of a word. As a result most hypertext CBI systems use links that are built manually by the author.

Since hypertext authoring systems have been on the market for several years, there are now thousands of large hypertext systems in place. They are used in on-line reference systems, just-in-time training modules, technical documentation, and many educational packages including computer based instruction modules. The proliferation of hypertext systems, and the unavoidable obsolescence of the information they contain, has given rise to the problem of hypertext system maintenance.

Problems of Hypertext Revision

There are many problems associated with hypertext maintenance, depending on how the system was created. If an automated text-to-hypertext conversion tool was used the process is fairly straightforward, especially if the authoring tool maintains a separate list of node keywords that can be used with newly revised documents. CBI authors unfortunately cannot apply this technique since they typically build most of their links manually. If an author has used an overlay button based tool, such as HyperCard, with invisible buttons placed over text, each time the text is edited all of the buttons and related links are pushed out of registration. To further contribute to the problem, most hypertext authoring tools do not offer the full functionality of dedicated word processors, and do not include spelling and grammar checkers, thesauruses, or style sheets. This makes it very inconvenient, if not impossible, to use hypertext authoring systems to edit documents. If a hypertext authoring system uses hidden embedded codes to define links, links can also be damaged during the text editing process. All of these factors contribute to making hypertext revision a very labor intensive and frustrating process, especially for a subject matter expert or author who does not work with these tools on a daily basis. Ideally, the hypertext authoring system should let the subject matter expert use the word processor of his choice to compose and revise his documents. The ideal system would automate repetitive authoring tasks, including the link rebuilding process that takes place after any major document revision. The project described below was developed to meet these goals for one specific hypertext environment. The strategies developed in this project may be applied to many other types of hypertext systems.

Project Description

In 1990 Dr. Brian Duling, a physiologist at the University of Virginia Medical School, proposed a large hypertext system that would provide medical students with a set of computerized practice questions for their review before examinations. Each question would have feedback for each possible response and be cross referenced to an extensive set of hypertext course handouts that would provide more detailed explanations. The students and faculty would also be able to search through questions or handouts for specific terms within a given course section or across several courses. Formatted text and graphics for both questions and handouts were to be imported from existing word processor files. The documents were heavily formatted and contained many illustrations, scientific formulae, and Greek characters. Dr. Duling sought to design a system that encompassed the entire first two years of the medical curriculum at the University of Virginia, including several thousand questions and many thousands of pages of course handouts. As many as 100 faculty authors would be involved in the project at its maturity. Key to the project was that all course handouts would be revised annually along with all the related hypertext links to the practice questions. Questions would also be revised, but on a less regular basis. Basic assumptions were that the system must be extremely easy to use by the students and faculty authors, and that the faculty must be able to use their word processors to write and revise all documents.

Dr. Duling's laboratory built the first prototypes using HyperCard® to define the types of interactions and interfaces necessary for the system. Using the version of HyperCard® available at the time, it was necessary to rely upon codes embedded in the course handouts to maintain hypertext links during the revision process. HyperCard® also could not easily import the formatted text and scientific equations essential to the project. The HyperCard® prototype helped define the needs of the proposed system, but it was concluded that it did not include many features essential for the success of the project.

After an extensive review of hypertext tools available at the time, Dr. Duling and the author developed a second prototype using Guide 3.0® running under Microsoft Windows®. Guide® is a frame based authoring system with a dedicated programming language, Logiix®, and is capable of opening several documents simultaneously. It will import and export Rich Text Files (RTF), maintaining all text formatting in the process It can import several graphics file formats, both bitmap and vector, though they can only be imported on an individual basis, not embedded within a word processor file. An authoring shell along with authoring macros were developed using Guide® and Logiix®, in order to speed the authoring process and to encourage widespread use among the faculty. A beta version of the system was implemented in the fall of 1991 and tested with 140 medical students in a microbiology course. Early testing showed that heavily imported text could be imported successfully, the authoring process could be accelerated through the use of macros, and that links could be rebuilt automatically after documents were revised using word processors (Jackson & Duling, 1991). After additional revisions, version 1.0 of the authoring shell was used by two faculty members to develop questions and links to handouts for 140 students in a physiology course. Currently the system is being used by seven faculty members in two courses using four different word processors. The system is heavily utilized and has received an enthusiastic response from the students in both formal and informal evaluations.

The authoring shell developed in Guide 3.0® includes hypertext document templates for questions and course handouts, a standardized interface for the student users, and a set of macros for faculty authors that speed the creation of hypertext links. The macros create feedback in pop up windows and 'reference' links to the course handout documents through a simple dialog process. Faculty authors typically require about thirty minutes or less of training before being able to author their first set of hypertext practice questions. Most importantly, the macro for building links to the handouts uses a technique that automates the reconstruction of hypertext links after a document is revised. After the faculty authors update their handouts each year, they give their new word processor documents to the system administrator who imports them into Guide®, and executes a macro in the Guide® shell that rebuilds the links to the questions.

The logic of the macro that creates rebuildable links to the handouts is relatively simple. The pseudo code is included in Figure 1. The author must have a document open that he wants to link to before executing the macro. Upon clicking on the "Make Reference" button the macro creates a 'Reference' button at the top of the question frame, then asks "What document do you want to link to?" The macro next opens the document the author specifies and asks "Search for what term?" After the author enters a search string and clicks an "OK" button, the

```
Make Reference Button macro
docA= question document
docB= handout document

Begin
  Create Reference button at top of frame in docA
  docB=Ask "What document do you want to link to?"
  Open(docB)
  searchterm=Ask "Search for what term?"
  hitword=Find(searchterm)
  On finding searchterm Ask "Link to this word?" Yes/No
  If No, repeat Find(searchterm)
  If Yes
    begin
      Make hitword a reference button
      Set hitword to red and italic
      Complete link from docA reference button
      hit+10=hitword plus the following ten characters
      Begin link from reference button in docB
      Open docA
      Insert hit+10 into top of frame of docA
      Set text color of hit+10 to white
      Complete link to reference button in docA
   End if
End
```

Figure 1. Pseudo code of linking macro.

macro searches through the target document until it finds the word, highlights the word, then asks, "Link to this word?" If the author clicks "No," the macro searches to the next instance of the term and repeats the process. When the author clicks "Yes" the macro makes that instance of the word a 'reference' button, sets the text style to red and italic, and completes the link to the 'reference' button in the question document. Then the macro puts the *search term plus the next ten characters* that follow it in the handouts document into a string variable. The macro also begins a link in the handout document. Next it reopens the question document and inserts that string variable into the original question frame, setting the text color to white so that it will not be visible against the white background. The macro completes the link from the notes document, creating two hypertext nodes that cross reference each other. The actual code contains many other elements and error handling routines that are not included here since they are not the topic of discussion.

Rebuilding Hypertext Links

Faculty authors typically revise their course handouts annually with the word processors of their choice. Once they have completed their revisions, the formatted and revised handouts are converted to Rich Text Files (RTF), and imported into a Guide® template. The system administrator executes another macro that rebuilds the hypertext links between the question documents and the new course handouts, which have no hypertext links initially. This macro goes to each question frame, extracts the search term plus ten characters string, opens the new course handouts, searches for the search term plus ten, rebuilds the cross-referencing links, goes to the next question frame, and repeats the process until all the hypertext links have been rebuilt. See Figure 2 for the pseudo code of this macro. Typically this procedure can rebuild around 95% of all links automatically. The macro creates an error log of all of those links it cannot rebuild, due to the target area having been edited by a word processor, so

Rebuild Links macro

```
docA=question document
docB=handout document
question document must be open to first question frame

Begin
hit+10=Get hidden string at top of docA question frame
Begin link from reference button in question document
docB=Ask"Rebuild links to what document?"
Open(docB)
result=Find(hit+10)
If cannot find hit+10
  begin
     put question number and hit+10 into error log
     Answer "Can't rebuild link!" OK/Cancel
  else
     original_term=Drop last ten characters from result
     Make original_term a reference button
     Set text of reference button to red and italic
     Complete link from question document
     Begin link from docB
     Open(docA)
     Complete link from docB to question reference button
  end if
Go to next question frame
Repeat until all questions relinked
```

Figure 2. Pseudo code for macro to rebuild links

that those links can be manually reconstructed at a later time.

Core Logic

The core logic of the above macro is a very simple procedure that can be applied within many hypertext authoring systems. When a reference is made from one document to another, or within a document, the target term plus the next ten characters that follow it are saved in an indexed area. (Through extensive testing with 20-50 page documents, the author determined that the target plus the next ten characters was the shortest string that is extremely likely to be unique within any document.) The target document may be revised using a word processor and imported anew into the hypertext system, lacking any hypertext link information. A macro can use the indexed target term plus the next ten characters to search for the sites of the original links. Once those sites are located the links can be rebuilt automatically. The requirements of an authoring system that can execute this type of logic include: a robust programming language with text string handling capabilities, the ability to open several documents simultaneously, and the option of storing strings in a data array or some other indexing system. Most hypertext authoring systems can meet these minimal requirements.

Limitations of the Approach

This approach to rebuilding hypertext links is not appropriate in some circumstances. If the hypertext application contains a large percentage of links to graphics, rather than text, this approach will be of little use. If the target documents are radically rewritten, changing a large percentage of the text in the hypertext target areas, this approach will not be able to rebuild many links automatically. Links will have to be built manually if the source document undergoes editing that requires referencing a different area in the target document. This system is optimal when two documents are cross referenced to one another and only one undergoes significant periodic editing.

Advantages of the Approach

The advantages of this approach fall into two categories: those applying to the shell/macro based system as a whole, and those that apply to the automated hypertext link rebuilding system alone.

The primary advantage to the shell/macro based system is that content experts can use the word processors that they are most comfortable with when creating, editing, and formatting documents rather than having to learn yet another software package. Although this may seem insignificant, in many cases this factor will determine whether teaching faculty will take on the additional responsibility of authoring and maintaining a hypertext system. Another advantage in this implementation is a shell that makes interface design decisions for authors who are not trained in software interface development. A more critical advantage is that all routine links are built through a dialog process rather than a scripting process so authors can concentrate on content rather than mastering a programming language. Authors do, however, still retain access to the full authoring features of the hypertext system, and are not limited to the use of the macros alone. The use of macros to automate routine tasks, such as creating links within and between documents, speeds development, relieves the authors of repetitive tasks, and reduces clerical errors. Since the system is fast and easy to use, more faculty are likely to begin authoring hypertext systems. Perhaps most significantly, since a macro rebuilds nearly all of the hypertext links after document revisions, the faculty have no involvement in hypertext document maintenance and the system administrator has only a minimal time investment. Overall the system removes about 95% of the repetitive tasks that make up hypertext development and maintenance in our project. The savings on other projects will be determined by the project design and demands, but the approach should prove useful in many situations.

Conclusions

The approach described can reliably rebuild up to 95% of the hypertext links between two documents when one has been significantly edited using any word processor. The core logic of this approach can be used with many hypertext authoring systems and is useful in many, but not all, situations. The approach, combined with an authoring shell/macro system, radically accelerates the hypertext authoring and revision process making it more efficient and more attractive to prospective faculty authors. In general, the approach is well suited to the development of hypertext based CBI developed by faculty authors with a minimum of computer experience.

This case study points out several areas that need further investigation. Should this approach to rebuilding hypertext links be integrated into the hypertext authoring systems themselves rather than as macros? Besides making the authoring process more efficient for content experts, what would the implications be of designing authoring systems to emulate a variety of word processors? Would it be possible to integrate this approach with the automatic text-to-hypertext systems, including those based on SGML? Ideally one system would allow the author to choose between several methodologies of making and rebuilding hypertext links based upon the structure and needs of the final application.

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Navigation Maps and Cognitive Styles in Hypertext Assisted Learning

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Abstract

This paper presents the results of a study which investigated the interactions between cognitive styles (learning styles and spatial ability) and navigation maps in hypertext assisted learning. Learning outcome and user satisfaction were used as dependent variables in an analysis of the interaction of learning styles and mental maps in the design of hypertext documents used for exploratory learning.

Three research questions were addressed: (1) Does cognitive style (learning style or spatial ability) affect learning outcome or user satisfaction in hypertext assisted learning? (2) Does the presentation method of navigational maps affect learning outcome or user satisfaction in hypertext assisted learning? (3) Are there interaction effects between cognitive styles and method of presentation which affect learning outcome or user satisfaction in hypertext assisted learning?

A total of 282 students enrolled in an introductory computer science course volunteered for the study. Students completed a spatial ability test, and were categorized into one of Kolb's four learning styles. The students were sequentially assigned to one of four treatment groups, each using different navigation methods in a hypertext document. Students spent one hour learning as much of the text in the document as possible. Upon reading the document, students completed a questionnaire which measured the amount of material learned, and the level of satisfaction in using the lesson.

An ANOVA procedure was used to compare the means of cognitive styles between the various presentation methods. Analysis of the data produced several results. (1) Significant differences among learning outcomes or satisfaction between learning styles were not found. (2) Method of presentation indicated significant differences in both learning outcome and user satisfaction level. (3) Spatial ability of learners produced significant differences in general satisfaction and disorientation effects. (4) There were interaction effects involved between learning styles and presentation method which had a significant effect on user satisfaction, but not on learning outcome.

Conclusions from this study indicate that while there are differences in some aspects of cognitive style, such as spatial ability, it could not be determined that learning style affects either learning outcome or satisfac`on in the use of a hypertext lesson. However, the design of navigation methods for presenting hypertext material, does significantly affect both learning outcome and the level of satisfaction in using such a method. Given the fairly small percent of variance explained, additional factors accounting for the variation in learning outcome should be explored in future research.

Introduction

Hypertext, described as nonlinear text or nonsequential writing (Conklin, 1987) provides a dramatic tool for enhancing computer-assisted learning. Lessons prepared with traditional computer-assisted instruction technologies are limited in their ability to address the needs of individual learners. With traditional methods the developer must have programmed the lesson to present the material with as many imaginative paths as possible. Instead of developing lessons for the typical learner, the use of hypertext technologies provides a "customizable" lesson that the learner may adapt to meet individual preferences. Matching the presentation method of a lesson with a student's preferred learning style can enhance learning outcomes and encourage a more active approach to learning (Smith and Rezulli, 1984). Throughout this paper, the term hypertext assisted learning (HAL) refers to the addition of hypertext to traditional computer aided instruction or computer assisted learning.

The interest in using hypertext in HAL lies in the ability to present large amounts of knowledge, and the ability to motivate students to seek that knowledge. Students are more likely to absorb concepts when given the opportunity to explore and experience these associated concepts. Early works in the hypertext field (Bush, 1945 and Nelson, 1974) postulated that students using hypertext might develop a more thorough knowledge of the subject and its connections with other areas of inquiry. Mayes et al. suggest hypertext improves learning because it focuses attention more on the relationships between ideas than on memorizing isolated facts. These associations, that could be symbolized through the linking capabilities in hypertext, facilitate remembering, concept formation, and understanding. Also, there is the possibility that the greater amount of control over the reading/learning process may increase involvement and desire to read and learn more (Mayes et al., 1990). A study that found persons preferred a computer-based hypertext presentation of information over a paper version confirmed this enhancement in learning (Shneiderman, 1989). The challenge is to design the hypertext presentation of information, with the associated links, to offer options that best match an individual students' preferred learning style.

Hypertext enhanced learning is different from text based CAI in that nonlinear, linked topics can be presented one way by the author, and then viewed differently by the learner. A primary strength of hypertext is the ability to browse, in a nonlinear style. Although an author can group topics and the interlinkages of ideas in one manner, the reader can examine ideas in a manner better suited to individual preferred modes of exploratory learning (Shneiderman, 1989). However, this structural diversity creates a problem with user disorientation and cognitive overhead, knowing what information is available, how to get there, and remembering where previous information is (Conklin, 1987). Thus, the very characteristics of hypertext that often make it desirable also cause learning problems for some students. One solution for these students may may be a guide, in the form of a graphical map, to make hypertext more effective for a wide diversity of learning styles.

Disorientation is the tendency to lose one's sense of location and direction in a nonlinear document (Conklin, 1987). The problem of disorientation is a function of having to know where you are in a network of associative paths, and how to get to some other place that you know (or think) exists in the network. Hypertext provides multiple paths in which to move, increasing the potential for the user to become lost or disoriented while searching for information. Information can easily become hard to find or even forgotten altogether. A solution for coping with disorientation is to use graphical maps, often called **browsers**. Browsers rely on the highly developed visuo-spatial abilities of the human visual and information processing system to help create and store a mental map of the pathways in a hypertext system (Conklin, 1987).

Cognitive overhead is the additional effort and concentration necessary to maintain several mental tasks at one time (Conklin, 1987). The problem of cognitive overhead occurs while reading hypertext, when presenting the reader with alternative paths to follow. These choices engender a certain overhead in decision making that is absent when the author already has made many of these choices for you. The problem can be eased by having a graphical map or browser showing the local subnetwork to which the link leads, and where the link originated.

While the use of hypertext has received considerable attention for the advantages it affords, all students are not assured of benefiting from such a method of learning. Each student has an individual learning style that may not benefit from the use of hypertext browsing. While some students prefer to learn by observation through listening and watching, other students prefer to learn with a more 'hands-on' approach of experimentation. The designer of a hypertext assisted lesson could include a learning aid that would match the different learning styles of students. David Kolb (1984) developed an inventory of four primary learning styles that categorize persons as one of four individual learning types.

In addition to the individual nature of learning styles, a major aspect of cognitive styles related to the presentation of hypertext learning aids is the spatial visualization ability of individuals. The cognitive overhead required in the navigation through a hypertext document places a demand on the visuo-spatial ability of the reader. This study addresses the interaction between these cognitive styles (learning style and spatial abilities) and the use of hypertext in exploratory learning of information.

<u>Problem Statement</u>

The purpose of this study was to investigate a user's ability to assimilate and use a mental map of information in order to navigate hypertext enhanced computer aided learning. This study assessed the relationship between cognitive style (Kolb's LSI and spatial ability) and various navigational mapping techniques, and their effect on learning outcome and learner satisfaction in a hypertext environment. Learning outcome and the subjective nature of the user's satisfaction were measured with a posttest questionnaire.

This research seeks to answer the general question; do individual cognitive styles or hypertext navigation methods affect learning outcomes or learner satisfaction? The general research question can be restated with the following specific questions:

(1) Does an individual's cognitive style (learning style and spatial ability) affect learning outcome or satisfaction level?
(2) Do navigational maps presented in a hypertext learning system affect learning outcome or satisfaction level?
(3) Are there <u>interaction effects</u> between cognitive style and navigational presentation methods provided on learning outcome and learner satisfaction?

<u>Overview of the study</u>

A document with material to be learned was created using four different presentation methods (Appendix A). Each version contained the same data and operated under the same hardware and software platform. HyperCard® on the Macintosh™ computer was used to provide a tool where information could be presented in a variety of computer formats.

The Kolb learning style inventory and paper folding test provided a means of categorizing students' cognitive styles. Subjects were sequentially assigned to one of four presentation methods based on their learning style. Students spent one hour learning material using one of the four presentation methods. A posttest on the material measured the quantitative learning outcome, and a questionnaire addressed the subjective nature of learner satisfaction.

The dependent variables used in the study were: (a) an objective measurement of learning outcome and (b) subjective measurements of learner satisfaction. The independent variables include: (a) the cognitive style of the learner, as measured by Kolb's LSI and spatial ability measured with the Paper Folding Test and (b) methods of presentation of material. There were four presentation methods used: linear text only, hypertext without a browsing map available, hypertext with a textual navigation map available, and hypertext with a spatial navigation map available. Univariate analyses of variance and covariance were used to test for significant differences in the means of the learning outcome scores and satisfaction levels between the different presentation methods and the individual cognitive styles. Specifically, a two-factor ANOVA was used to investigate presentation method and learning style with spatial ability specified as a covariate.

Literature Review

The use of hypertext systems, as an aid in enhancing computer aided learning systems, is the focus of this research. The foundation for this study is assessing individual cognitive style differences as measured by learning styles and spatial ability, and hypertext navigation methods. This section reviews previously reported studies and developments in computer aided instruction, hypertext systems, learning styles, and spatial ability.

Computer Aided Instruction

An increasing number of microcomputers available to students and schools shifted the emphasis from drill-and-practice to independent learning in a self-taught environment. A review of the literature revealed a number of research studies that utilized a cognitive or learning style assessment tool and a CAI treatment (Benbasat and Taylor, 1982; Robey and Taggart, 1981). Many previous research efforts have concentrated on the use of cognitive style on system design issues. These studies have examined learning style, field-dependency, and personality types such as the Meyers-Briggs type indicator. This line of research has found only limited success and the findings have been inconclusive.

Research into individual differences that influence learning via computer systems has looked mainly at educational backgrounds and issues. While cognitive factors have often been unable to predict learning performance by themselves, they were influencing factors in conjunction with training methods (Bostrom et al., 1987). In their study, Bostrom et al. predicted a strong interaction between a user's characteristics and the conceptual model used. There is considerable debate in education literature regarding the success of research into matching or tailoring instructional methods to suit individual needs. Many findings indicate that high ability subjects do well regardless of the method, while less-able subjects will benefit from tailoring the instructional approach (Cronbach and Snow, 1977).

Development of hypertext learning systems

The origins of hypertext may be traced to Vannevar Bush (1945) who predicted the problem of information explosion. He proposed Memex, a machine that would allow users reading one document to switch to associated material in another document. Bush based this concept on the assumption that human idea processing occurs through omnidirectional association. Memex would provide a method of storing and retrieving information to support human information processing more effectively.

The term "hypertext" first appeared in the writings of Ted Nelson (1974) who proposed creating a unified on-line system that would contain one's entire literary holdings. This system would only be practical by the use of his concept of using the nonsequential characteristics of hypertext. He envisioned hypertext as allowing readers to create personal browsing paths through information based on their own interests.

Although there are many hypertext systems available today, most have expanded on the earlier text-only versions and now provide graphics, sound, video, animation, and programming capability. One way to describe a hypertext system is to envision a database with a node-link network added to it. Each node is analogous to a window on a computer screen. A link is a word or icon highlighted in such a way that it provides the reader with forward or backward branching to other nodes. When the reader activates a link by selecting it with a mouse or a function key, a new window/node appears with the target information (Conklin, 1987). Unlike traditional linear text , such as information on paper, or hierarchical text like chapters and sections of a textbook, hypertext may be organized so that the reader may move from one *node* (a module of information) to another along any number of paths around the web by activating a visible *link*. This technique allows for what Carlson (1990) calls "three-dimensional navigation through the data." These non-linear links, via hypertext, provide information in themselves through the associations the reader creates about the different nodes.

Carlson (1990) classifies hypertext applications according to the cognitive activities that they support, reading and learning. Reading is goal-oriented information-seeking navigation through a large unstructured library of information via browsing through text. Learning is the use of hypertext to accommodate varying learning activities, varying the speed and structure of navigating the material in a personalized structure. This study investigates the use of hypertext in a reading for learning environment.

The relationship between hypertext and computer assisted learning seems contradictory at first glance. Hypertext by nature allows readers to follow links freely wherever they choose. Most CAL programs on the other hand, are based on the principal of programmed instruction whereby the next appropriate piece of information is presented to the learner when he/she has previewed prerequisite information. The most significant factor in applying hypertext to computer assisted learning is giving the learner control over the choice of material and the route through that material. As such, responsibility for the learning process is relinquished to the learner (Mayes, et al., 1990). The emphasis shifts from an *instruction* system to a *learning* system, thus the term HAL would accurately represent an emphasis on learning in a discovery or exploratory mode.

Although browsing in hypertext learning is often thought of as meandering through information, the added value of curiosity and the freedom of choice can not be undervalued (Duchastel, 1990). The learner has the freedom to follow either a specific path for a focused search of information, or an even less focused search based on open curiosity. Hypertext enhanced search of information then is a technological answer to an unabridged human curiosity for more information.

The added dimension of freedom of choice, or lack of structure, may cause problems for some learners. For some learners, the linear structure makes sense and is easier to use. The table of contents serves as a visual image of the structure of the material and as a map of where to go next. Not only does the table of contents serve as a mental map of the organization of the contents, but reading a given page in a book also establishes a reference point to where the reader is at any given time. In contrast, it may be difficult for some learners to form such a model of hypertext based structures. This difficulty causes the reader to become disoriented or "lost in hyperspace." Disorientation also leads to an additional problem, the extra mental effort required of the learner to navigate the complex structure requires cognitive overhead (Conklin, 1987).

Textbooks and traditional computer-aided instruction do not require the extra cognitive effort required of hypertext documents. The requirement of additional cognitive capacity may mean that information processing normally allocated to thinking about the material would be used in the processing of maintaining the hypertext structure (Mayes et al., 1990). Although Mayes suggests that the use of hypertext enhances the instructional process, the cognitive overhead and disorientation problems may offset these advantages for many learners. One challenge in designing hypertext learning systems is determining whether the cognitive overhead required to use hypertext is a significant factor in the effectiveness of such a system. Adopting a form of spatial visualization in the presentation to provide a navigational aid for some students could offset this problem by indicating conceptual relationships. The problem with providing such a system lies in designing an interface that would allow for a wide variation in visual ability. A user of a hypertext enhanced system needs to have a level of navigation aid consistent with his/her visual cognition. Such a system should also provide the ability to change the level or complexity of detail while navigating paths (Mayes et al., 1990).

A key aspect of this study is to investigate how cognitive style (learning styles and spatial cognition) interacts with the use of hypertext learning. For example, learners with high spatial ability may not need (or prefer) as much help developing a mental map as those with lesser abilities.

Learning Styles

The knowledge that all students do not learn in the same manner has led researchers to identify students' preferred learning styles. A learning style is part of an individual's cognitive structure and refers to the pattern of behavior and performance by which an individual approaches educational or learning experiences. Carl Jung was one of the first persons to use the concept of personality types to explain the different ways people perceive and process information (Kolb, 1984). Jung identified a person's orientation toward the internal (introverted) world of self, or the external (extroverted) world. Jung's second aspect of a person's orientation with the environment was to analyze how he/she perceives input from the environment through sensation or intuition. A third aspect was the way of processing that information, or judgement about that data via thinking or feeling.

Jung's work has served as the foundation for many theories in the areas of personality types, cognition, and learning styles. His research has been used to formulate numerous instruments to identify learning differences among individuals. Jung's work formed much of Kurt Lewin's "Field Theory" which suggests that human behavior is a function of a person and the environment (Kolb, 1984). Lewin believed that learning should be viewed in a four-stage cycle. The first stage, immediate concrete experience, forms the basis for the second stage, the observations and reflections about the experience. The third stage, the formation of abstract concepts and generalizations, focuses on the information gained in stage two and yields "theories" from which new implications of actions can be deduced. The fourth stage, testing these theories in new situations, guides the individual to new experiences, and then the learning cycle begins again, only this time with the added benefit of previous experience and knowledge (Kolb, 1984).

Lewin's theory had a major influence on David Kolb as he developed his "theory of experiential learning." Kolb's theory suggests that knowledge is developed through a transformation of experiences (Kolb, 1976, 1984, 1985). Kolb believes that these experiences require an individual to use combinations of four basic "learning modes":

1. Concrete Experience (CE) based on "feeling"
2. Reflection and Observation (RO) based on "watching"
3. formation of Abstract Conceptualizations (AC) based on "thinking"
4. Active Experimentation (AE) based on "doing"

The four-stage learning process reveals that learning requires abilities that are polar opposites, therefore the learner is forced to decide which set of learning abilities is needed to apply to each learning situation. When the four learning abilities (CE, RO, AC, AE) are represented in the experiential learning model they form two axes that represent the two primary dimensions of the learning process (Smith & Kolb, 1986).

The individual's "learning style" is a function of how the four modes are used. Kolb places these four modes in a two dimensional model; the active-reflective dimension and the concrete-abstract dimension. (See Figure 1) The concrete-abstract dimension places abstract conceptualization on one end of the learning mode and concrete experience on the other. This scale indicates how an individual perceives information. Persons who prefer to sense and feel their way through new experiences and information are located at the concrete end of this scale, and prefer the more tangible aspects of new experiences and information. On the other end of the scale, the abstract learner prefers to think about their experiences in an analytical method using symbolic methods. (Smith & Kolb, 1986)

Insert Figure 1 about here.

The active-reflective dimension places active experimentation learning mode on one end and the reflective observation on the other. This scale indicates how an individual processes the information perceived. Kolb believes that individuals have a favorite mode in each learning dimension. An individual with a score in the "active" portion of the active-reflective scale typically prefers to learn in a hands-on, learner controlled "doing" environment. A person with a score in the "reflective" portion normally prefers to learn by "watching" such as in a lecture setting. As with the concrete-abstract dimension, persons will be located throughout the active-reflective scale, and no score is identified as being better than another (Smith & Kolb, 1986). There is a dominant and a suppressed mode in each of the dimensions. Although an individual must draw on each of the four modes, when in a learning situation, a favorite will develop among the four and be developed further. This is what he calls the "learning style" of an individual. Kolb (1984) describes the characteristics of the four learning styles and environment from which an individual develops learning skills as follows.

Divergers. (low AC-CE and low AE-RO scores) The dominant learning abilities are concrete experience and reflective observations. These persons tend to be more oriented toward observation than action. The diverger's greatest strength lies in imaginative ability and awareness of concrete situations from many perspectives. This learning style does better in instances that call for generation of ideas such as a "brainstorming" idea session.

Convergers. (high AC-CE and high AE-RO scores) The dominant learning abilities are abstract conceptualization and active experimentations. The greatest strength of this approach lies in problem solving, decision making and the practical application of ideas. This style seems to do best using hypothetical and deductive reasoning, where there is a single correct answer or solution to a question or problem.

Accommodators. (low AC-CE and high AE-RO scores) The dominant learning abilities are concrete experience and active experimentations. Their greatest strength lies in doing things; carrying out plans and experiments and involving themselves in new experiences. They prefer new experiences and opportunities. Problems tend to be solved in an intuitive trial-and-error method, relying on other people for information rather than using their own analytical abilities. Accommodators excel in those situations where they must adapt to specific immediate circumstances.

Assimilators. (high AC-CE and low AE-RO scores) The dominant learning abilities are abstract conceptualization and reflective observations. Their greatest strength lies in inductive reasoning and the ability to create theoretical models. This style is less focused on people and more concerned with ideas and abstract concepts.

The Learning Style Inventory

Kolb developed an instrument to measure where an individual falls on the two (AC-CE and AE-RO) dimensions; the Learning Style Inventory (LSI). Using both linear scales, the intersection of the scores places an individual in one of the four quadrants in Kolb's LSI. (See Figure 1) Those in the concrete-active portion are referred to as "accommodators." In the concrete-reflective quadrant, individuals are referred to as "divergers." If the intersection of scores is in the active-abstract quadrant, individuals are a "converger," and in the abstract-reflective quadrant the term "assimilator" is used to characterize learning style preference.

Kolb first developed his Learning Style Inventory in 1976 and revised it in 1985. Using Kolb's instrument, responses to twelve self-administered, self-scoring questions can be tabulated to determine a score for each of the four learning modes. The 1985 instrument has twelve sets of four self-descriptive sentence endings, corresponding to the four learning modes. Subjects rank endings for each sentence from 1 to 4, where a 1 would be least descriptive of one's learning style and a 4 would best characterize one's learning style. Scores are then summed for each column (sentence ending) of each statement, giving a total for each learning mode. To determine preferred learning style, these four scores are combined by taking the abstract conceptualization (AC) score and subtracting the concrete experience score (CE), giving the AC-CE score, indicating 'thinking' vs. 'feeling' preference of learning. The active experimentation (AE) minus reflective observation (RO) score provides the AE-RO score, that indicates 'doing' vs. 'watching' preferences. By plotting each of these two combined scores on the LSI grid and drawing a corresponding line, the intersection point generated will fall in one of the four quadrants, representing an individual's dominant learning style.

Validity and Reliability of the LSI. The LSI has become one of the most commonly used measures of learning style. This section will address the validity and reliability of the LSI instrument. The 1985 version was revised to answer criticisms of the 1976 instrument. The revised version doubled the number of sets to be ranked, changed from ranking four word sets to completing sentences with four endings. These changes were designed to make the instrument easier to understand, and clarify the concepts being measured. Kolb used a larger sample to establish the 1985 statistics (n=268). Smith & Kolb (1986) report improved reliability in the 1985 instrument with a good internal reliability for the four learning modes and two combined scores as measured with Cronbach's alpha. (Kolb, 1985).

Spatial Ability

The art of navigating information systems is compared to navigating in the real world. It is necessary to maintain a sense of direction within an information system, much as one must develop an orientation to real world environments (Shum, 1990; Bolt, 1979; Canter, et al., 1985). The ability to assimilate and maintain a mental image of navigational paths is directly related to one's spatial ability. Spatial ability refers to a persons ability to manipulate or transform an image of spatial patterns into other arrangements (Ekstrom et al., 1976).

Hypertext is particularly associated with spatially demanding tasks: jumping from node to node, following a path in the hypertext web, and getting lost or disoriented while browsing a hypertext document. A person keeps an orientation with a cognitive map, or an orienting schema, that is a mental representation of information in a spatial arrangement. Downs and Stea (1973) define the development of a cognitive map where "an individual acquires, codes, stores, recalls and decodes information about the relative location and attributes of phenomena in his everyday spatial environment." This definition emphasizes that cognitive maps contain not only the information, but also the attributes about 'where' that information is, including how to get there and the environment around the 'place'.

Just as one develops a mental map of how to get to a familiar place, such as a local school or store, a hypertext reader also forms a mental map of how to get to a particular piece of information. Whether or not the development of such a cognitive map is contingent on the availability of a visual map is an aspect of this study. Downs and Stea (1973) distinguish two different ways by which hypertext readers develop this spatial information -- direct and vicarious. Direct source of information refers to experiencing and personalizing information in what is called a 'learning by doing' method. Vicarious sources are gained by second-hand information, such as a graphical map or narrative description. A vicarious source is one that is provided by someone else through a graphical browser or graphical map. This second method makes it possible for a learner to form a mental map of what is available without having to visit each node, made possible through a visual display that is part of the software program. An example of this idea would be supplying a map of the structure of the links and nodes. Often these maps function as an interactive menu with the map of the nodes serving as buttons to link the nodes together.

It is a natural human propensity to impose structure on everyday concepts. Just as it is natural to describe everything as "on top of...," or "just east of ...," etc., it also is natural for human processing to impose structure on information sources. Thus in a hypertext environment, the use of an absolute reference (such as a page number) would not be as efficient as using names of nodes in a cluster arrangement. For example, in the hypertext version of Jakob Nielsen's Hypertext '87 Trip Report, (Nielsen, 1988) a reader selects one of several topic clusters, and then a particular topic under that cluster. It is easy then, for readers to remember that they selected the cluster "Hypertext Systems" and the topic "HyperCard."

The Paper Folding Test

Spatial ability can be evaluated and measured with a variety of instruments. One of the most consistent and reliable instruments used in recent spatial research has been the Paper Folding Test, part of the Kit of Factor-Referenced Cognitive Tests. The spatial orientation and visualization tests originated from the work of L. Thurstone and H. A. Witkin (Smith, 1964; Ekstrom, et al., 1976).

The visualization and spatial orientation measurements offered in the Kit of Factor-Referenced Cognitive Tests measure much of the same spatial abilities as the cognitive factors. However, the visualization test requires more mental restructuring, and therefore, reflects a more significant element of spatial orientation. Cattell (1971) suggests that the visualization factor test is actually a second-order factor and includes spatial ability. Carroll (1974) notes that the visualization test requires the subject to do additional serial operations in addition to simple mental rotation of spatial images (Ekstrom, et al., 1976).

The Paper Folding Test presents the subject with an illustration of a piece of paper with two or three folds (indicated by dashed lines) and with a hole punched in it after the last fold. The subject then is asked to select one of five drawings that shows the correct version of how the paper would look like when unfolded (Ekstrom, et al., 1976). This test is designed to measure an individual's ability to visualize and manipulate an image of spatial patterns (Ekstrom, et al., 1976).

Reliability of the Paper Folding Test

Statistical data provided with the manual for the Paper Folding Test gives reliability figures from two different studies. A study of 46 college students reported a mean Vz-2 score of 13.8 and a Cronbach's alpha value of .84. In another study of 82 Army enlistees, a mean score of 10.4, also with a Cronbach's alpha value of .84 was found (Ekstrom, et al., 1976).

Research Method

This study compared the interactions of cognitive style (as measured by learning style and spatial ability) and the availability of navigation maps in the use of hypertext assisted learning. The cognitive styles of students were correlated with various presentation methods within a predefined map of information. This section describes (a) the general research questions, (b) subjects, and their assignment to an experimental group, (c) the measurement of cognitive style (Kolb's LSI and spatial ability Vz-2), (d) the treatment methods of presentation of material, (e) the measurement of both the objective and subjective data, and (f) design and analysis procedures. The resulting design is represented graphically by Figure 2.

Insert Figure 2 about here.

General Research Questions

Three research questions were addressed: (1) Does cognitive style (learning style and spatial ability) affect learning outcome or user satisfaction in hypertext assisted learning? (2) Does the presentation method of navigational maps affect learning outcome or user satisfaction in hypertext assisted learning? (3) Are there interaction effects between cognitive styles and method of presentation which affect learning outcome or user satisfaction in hypertext assisted learning?

To answer the research questions, this study investigated the interactions between cognitive styles and navigation maps in hypertext assisted learning. Cognitive styles were measured considering two aspects of interest in this study; learning styles and spatial ability. Learning outcome and user satisfaction were used as dependent variables in an analysis of the interaction of learning styles and mental map aids in the design of hypertext documents used for exploratory learning. Table 1 provides a summary of variables used in this study. The research questions above were addressed by first analyzing learning outcome scores, and then analyzing satisfaction levels for each of the questions.

Insert Table 1 about here.

Hypotheses and Expected Results

The experimental design described in the following sections will be used to test the null hypotheses listed below. The three general research questions are restated into specific statistical hypotheses, each dealing alternatively with learning outcome, and then the factor scores of satisfaction levels for each general research question.

$H1_{\emptyset}$. Learning Style Differences. *There are no significant differences in outcome measures or satisfaction level among different learning style groups of students.* This could be stated as $H1_{\emptyset}$: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ where μ_i represents the mean of the outcome measure for one of the four learning style groups. Learning style differences are analyzed as a main effect in an ANOVA analysis.

If rejected, this hypothesis suggests that students with different learning styles will perform differently within this study. Specifically, it is predicted that those in the reflective - abstract mode (assimilators) will tend to prefer a lecture over a computer, and thus may not learn as well with the material presented in this research.

$H2_{\emptyset}$. Spatial Abilities. *There are no significant differences in the means of learning outcome or satisfaction level among different spatial abilities of students.* This could be stated as $H2_{\emptyset}$: $\beta_1 = 0$ where β_1 represents the linear relationship between spatial ability and performance on the dependent variable. Spatial ability is measured with the paper folding test and analyzed as a covariate in an ANOVA analysis.

The alternative hypothesis suggests that students with higher spatial abilities will tend to score higher on the objective outcome measure, and will be more satisfied with a hypertext system, than those with low spatial ability.

$H3_{\emptyset}$. Presentation Methods. *There are no significant differences in the means of learning outcome or satisfaction level among different presentation treatment method groups of students.* This could be stated as $H3_{\emptyset}$: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ where μ_i represents mean of the outcome measure for one of the four treatment method groups for the presentation of the material. Presentation method is analyzed as a main effect in an ANOVA analysis.

It could be expected that presentation methods three and four will produce better learning outcomes, if for no other reason than it helps students of all learning styles to create and use a structure of the material.

$H4_{\emptyset}$. Interaction Effects. *There are no significant interaction effects between learning style and treatment method in their effect on learning outcome and satisfaction level.* The interaction of learning style and treatment method is $H4_{\emptyset}$: $\mathrm{All}(\mu_{ij} - \mu_{i.} - \mu_{.j} + \mu) = 0$ that states for all treatment groups, when you subtract the effect of learning style ($\mu_{i.}$) and the effect treatment method ($\mu_{.j}$) from the total effect (μ_{ij}), and then add in the total μ, the remaining value should be zero. The interactions between learning styles and treatment groups are analyzed as the interaction effect in an ANOVA analysis.

It is expected that students' learning style will interact with a particular presentation method in such a way to improve or degrade the learning performance and satisfaction levels. For example, those students on the reflective end of the AE-RO scale, would not learn as well with a hypertext system as much as with a sequential linear or hierarchical presentation.

Subject population

The subjects of this study were 282 undergraduate students enrolled in introductory Computer Science courses. The selection of students at this level as subjects for this study was based on the assumption that they would have at least a passing interest in a hypertext lesson, while at the same time have little or no previous exposure to the topic. Each student completed two instruments of cognitive style: a learning-style inventory (Kolb's LSI) and a paper folding test for spatial ability (Vz-2).

Measurement of cognitive style

Kolb's LSI. The Kolb Learning Style Inventory (1985 version) was used to measure each subject's dominant learning style. The 1985 version of the LSI is a 12-question, one-page instrument with 12 sentences, each with four different ending statements corresponding to the four learning modes. Each set begins with a sentence like "I learn best by:" followed by four sentence endings such as; "a. feeling, b. watching, c. thinking, d. doing". The subject assigns a value of 4 to the ending that best fits their preferred method of learning. The remaining three are assigned a value of 3, 2, or 1, corresponding to decreasing values for their preferred method of learning.

After ranking the four endings for all 12 sentences, subjects scored the LSI by totaling the values assigned for each column. Each column corresponds with one of the four preferred learning modes. These four column totals indicate the emphasis each student places on the four learning stages as an approach to learning. These four scores were then combined to show the respondent's emphasis of abstract conceptualization over concrete experience, and active experimentation over reflective observation. These two combined scores are plotted on the Learning-Style Type Grid. The intersection point of the two modes will fall in one of the four quadrants and identify the subject's preferred learning style.

The Paper Folding Test. The Paper Folding Test, a variation of Thurstone's "Punched Holes" test, measures an individual's spatial ability. A piece of paper is presented to the subject with illustrations of two or three folds (indicated by dashed lines) and with a hole punched in it after the last fold. The subject then is asked to select one of five drawings that shows the correct version of how the paper would look like when unfolded. The student had three minutes to complete the first 10 drawings, and another three minutes for a second set of 10 drawings. The score of the Vz–2 was calculated by adding one point for each correct selection, and subtracting 1/5 point for each wrong selection.

Treatment Methods

There were four groups of students different methods of presentation of information (Refer to Figure 2). All four groups were provided with the same information, differing only in the amount of hypertext links and navigational maps. The material presented was a copy of Jakob Nielsen's "Trip Report of Hypertext '87." (See Appendix A) provides sample screens of these groups) The four text treatment groups are: (1) sequential text only, with only a page forward, page back, or return to the table of contents available. (Appendix A-1) (2) a hypertext version of the report with buttons available to move to other parts of the report, but without mapping to information available. (Appendix A-2) (3) a hypertext version of the report, with a textual map visible on the screen that not only served as a map, but also as a menu to select other parts of the report, (Appendix A-3) (4) a hypertext version of the report, with a spatially organized map visible on the screen that served as both a map and as a menu to select other parts of the report. (Appendix A-4) All of the methods were presented with an Apple Macintosh HyperCard stack.

The HyperCard stacks were modified so that all of the text material was identical, with the only difference being hypertext navigation options. The selection of this stack was made for a number of reasons. First, the second and fourth treatment methods were already available, with only minor modification necessary. Secondly, the material in the report should have been of interest to computer science students, who had little or no previous knowledge of the subject matter -- providing approximately equal base knowledge level. Random assignment to treatment conditions also helped ensure balance of initial topic knowledge. A posttest only design eliminated pretest sensitivity potential threat to the internal validity of the study.

Subject assignment to treatment method

Upon completion of the cognitive style tests, the students were sequentially assigned to one of four different presentation methods after they were classified into one of the learning style groups. This method of assignment assured an approximately equal number of subjects from each learning style in the four different treatment groups. A total of 282 students took part in the study. The subjects were given one hour to complete the study. This time allocation was calculated from a pilot-test conducted on a group of twelve students. The pilot test asked students to take the Kolb and Vz-2 tests, study the material, and complete the objective questions on the material and subjective questionnaire. In the pilot-test, students were given one hour to complete the study and were asked approximately how much of the material they were able to study thoroughly. The one-hour time limit was found to be adequate for the material to be covered in significant detail.

Measurement of learning outcome

Learning outcome was measured by a 20 question, posttest questionnaire based on the material, which resulted in a single score. Operationalized, this score was the number of correct answers, minus .2 for each incorrect answer. Questions were developed from direct quotations in the material and presented in a multiple choice format. All questions given included a fifth choice "I don't know" as an option to reduce guessing. This was an effort to collect an accurate measure of the amount of material learned and comprehended from reading the material. Questions also were included in the pilot-test to both evaluate readability and to assess the assumption that this population of students had little or no knowledge of hypertext. Students in the pilot group reported that they understood the questions, and in addition had no prior knowledge of hypertext.

Reliability of Learning Outcome Measure. A Kuder-Richardson 21 reliability test was run on the completed questionnaire from 282 actual subjects. A K-R 21 score of .65 on the aggregate data suggests satisfactory reliability. If the questionnaire were to be used for a second or follow up analysis, a K-R 20 and individual item analysis would be calculated to revise the survey and improve its overall alpha value.

Measurement of satisfaction level

A questionnaire collected (a) demographic information about the student and his/her prior computer experience and (b) the satisfaction level from having used the method of presentation of that material. Questions concerning user satisfaction measured satisfaction (or dissatisfaction) with various aspects of the text presentation. Satisfaction level was measured with a questionnaire of 12 questions with five point Likert scale responses. Those 12 questions asked for responses in four general areas; general satisfaction, satisfaction with the text structure, disorientation effects caused by hypertext links, and satisfaction with the material itself.

Factor Analysis on Satisfaction Variables. A factor analysis performed on the 12 satisfaction variables produced four factor scores, each relating to the four general areas of satisfaction. Therefore, when analyzing satisfaction levels, the analysis considered these four factor scores instead of the actual 12 questions concerning satisfaction. (See Table 3 and Table 4) Using factor scores in place of individual questions, provides a way of summarizing a composite view of the user satisfaction dimension. These factor scores provide independent measures of satisfaction rather than using sets of questions that would not necessarily be independent.

Insert Table 3 and Table 4 about here.

As Table 3 shows, four factors had eigenvalues greater than 1.0, cumulatively explaining two thirds of the variability. The factor matrix (See Table 4) identifies the four factors which were converged in 6 iterations by a Varimax rotation. Factor 1, (questions 1, 5, 8, 10, and 12) are those questions asking about general satisfaction with the the lesson. Factor 2 (questions 3, 9, and 11) were those reflecting the text structure and thus the ability to choose the order by which to view the material. Factor 3 (questions 2 and 4) reflected the amount of disorientation caused by the hypertext movement. The fourth factor, (questions 6 and 7) measured the extent to which the student enjoyed reading about the material in the lesson.

Jakob Nielsen (1990a) supports the use of user satisfaction as one measurement of software usability. Satisfaction was used in his research to determine whether a particular method of a hypertext lesson was preferred by a particular learning style, and would thus have a greater probability of being used. This was based on the assumption that a user will use a program if he likes that method of presentation and/or navigation techniques.

Reliability of Satisfaction Measures. An analysis of 282 student responses to the 12 satisfaction questions produced a .85 Cronbach alpha value. Thus, the use of these satisfaction questions and the resulting four factor scores is considered an acceptable reliability level.

Operational view of the variables:

The independent variables are Cognitive Style as measured by the LSI and Vz-2 and the Treatment Method.

LSI. The LSI is measured with an interval scale that determines a nominal assignment to one of four quadrants and identify the subject's learning style.

Vz-2. The Vz-2 is measured with an interval score. Often referred to as the Paper Folding Test, the Vz-2 presents the subject with drawings illustrating a series of two to three folds in a square piece of paper and a hole punched in the paper after the last fold. The subject then is asked to select one of 5 drawings that shows the correct version of how the paper would look when unfolded. The subject has three minutes to complete the first 10 drawings, and another three minutes for a second set of 10 drawings. The score of the Vz–2 is calculated by adding one point for each right selection, and subtracting 1/5 point for each wrong selection. This results in a maximum possible score of 20 and a minimum of -4 (Ekstrom, 1976).

Treatment Methods. (See Appendix A) The treatment method also will be a nominal scale with four methods identified. All four will differ only in the presentation method of the material. The four text treatment groups are: (1) Linear/sequential text only, with only a page forward, page back, or return to the table of contents available. (2) A hypertext version of the report with buttons available to move to other parts of the report, but without any visual map of the structure of the information available. (3) a hypertext version of the report, with a sequentially/vertically organized interactive map available at all times that will not only serve as a map, but also as a menu to select other parts of the report, and (4) a hypertext version of the report, with a spatially organized interactive map available at all times that will serve as a map and as a menu to select other parts of the report. All of the methods will be in the form of a HyperCard stack with identical text material, differing only in navigation options.

The dependent variables are both constructed and interpreted using interval scales. There are two separate categories of the dependent variable measures. Learning outcome is measured by taking a posttest of twenty questions that were based on the material presented in the lesson. Questions were constructed directly from each major section in the hypertext document. The level of satisfaction measured the student's subjective response to the treatment method. Specifically 12 questions measuring the subjects response to the major issues in hypertext navigation, such as disorientation, ability to keep a mental map, and whether they prefer to follow a linear path, or have associative paths to follow. A factor analysis identified four dimensions of satisfaction and these four factors were used to measure satisfaction. Both independent and dependent variables are summarized in Table 1.

Study Design: The experimental design used to examine learning outcome and learner satisfaction is the "Posttest Only Design." (Campbell and Stanley, 1963). In addition, for this research, each treatment group serves as a control for the next, by holding constant factors in the previous method and adding one additional treatment variation. For example, the first treatment method, linear presentation of the text only without hypertext measures factors without associative linking effects. The second treatment method, hypertext without a map, provides a method for measuring the effect of associative links. The third method assesses the impact of adding a navigational map and the fourth method assesses the additional impact of a spatially organized navigational map.

The resulting study can be demonstrated with a three-dimensional diagram (refer to Figure 2). The analysis required a 4 X 4 + covariate ANOVA design. The main effects of the ANOVA are Treatment Method and Learning Style, with Spatial Ability serving as a covariate in an analysis of covariance.

Results

Multiple ANOVA procedures were conducted for each of the dependent variables. For example, to test the first null hypothesis, "*There are no significant differences in learning outcome or satisfaction level among different learning style groups of students.*" an ANOVA procedure was used to indicate the amount of variance of a student's learning outcome between cognitive styles, and separate ANOVA procedures were used for each of the satisfaction factors. The sums of squares for each of the independent variables (Method, and LSI) were the main effects, while the interactions between them were tested separately. Hypotheses were tested by the ratio of the mean squares of each source of variation variable to the mean square for the residual. In addition, the use of a covariate (a student's spatial ability) was added to adjust the measurement of the main effects to account for that aspect of cognitive style. For this research, a significance level of .05 was used. The data were analyzed to address the four hypotheses given in the preceding section. Each of the hypotheses were addressed in five stages, first as they relate to learning outcome, and then in regard to satisfaction levels measured by the four satisfaction factor scores.

Learning Outcome and Satisfaction Factor Score Means

The mean scores for learning outcome and the four satisfaction factor scores are presented in Tables 5 and 6. These tables will be used in the analysis of the data reported in this chapter and interpreting these results in the following chapter.

Insert Tables 5-12 about here

Learning Outcome Scores. The learning outcome score means for each of the study design groups are presented in Table 5 along with the number of subjects in each group and the standard deviation for each group. As indicated in the table, the mean score of divergers ($\mu = 8.25$) was the highest of the four LSI types. Presentation Method 1 had the highest overall mean score ($\mu = 8.81$).

Satisfaction Factor Scores. The factor scores generated in the factor analysis of satisfaction questions for each of the study design groups are presented in Table 6. Data in this table will be used throughout this chapter and the next two in the analysis of learner satisfaction means.

Summary of Results

The initial results of the statistical analysis are summarized for of each of the four hypotheses, with the four dependent variables (learning outcome, general satisfaction, satisfaction with text structure, disorientation effects, and satisfaction with the material content) listed for each hypothesis These results are presented in Table 7. As described in the previous chapter, the method of analysis first used an ANOVA procedure, matching the study design in Figure 2. Method of presentation and learning style were used as the main effects on learning outcome with spatial ability (Vz-2) used as a covariate. The remainder of this chapter will address the statistical results for each of the dependent variables for each hypothesis.

H1$_\varnothing$ Learning Style Differences

Learning Outcome among Learning Styles. As shown in Table 8, differences among the mean scores between learning styles ($F_{3,265} = .899, p = .442$) were not significantly different. Thus the first part of H1$_\varnothing$, that there would be no significant differences of learning outcome scores among learning styles, can not be rejected, and the alternate hypothesis can not be supported.

Satisfaction among Learning Styles. As described in the previous chapter, learner satisfaction was measured with four factor scores. Thus, to test the second part of the first three hypotheses, four separate ANOVA procedures were used for each of the satisfaction factors.

General satisfaction; as shown in Table 9, differences in general satisfaction between learning styles were not significant. ($F_{3,265} = .285, p = .836$) Satisfaction with Text Structure; Table 10, indicates differences in satisfaction with the structure of the text, between learning styles ($F_{3,265} = .778, p = .507$) were not significantly different. Disorientation Effect; differences in satisfaction levels between learning styles as affected by the amount of disorientation were not significantly different, $F_{3,265} = .584, p = .626$. (See Table 11) Satisfaction with Material Content; as shown in Table 12 differences in satisfaction with material content between learning styles were not significantly different. ($F_{3,265} = .195, p = .900$)

As indicated by the four ANOVA tables, the second part of H1$_\varnothing$, "*there would be no significant differences of satisfaction levels among learning styles*", could not be rejected, and the alternate hypothesis can not be supported.

H2$_\varnothing$ Spatial Ability Differences

Learning Outcome and Spatial Ability. As shown in Table 8 differences among the mean learning outcome scores based on spatial ability (the covariate Vz-2) were not significantly different. ($F_{1,265} = .559, p = .455$) Thus the first part of H2$_\varnothing$, that "*there would be no significant differences of learning outcome scores among different spatial abilities*", can not be rejected, and the alternate hypothesis can not be supported.

Satisfaction and Spatial Ability. As in the previous section, learner satisfaction based on differences in spatial abilities, were analyzed using the four separate ANOVA procedures for each of the satisfaction factors.

General satisfaction; as shown in Table 9, general satisfaction between different spatial abilities (the covariate in the ANOVA) indicated significant differences. ($F_{1,265} = 6.941, p = .009$) The correlation between general satisfaction and Vz-2 is quite significant ($p = .005$) and is also a negative correlation. Satisfaction with Text Structure; Table 10 indicates differences in satisfaction with the structure of text, between different spatial abilities ($F_{1,265} = 2.775, p = .097$) were not significantly different at the .95 significance level. However, with a 90% significance level, it would be of some benefit to look at the differences that were shown. The correlation coefficient indicated a slightly negative correlation between Vz-2 and the second factor score at a significance level of .052. Disorientation Effect; differences in disorientation levels between different spatial abilities were significantly different. (See Table 4.7) ($F_{1,265} = 7.007, p = .009$) A correlation coefficient of

-.1542 at p=.005 indicates a significant difference among spatial abilities. However the fact that the correlation is so small and in the opposite direction than one would expect, suggests that the correlation is not one which would affect differences in learning with a hypertext document. Satisfaction with Material Content; as indicated in Table 12, differences in satisfaction with material content between spatial abilities were not significantly different. ($F_{3,265}$ = 2.405, p =.122)

Therefore, the second part of $H2_{\emptyset}$, "*there would be no significant differences of satisfaction levels among spatial abilities*," produced mixed results, with at least some support for differences in satisfaction levels by spatial ability. General satisfaction, and disorientation indicate significant differences among differing spatial abilities. Satisfaction with the flexibility of hypertext is supported at the 90% confidence level, while spatial ability appears to have little effect on satisfaction with the material content.

$H3_{\emptyset}$ Presentation Method Differences

Learning outcome scores and Presentation Method. The differences among these means were significant ($F_{3,265}$ = 2.983, p=.032), (See Table 8) although accounting for a very small portion (3%) of the difference among learning types. A multiple range test using a Duncan Procedure identifies the differences between Presentation Method 1 and the other three as being significant at the .05 level. The mean scores of those subjects who were presented with Method 1 (μ = 8.81), were higher than for those who were presented with hypertext, with or without a graphical map (μ = 7.51, 7.30, and 7.38 for Methods 2, 3 and 4 respectively). These results indicate that the first part of $H3_{\emptyset}$, stating "*there would be no significant differences of learning outcome scores among presentation methods*", can be rejected, and an alternate hypothesis supported.

Satisfaction Level and Presentation Method. To analyze the relationship between learner satisfaction levels and the method of presentation of hypertext material, four separate factor scores were studied.

General satisfaction; An analysis of variance of general satisfaction (Table 9) ($F_{3,265}$ = .538, p=.657) indicates that presentation method did not account for a significant difference in general satisfaction level.

Satisfaction with text structure. There is support of a significant difference ($F_{3,265}$ = 5.883, p=.001) in the satisfaction with text structure among presentation methods. (Table 10) A Duncan Procedure for a multiple range test identifies a significant difference at the .05 level between a text only presentation method and those providing hypertext. The text only presentation method was the only method with a negative mean score for the second factor score relating to hypertext. This result however is in keeping with expectations since the text only presentation did not allow hypertext jumps. Figure 5 indicates the differences between presentation methods and general satisfaction. There is a clear distinction of satisfaction with a lesson presented with a hypertext format. This difference, however, is a factor of the interaction between method of presentation and learning style which is discussed in the next section.

Disorientation effect on satisfaction. The amount of disorientation increased with the amount of hypertext provided. (See Figure 5) These differences in the amount of disorientation were significant ($F_{3,265}$ = 4.819, p=.003) and account for about 5% of the variance. (Table 11) A multiple range test using the Duncan procedure indicates a significant difference between a textual presentation method and those with hypertext links. In addition, the means for the disorientation effect by presentation method indicate the increasing amount of the effect as the amount of flexibility is provided.

Satisfaction with Material Content. Table 12 indicates a significant difference ($F_{3,265}$ = 5.530, p=.001) in the satisfaction with the actual material being presented. As Figure 6 illustrates, students were dissatisfied with the linear text only presentation, and more satisfied with a hypertext map using a spatial navigation map. A multiple range test using the Duncan procedure shows the significant differences between a textual presentation method and both versions of navigation methods in a hypertext lesson, and also a difference between a simple hypertext lesson and a spatial navigation map. The means of these methods indicate a positive satisfaction with hypertext with either form of a map and a negative satisfaction level for textual presentation only.

Thus, the second part of $H3_{\emptyset}$, "*there would be no significant differences of satisfaction levels among presentation methods*," can be rejected and an alternative hypothesis supported. Although there was not a significant level of difference in general satisfaction, there clearly were significant differences between textual presentations and hypertext based methods.

$H4_{\emptyset}$ Interaction effects

Interaction effects between Learning Styles and Presentation Method. There are two aspects of interaction effects that we are interested in, the affect on learning outcome and on satisfaction levels. As indicated in Table 8 there was no support for a significant difference in learning outcomes and any interaction effects between learning style and presentation methods.

The second aspect of $H4_{\emptyset}$, "*There are no significant interaction effects between learning style and treatment method in their effect on satisfaction level*," requires an analysis of several aspects. Analysis of variance of the general satisfaction level ($F_{9,265}$ = 2.412, p=.012) indicates a significant difference in the interaction effects between learning style and presentation method accounting for 7% of the variance. (See Table 9) At the same time, an analysis of the other three satisfaction factor scores do not indicate a significant difference in the interaction effect.

Figure 3 illustrates a wide difference between general satisfaction with hypertext lessons between students who prefer active experimentation (convergers and accomodators) and those who prefer reflective observation (assimilators and divergers). As the line chart shows, there does appear graphically to be a distinction between these two groups in their preference of presentation methods when hypertext is involved. In addition, as multiple range tests using the Duncan procedure (See Tables 10, 11, and 12) indicate, a significant difference between the satisfaction levels with a text only presentation method and the use of hypertext. In all three cases, students indicated a higher level of satisfaction with some form of the use of hypertext.

Insert Table 13 about here

Summary of results

To summarize the results of the statistical analysis, Table 13 lists the *p* values for each of the dependent variables, for each hypothesis. The results for each of the hypothesis are next summarized according to the statistical hypotheses.

$H1_{\emptyset}$. *There are no significant differences in outcome measures or satisfaction level among different learning style groups of students.*

There was no support for a significant difference in the learning outcome or satisfaction levels based on Kolb's Learning Style Inventory. Thus the null hypothesis can not be rejected.

$H2_{\emptyset}$. *There are no significant differences in the means of learning outcome or satisfaction level among different spatial abilities of students.*

There was no statistical support for differences in learning outcome based on a students spatial ability. Satisfaction levels however did have some statistical support for a significant level of difference based on spatial ability. Thus, the null hypothesis relating to learning outcome can not be rejected. The null hypothesis relating to satisfaction levels based on spatial ability however can be rejected and conclusions made about the spatial ability and its affect on satisfaction with a learning system.

$H3_{\emptyset}$. *There are no significant differences in the means of learning outcome or satisfaction level among different treatment method groups of students.*

There were statistically significant differences in both the learning outcome and satisfaction levels based on presentation methods. The null hypothesis can be rejected and conclusions made about the impact of method of presentation on learning with a hypertext assisted lesson.

$H4_{\emptyset}$. *There are no significant interaction effects between learning style and treatment method in their effect on learning outcome and satisfaction level.*

There was no support for statistical differences in learning outcome based on the interaction effects between learning style and methods of presentation. There was statistical support for significant differences in the interaction effects between learning style and methods of presentation on learner satisfaction levels.

Discussion of Findings

This study investigated the interactions between cognitive styles (measured by learning styles and spatial ability) and navigation maps in hypertext assisted learning. Learning outcome and user satisfaction were used as dependent variables in an analysis of the interaction of learning styles and mental maps in the design of hypertext documents used for exploratory learning.

Three research questions were addressed: (1) Does cognitive style (learning style or spatial ability) affect learning outcome or user satisfaction in hypertext assisted learning? (2) Does the presentation method of navigational maps affect learning outcome or user satisfaction in hypertext assisted learning? (3) Are there interaction effects between cognitive styles and method of presentation which affect learning outcome or user satisfaction in hypertext assisted learning? This section will address each of the three general questions.

Does cognitive style, either learning style or spatial ability, affect learning outcome or user satisfaction in hypertext assisted learning? This question was addressed in two parts, first the effect of learning style and spatial ability on learning outcome, and then the level of satisfaction. The lack of support for learning style having any effect on learning outcome or user satisfaction was rather unexpected. As indicted in the literature review, there has been much research on the affects of learning styles on various learning environments. In addition, there has been support for Kolb's learning style inventory as an indicator of differences in learning in previous research. However, as Huber proposes, there are more variables involved in cognitive styles than we currently know, and therefore any positive results in the area may be of limited use. The definition of Kolb's learning styles as a measurement of a student's 'preferred' learning modes, would indicate that the LSI would be a valid measurement of the amount of satisfaction from different learning. However, one other factor which may affect learning outcome and satisfaction is the amount of time necessary to learn 'how-to-learn' in a hypertext environment. In addition, by its nature hypertext's strengths and weaknesses do not become apparent until the size of a document becomes larger than one can maintain in a mental map.

Spatial ability, while not having a significant effect on learning outcome, did provide significant differences among learners. Previous studies using the Paper Folding Test have also found it to be quite accurate in measuring differences in the use of computers. It is not surprising that a person's spatial ability affects satisfaction with a specific interface. What is more difficult is to identify what types of presentation methods are best matched to different individuals.

Does the presentation method of navigational maps affect learning outcome or user satisfaction in hypertext assisted learning? Perhaps the most helpful findings of this study are the importance of the design of the presentation method of a learning environment. The response of this study to this particular question provides two different results. First, while not significantly different, learners had a higher learning outcome with a text only document. At the same time, students reported a significant level of difference in their satisfaction level among the four learning methods. There was a definite separation of active experimentation learners from reflective observation learners in the level of satisfaction. While those who preferred reflective observation were less satisfied with the use of hypertext links, they were more satisfied with hypertext documents when provided with a navigation map. This indicates that when care is taken to provide assistance in a hypertext learning process, differences among different learning styles are reduced. Therefore, this research concludes that while learning outcome was higher for non-hypertext methods, the satisfaction with hypertext indicates the potential of such systems, provided an effective interface design.

Are there interaction effects between cognitive styles and method of presentation which affect learning outcome or user satisfaction in hypertext assisted learning? Learning outcome was not affected by interactions between cognitive styles and methods of presentation. In addition, specific aspects of satisfaction (preference for hypertext, and disorientation) also lacked support for interaction effects. However, a student's general level of satisfaction with a method of a hypertext learning environment did have a significant difference in the amount of interaction effects. This would imply that there is some support for further research into what specific cognitive design issues are important for future interface design of hypertext navigation maps.

<u>Limitations of the study</u>

In order to accurately measure aspects of hypertext learning such as disorientation and differences in learning outcome, the hypertext document must be of a large enough nature to cause the cognitive overhead to require specific assistance from the learning system. Such was not the case of this study. Instead, as with much research, the need for controlling time and effort spent among students, required that the size of the material be kept to a manageable size. The use of a large document (more than 1,000 nodes of information) might have created a more significant level of difference in both learning outcome and satisfaction. Another limitation was that the level of technical detail and nature of the material included in the lesson may not have been appropriate for an introductory computer class. In addition, satisfaction with the lesson presentation was measured in general terms for each of the areas of interest. For example, the satisfaction questions dealing with disorientation only measured the general amount of disorientation. Further details about specific aspects of what caused disorientation would help in the analysis of the results.

In hindsight, a larger hypertext document, with simpler concepts of specific interest to this population of students may have produced significantly different results. More specific information on satisfaction variables, and what level of learning was achieved, would greatly enhance the findings of a study such as this.

<u>Conclusions and Implications</u>

Conclusions from this study indicate that while there are differences in some aspects of cognitive style, such as spatial ability, it could not be determined that learning style affects either learning outcome or satisfaction in the use of a hypertext lesson. However, the design of navigation methods for presenting hypertext material, does significantly affect both learning outcome and the level of satisfaction in using such a method.

Implications for the use of hypertext in different applications are evident. First, there are some differences in cognitive style which affect the success of such a system. Therefore, while this study, and many others to-date, have not definitively identified which of those cognitive style aspects hold the most potential for improving learning, there is support of the need for future research. Specifically, user satisfaction has been shown to be a successful indicator of learning success in other environments. Clearly, satisfaction is affected by the interface method provided with a learning system. Therefore, when contemplating the design of the user interface of both hypertext documents and learning environments, more information on specific, critical issues that have a significant affect on the success of that system would be of interest to designers.

Secondly, the design of the presentation method of the material did have a statistically significant affect on the learning outcome of a lesson. Therefore future research should continue to identify those aspects of a user interface which would improve the learning outcome for students.

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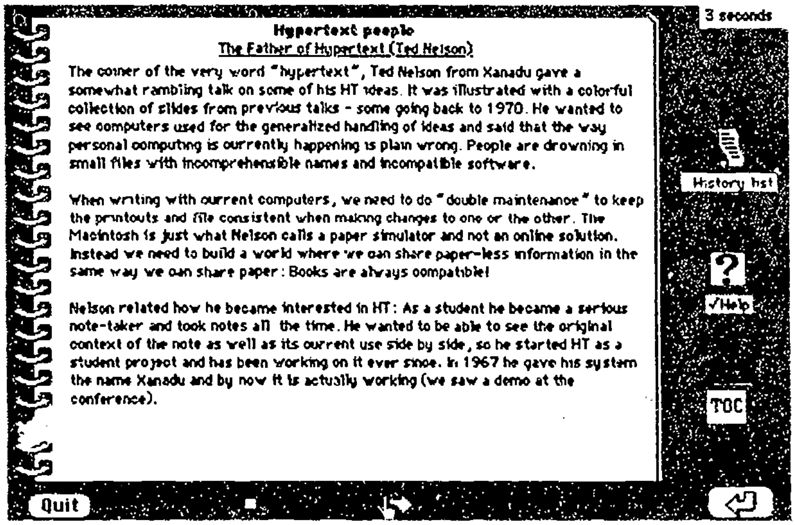
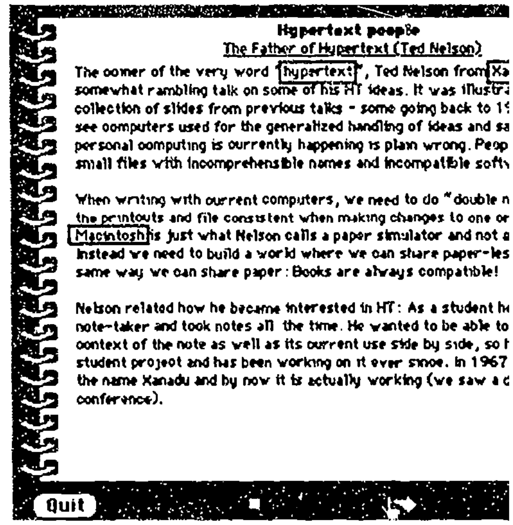
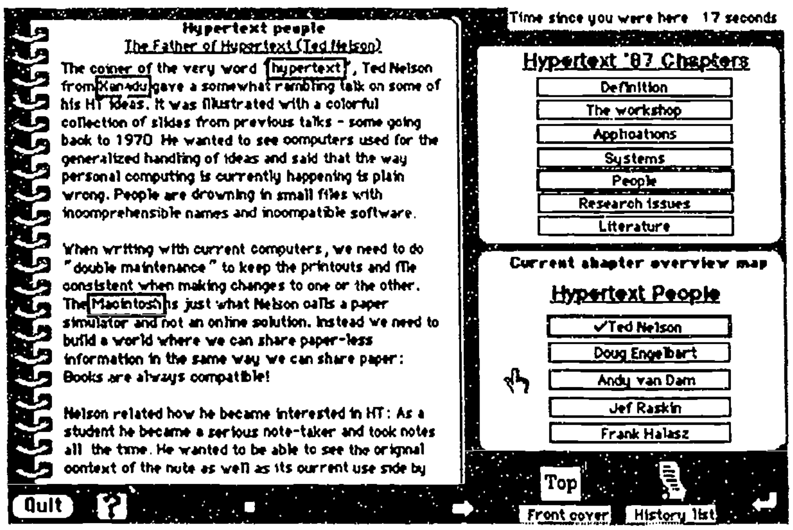
Appendix A
Presentation Methods



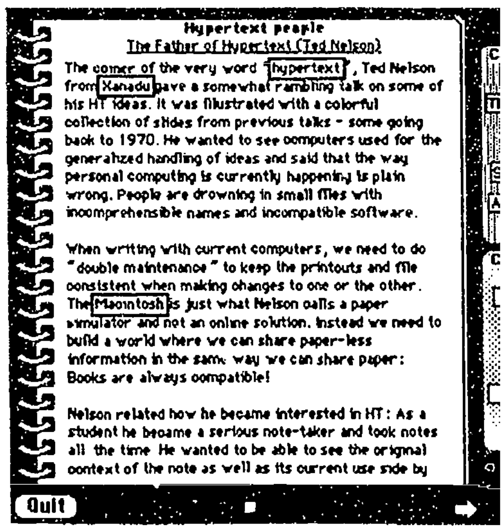
A-1 Sequential Text Only



A-2 Hypertext without a Nav



A-3 Hypertext with a textual Map



A-4 Hypertext with a Spa

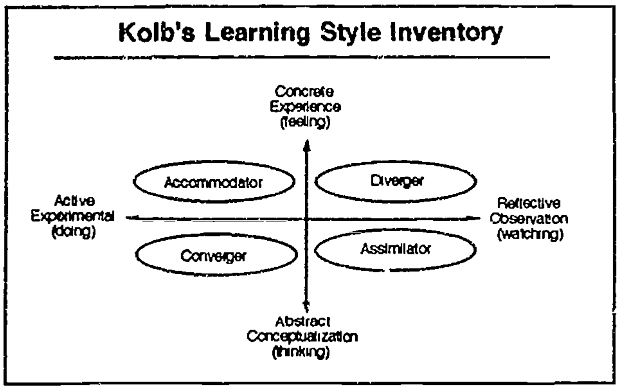


Figure 1 - Kolb's Learning Style Inventory

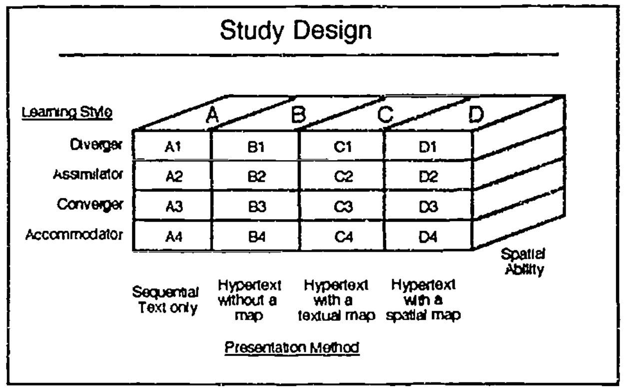


Figure 2 - Study Design

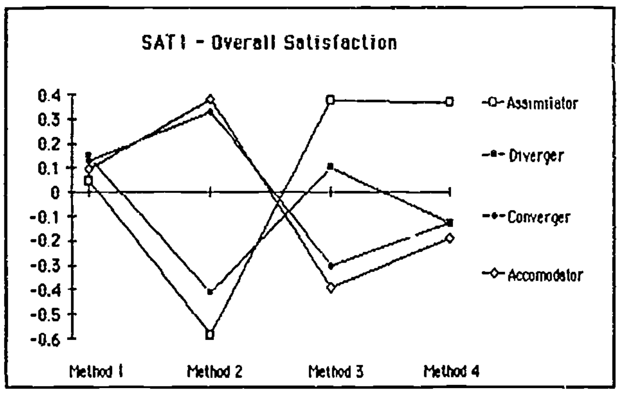


Figure 3 - Overall Satisfaction

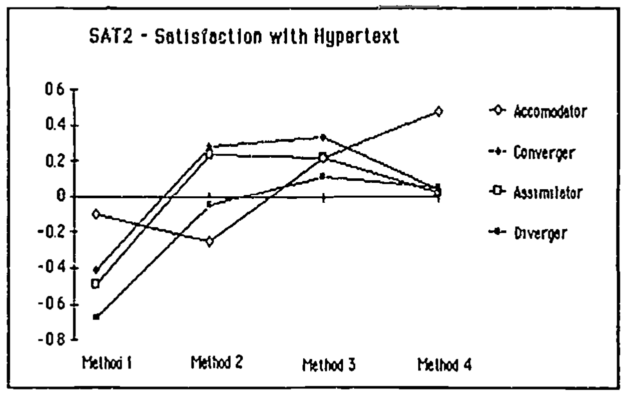


Figure 4 - Satisfaction with Hypertext

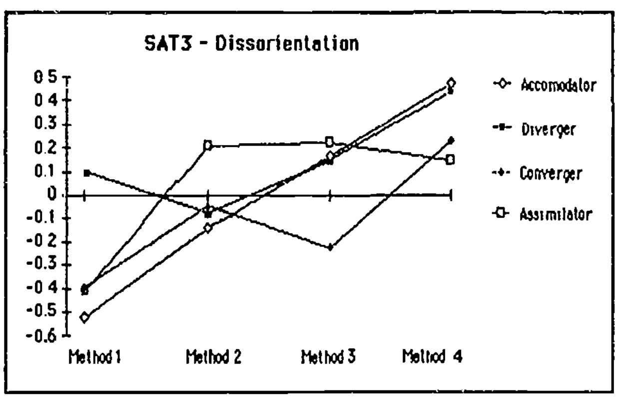


Figure 5 - Dissorientation Effect

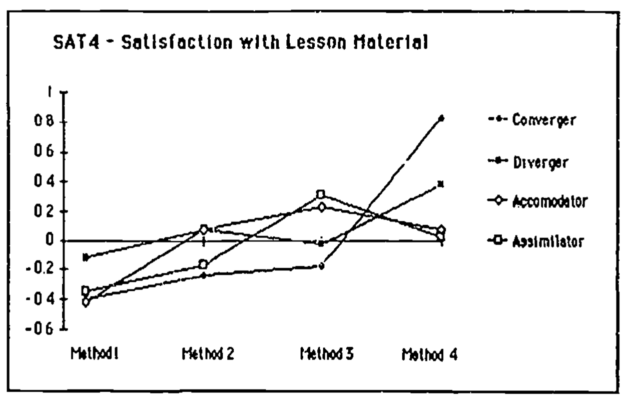


Figure 6 - Satisfaction with Material Content

Table 1 List of Variables

Independent Variables:

- A Treatment Method
  (Variable categories)
  1. Linear text only
  2. Hypertext without a navigation map
  3. Hypertext with a textual navigation map
  4. Hypertext with a spatial navigation map
- B Individual Cognitive Style:
  - B_1 Kolb's Learning Style Inventory
    (Variable categories)
    1. Diverger
    2. Assimilator
    3. Converger
    4. Accommodator
  - B_2 Spatial Ability / Paper Folding Test
    (one quantitative variable)

Dependent Variables:

- A Objective: learning outcome score
  (one quantitative variable)
- B Subjective: satisfaction level
  (Four factor score variables)
  1. Factor Score 1 - General Satisfaction
  2. Factor Score 2 - Text Structure
  3. Factor Score 3 - Disorientation
  4. Factor Score 4 - Content of Material

Table 2 Summary of Hypotheses

$H1_{\emptyset}$. Learning Style Differences. There are no significant differences in outcome measures or satisfaction level among different learning style groups of students.

$H2_{\emptyset}$. Spatial Abilities. There are no significant differences in the means of learning outcome or satisfaction level among different spatial abilities of students.

$H3_{\emptyset}$. Presentation Methods. There are no significant differences in the means of learning outcome or satisfaction level among different presentation treatment method groups of students.

$H4_{\emptyset}$. Interaction Effects. There are no significant interaction effects between learning style and treatment method in their effect on learning outcome and satisfaction level.

Table 3
Factor Analysis of Satisfaction Variables: Statistics

---- FACTOR ANALYSIS ----

Analysis Number 1 Listwise deletion of cases with missing values
Extraction 1 for Analysis 1, Principal-Components Analysis (PC)

Initial Statistics:

Variable	Communality	Factor	Eigenvalue	% Var	Cum %
S1	1.00000	1	4.46083	37.2	37.2
S2	1.00000	2	1.30219	10.9	48.0
S3	1.00000	3	1.15865	9.7	57.7
S4	1.00000	4	1.07003	8.9	66.6
S5	1.00000	5	.71853	6 0	72.6
S6	1.00000	6	.68836	5.7	78.3
S7	1.00000	7	.60981	5.1	83.4
S8	1.00000	8	.55446	4.6	88.0
S9	1.00000	9	.44558	3.7	91.7
S10	1.00000	10	.37115	3.1	94.8
S11	1.00000	11	.34932	2.9	97 7
S12	1.00000	12	.27108	2.3	100.0

PC Extracted 4 factors. Final Statistics:

Variable	Communality	Factor	Eigenvalue	% Var	Cum %
S1	.67302	1	4.46083	37.2	37 2
S2	.79871	2	1.30219	10.9	48.0
S3	.53448	3	1.15865	9.7	57.7
S4	.76741	4	1.07003	8.9	66.6
S5	.66254				
S6	.74952				
S7	.70768				
S8	.66473				
S9	.57934				
S10	.74475				
S11	.60577				
S12	.50379				

Table 4
Factor Analysis Of Satisfaction Variables: Factor Matrix

---- FACTOR ANALYSIS ----

Varimax Rotation 1, Extraction 1, - Kaiser Normalization
Varimax converged in 6 iterations.

Rotated Factor Matrix.

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
S8	.78794			
S10	.75740			
S5	-.74478			
S1	-.60199			
S12	44095			
S11		.76295		
S9		.71869		
S3		.64471		
S2			.86157	
S4			.82130	
S6				-.83885
S7				.80014

Factor Transformation Matrix:

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
FACTOR 1	62551	-.48930	.44105	-.41809
FACTOR 2	-.43406	-.49733	.54943	.51223
FACTOR 3	-.34822	.51809	.62760	-.46523
FACTOR 4	.54688	.49480	.33124	.58854

Table 5 Outcome by
Learning Style and Presentation Method

		METHOD 1	METHOD 2	METHOD 3	METHOD 4	LSI TOTALS
Divergers						
	mean	9.38	8.67	7.72	7.28	8.25
	sd	3.12	2.92	5.22	3.19	3.73
	n	14	16	15	15	60
Assimilators						
	mean	8.60	7.04	7.55	7.31	7.65
	sd	3.71	3.36	3.12	2.97	3.30
	n	22	19	20	22	83
Convergers						
	mean	8.87	7.54	6.71	8.34	7.87
	sd	3.51	4.96	2.99	3.07	3.72
	n	19	18	19	19	75
Accommodators						
	mean	8.57	6.88	7.32	6.37	.34
	sd	2.96	3.47	3.12	3.69	3.34
	n	18	16	15	15	64
METHOD TOTALS	mean	8.81	7.51	7.30	7.38	7.76
	sd	3.33	3.68	3.61	3.23	3.52
	n	73	69	69	71	282

Table 7
Summary of Results

Summary of Results

Hypothesis		p value	reject H_0?
$H1_0$.	Learning Style Differences		
	1. Learning Outcome	.442	no
	2. General Satisfaction	.836	no
	3. Satisfaction with Text Structure	.507	no
	4. Disorientation effects	.626	no
	5. Satisfaction with Material Content	.900	no
$H2_0$.	Spatial Abilities Differences		
	1. Learning Outcome	.455	no
	2. General Satisfaction	.009	yes
	3. Satisfaction with Text Structure	.097	no
	4. Disorientation effects	.009	yes
	5. Satisfaction with Material Content	.122	no
$H3_0$.	Presentation Methods Differences		
	1. Learning Outcome	.032	yes
	2. General Satisfaction	.657	no
	3. Satisfaction with Text Structure	.001	yes
	4. Disorientation effects	.003	yes
	5. Satisfaction with Material Content	.001	yes
$H4_0$.	Interaction Effects Differences		
	1. Learning Outcome	.897	no
	2. General Satisfaction	.012	yes
	3. Satisfaction with Text Structure	.574	no
	4. Disorientation effects	.684	no
	5. Satisfaction with Material Content	.164	no

Table 6 Satisfaction Factor Score means by
Learning Style and Presentation Method

Satisfaction Factor Score Means

FACTOR SCORE 1 (General Satisfaction)

	Diverger	Assimilator	Converger	Accomodator
METHOD 1	.1473213	.0435190	.1274950	.0981950
METHOD 2	-.4064046	-.5865575	.3280063	.3840330
METHOD 3	.1009928	.3730503	-.3016294	-.3877529
METHOD 4	-.1236628	.3674708	-.1263760	-.1912216

FACTOR SCORE 2 (Text Structure)

	Diverger	Assimilator	Converger	Accomodator
METHOD 1	-.6744029	-.4896386	-.4108353	-.1015388
METHOD 2	-.0462843	.2385123	.2801728	-.2502052
METHOD 3	.1124850	.2163655	.3331746	.2222610
METHOD 4	.0554993	.0279992	.0380869	.4776869

FACTOR SCORE 3 (Disorientation)

	Diverger	Assimilator	Converger	Accomodator
METHOD 1	.0615183	-.4123635	-.3954425	-.5232912
METHOD 2	-.0875845	.2103351	-.0824467	-.1396350
METHOD 3	.1490613	.2243373	-.2230592	.1688231
METHOD 4	.4383380	.1422626	.2322715	.4754456

FACTOR SCORE 4 (Content of Material)

	Diverger	Assimilator	Converger	Accomodator
METHOD 1	-.1142075	-.3480358	-.3933063	-.4200705
METHOD 2	.0795037	-.1672814	-.2386889	.0764750
METHOD 3	-.0233894	.3092674	-.1773449	.2334970
METHOD 4	.3818548	.0285498	.8292379	.0793348

Table 8 ANOVA; Learning Outcome by
Learning Style and Presentation Method with Spatial Ability

*** ANALYSIS OF VARIANCE ***

SCORE
BY LSI
METHOD
WITH VZ2

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	6.879	1	6.879	.559	.455
VZ2	6.879	1	6.879	.559	.455
Main Effects	139.478	6	23.246	1.888	.083
LSI	33.213	3	11.071	.899	.442
METHOD	110.202	3	36.734	2.983	.032
2-way Interactions	51.610	9	5.734	.466	.897
LSI METHOD	51.610	9	5.734	.466	.897
Explained	197.967	16	12.373	1.005	.452
Residual	3262.851	265	12.313		
Total	3460.818	281	12.316		

Multiple Range Test
Duncan Procedure

Variable SCORE
By Variable METHOD

Variable SCORE

Mean	Group	Grp 3	Grp 4	Grp 2	Grp 1
7.3043	Grp 3				
7.3803	Grp 4				
7.5109	Grp 2				
8.8116	Grp 1	*	*	*	

(*) Denotes pairs of groups significantly different at the .050 level.

Table 9 ANOVA: General Satisfaction by Learning Style and Presentation Method with Spatial Ability

*** ANALYSIS OF VARIANCE ***

FACTOR SCORE 1 (General Satisfaction)
BY LSI
METHOD
WITH VZ2

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	6.585	1	6.585	6.941	.009
VZ2	6.585	1	6.585	6.941	.009
Main Effects	2.412	6	.402	.424	.863
LSI	.812	3	.271	.285	.836
METHOD	1.531	3	.510	.538	.657
2-way Interactions	20.594	9	2.288	2.412	.012
LSI METHOD	20.594	9	2.288	2.412	.012
Explained	29.590	16	1.849	1.949	.017
Residual	251.410	265	.949		
Total	281.000	281	1.000		

Table 10 ANOVA: Satisfaction with Text Structure by Learning Style and Presentation Method with Spatial Ability

*** ANALYSIS OF VARIANCE ***

FACTOR SCORE 2 (Text Structure)
BY LSI
METHOD
WITH VZ2

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	2.642	1	2.642	2.775	.097
VZ2	2.642	1	2.642	2.775	.097
Main Effects	18.774	6	3.129	3.286	.004
LSI	2.224	3	.741	.778	.507
METHOD	16.805	3	5.602	5.883	.001
2-way Interactions	7.250	9	.806	.846	.574
LSI METHOD	7.250	9	.806	.846	.574
Explained	28.666	16	1.792	1.882	.022
Residual	252.334	265	.952		
Total	281.000	281	1.000		

Multiple Range Test
Duncan Procedure

Variable FACTOR SCORE 2
By Variable METHOD

Variable FACTOR SCORE 2

Mean	Group	Grp 1	Grp 2	Grp 4	Grp 3
-.4089	Grp 1				
.0700	Grp 2	*			
.1315	Grp 4	*			
.2272	Grp 3	*			

(*) Denotes pairs of groups significantly different at the .050 level

Table 11 ANOVA: Disorientation effect by Learning Style and Presentation Method with Spatial Ability

*** ANALYSIS OF VARIANCE ***

FACTOR SCORE 3 (Disorientation effect)
BY LSI
METHOD
WITH VZ2

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Total	281.000	281	1.000		
Covariates	6.680	1	6.680	7.007	.009
VZ2	6.680	1	6.680	7.007	.009
Main Effects	15.476	6	2.579	2.706	.014
LSI	1.671	3	.557	.584	.626
METHOD	13.782	3	4.594	4.819	.003
2-way Interactions	6.233	9	.693	.727	.684
LSI METHOD	6.233	9	.693	.727	.684
Explained	28.388	16	1.774	1.861	.024
Residual	252.612	265	.953		
Total	281.000	281	1.000		

Multiple Range Test
Duncan Procedure

Variable FACTOR SCORE 3
By Variable METHOD

Variable FACTOR SCORE 3

Mean	Group	Grp 1	Grp 2	Grp 4	Grp 3
-.3444	Grp 1				
-.0163	Grp 2	*			
.0727	Grp 3	*			
.2993	Grp 4	*			

(*) Denotes pairs of groups significantly different at the .050 level

Table 12 ANOVA: Satisfaction with Material Content by Learning Style and Presentation Method with Spatial Ability

*** ANALYSIS OF VARIANCE ***

FACTOR SCORE 4 (Satisfaction with Material Content)
BY LSI
METHOD
WITH VZ2

Source of Variation	Sum of Squares	DF	Mean Square	F	Signif of F
Covariates	2.270	1	2.270	2.405	.122
VZ2	2.270	1	2.270	2.405	.122
Main Effects	16.259	6	2.710	2.871	.010
LSI	.552	3	.184	.195	.900
METHOD	15.656	3	5.219	5.530	.001
2-way Interactions	12.376	9	1.375	1.457	.164
LSI METHOD	12.376	9	1.375	1.457	.164
Explained	30.905	16	1.932	2.047	.011
Residual	250.095	265	.944		
Total	281.000	281	1.000		

Multiple Range Test
Duncan Procedure

Variable FACTOR SCORE 4
By Variable METHOD

Variable FACTOR SCORE 4

Mean	Group	Grp 1	Grp 2	Grp 4	Grp 3
-.3327	Grp 1				
-.0722	Grp 2				
.0865	Grp 3	*			
.3282	Grp 4	*	*		

(*) Denotes pairs of groups significantly different at the .050 level

Table 13 Summary of *p* values

	Learning Outcome	General Satis-faction	Text Structure	Disorien-tation	Material Content
Learning Styles	.442	.836	.507	.626	.900
Spatial Ability	.455	.009*	.097	.009*	.122
Presentation Method	.032*	.657	.001*	.003*	.001*
Interaction Effects	.897	.012*	.574	.684	.164

Strategies for Utilizing Hypermedia: Instruction vs. Information Access

Xiaoming Zhu

Electronic Data Systems Corporation

Abstract When hypermedia is demonstrating its amazing capabilities, its drawbacks such as disorientation, cognitive overhead, and content deficit for instruction and information access are identified. The techniques and strategies for relieving these effects have been recommended for the hypermedia applications as a whole. This article discusses the strategies based upon characterizing the differences between the use of hypermedia for instruction and the use of hypermedia for information access. which the author believes to be vitally important for the appropriate utilization of the new technology. For information access, integrated devices of orientation is the solution. For instruction, however, instructional predominance that consists of the instructional body centralized and sequential/hierarchical navigation schemata is the key. The two projects in which the techniques and strategies were applied for each of the two hypermedia application areas are described as the examples to support the discussion.

Introduction

Disorientation and *cognitive overhead* of the user in hypermedia system have been identified as the major drawbacks since the early proliferation of the hypertext and hypermedia applications (Conklin, 1987).

Hypertext or hypermedia starts with the assumption that text or any other piece information can be separated into items, and that reading means tracing the relations between concepts which link the items (Kommers, 1990). Hyperspace browsers can easily get lost within the structure, forgetting where they are and how they arrived there. They need additional mental "effort" to maintain simultaneous traversals through a hypertext system (Furata & Stott, 1988, 1989).

Rather than the disorientation and cognitive overhead, *content cohesion deficit* is a more conspicuous problem when applying hypermedia for instruction.

For instruction, the designer has attempt to structure the information presentation in a way that he or she believes to be the best for the learner to learn. The context weighs no less important than the information itself. The nature of hypermedia, however, that allows the information items being separated and the related or unrelated items being branched makes for a potentially choppy exposure to information, with the consequence that cohesion between the elements making up the whole of what the learner is exposed to may be deficient. Comprehension will potentially suffer if that is the case (Duchastel, 1990, Marchionini, 1988).

In this article I will discuss techniques and strategies for solving these problems based upon characterizing the differences between the use of hypermedia for information access and the use of hypermedia for instruction. Clarifying the differences is vitally important for the appropriate utilization of the new technology. Two projects in which the techniques and strategies were applied in each of the two hypermedia application areas are presented later in the article to support the discussion.

Utilizing Hypermedia for Information Access

Information access has been the biggest area in which hypermedia technology is applied. Retrieving information from a database, searching facts in a information system, using an computer application package, and even using a computer operating system all possibly features hypermedia application. The characteristics that the readability of information piece is more important than the validity of its outgoing relations of information access and the decontextualized nodes and links nature of hypermedia make the two a perfect match. This is one of the reasons that hypermedia has gained the great attention and development in the field of information access since it was originated.

With the technology breaking through, hypermedia is bringing forth a unprecedented navigational topologies in which the linear, hierarchy, hypercube or hypertorus, dag, and arbitrary browsing are possible (Parunak, 1989). Hypermedia becomes a fundamental technique for both the authors and users to build and to use the system for information exchange and communication purposes.

The user's hyperspace disorientation and cognitive overhead is a side effect of the powerful navigation. It is, however, not a fundamental problem of using hypermedia for information access. Imagining when tourists get lost in a big city where they have never been to before, they could hardly blame either the urban planning or the transportation system of the city although the improvement of the city orientation such as providing more traffic sign, city map, or tour guide is always preferred. The same hold true for using hypermedia for information access, clear orientation devices for guiding the navigation are always beneficial to the users (Nielsen, 1989; 1990). This should introduce the following strategy for the improvement.

The strategies is to create a transparent user interface. Through this interface, the users know where they are, where they have been, and where they can go next. For example, an overview diagram can provide some of the same assistance to a hyperspace browser as a map provided to a tourist. The following are a list of the techniques and actions for creating the transparent interface.

Tour Map: keep a map in the system that can be accessed any time from anywhere. The map shows all the significant nodes and the links of the system, very similar to a city map that shows all the buildings and the traffic ways.

Footprint : present a label in the map to indicate where the browser is in the system. Better than that a tourist who may need to ask someone in order to know where he or she is, hyperspace browser can get the information quickly and automatically.

Zoom and Roam Facility : Add zoom and/or roam functions in the tour map or other local maps. By using zoom, the browser can see more or less detail the map or part of the map through clicking the zoom in or out button. By using roam, the browser can let any part of the map displayed on the full screen (Beard & Walker 1990).

Compass : Include the label or function in the system that always directs the browser to the nodes that are important to them (Bernstein, 1988). This label should be dynamically updated according to the node the browser is on currently.

Fisheye View: Enhance the tour map so that the entire information space is shown on a single overview diagram but in varying level of detail by using the hierarchical chart (Furnas, 1986). This function can be integrated into the zoom, or vice versa, so that the overview diagram become much powerful.

Landmark: Create dynamically the labels that define an usable structure as part of the browsing process by highlighting the milestone nodes in the tour map.

Notebook: Make it possible to allow the browser to record the milestones of their browsing process (Slaney 1988). This function is similar to landmark but different in that the notebook allows browser to record the milestone for multiple paths and allows the browser to compare one to another.

Besides the transparent interface strategy, author defined navigation paths are also helpful for users to keep away from disoriented or cognitive overloaded. Researches call it *paths strategy* (Trigg, 1983; Canter, 1985; Hammond & Allinson, 1988; Marshall, 1989; Zellweger, 1989). Paths strategy gives the browser a procedural description of how to get to the target. Similar to the direction given to a tourist, "turn left at the first light and right at the second gas station, and it's the blue house on the right" for example, a direction for finding the desired node can be given to a browser by the paths. A path can be very simple, linear path, sequential path for example. A path can also be very complicated such as conditional or arbitrary path. Path gives author the control to some degree on how the information should be accessed. Author should leverage the control according to the complexity of the system and the familiarity of the user to the system. A completed path consists of the links mechanism and the orientation information to the browser. The way to author the path depends on the hypermedia system used. When using HyperCard as the authoring environment, for example, Hypertalk script is the basic mechanism for creating the path and the message on the cards will be the procedural description of the navigation.

Using hypermedia for instruction is a natural progress of computer-mediated instruction for its promise of ease of use, richness in presentation, and flexibility of hypermedia. The similar progress was made about twenty years ago when programmed instruction was shifting to computer-mediated instruction (Anglin, 92). The technology-mediated instruction history shows that the instruction and technology share joys and sorrow, weal and woe.

The educational potential of hypermedia is in connecting concepts by following paths, thus forming interpretation and synthesizing information (Marchionini, 1988). This potential, however, finds no ground in traditional instructional design paradigm in which instruction is defined as a series of prescribed events and activities for achieving specified learning objectives. Hypermedia provides the learner with the opportunities to diverge from the prescribed instructional path and sequence; to juxtapose text, animation, and sound; to turn the technology back on itself as an aid in reviewing, studying, and producing new interpretations of the content (Marchionini, 1988). As a result of this, cohesively organized contents become deficient, freedom becomes chaos. That's why hypermedia and formal learning are considered to be conceptually distant from one another; hypermedia is more appropriate for situated, associational, or discovery learning in which no learning outcomes are previously specified (Duchastel, 1990).

The orientation devices approach for releasing the user's "lost in hyperspace" recommended in last section of this article is not a fundamental solution of the problem. An new theory for interpreting the cognitive process and revealing the law of learning with hypermedia may be a solution. The theory should be sophisticated enough to prescribe the best course of actions for using and evaluating hypermedia for human learning. In this solution, content cohesion deficit is approached in a totally different way in which discovery learning, situated learning, or learning by making mistakes is considered to be the dominant transactions for human learning. In order to find the solution, knowledge representation of hypermedia that addresses both issues of readability of the text item and the validity of outgoing relationship need to be investigated. Explicating the mental effects of knowledge elicitation and knowledge acquisition by hypertext to reveal the pattern of learning with hypermedia is necessary. Hypermedia learning is creating a exciting research field, no doubt, but its current premature study methods, very limited research findings, and unproven cognitive validity can hardly provide convincing and practical solution for the design of an effective instruction (Mayers, 1990).

A practical and effective approach is to reduce the requirement for arbitrary navigation by setting a instructional body centralized predominant path to guide the learner in navigation (Zhu, 1992). This approach consists of two basic instructional navigation schemata. First, it allows learner to navigate, primarily, within the instructional dominance as well as between the dominance and their auxiliary components such as the course map, course glossary, references, etc (Figure 1). Second, within the instructional dominance , it combines sequential and hierarchical navigation paths that differentiate information from one level to another (Figure 2).

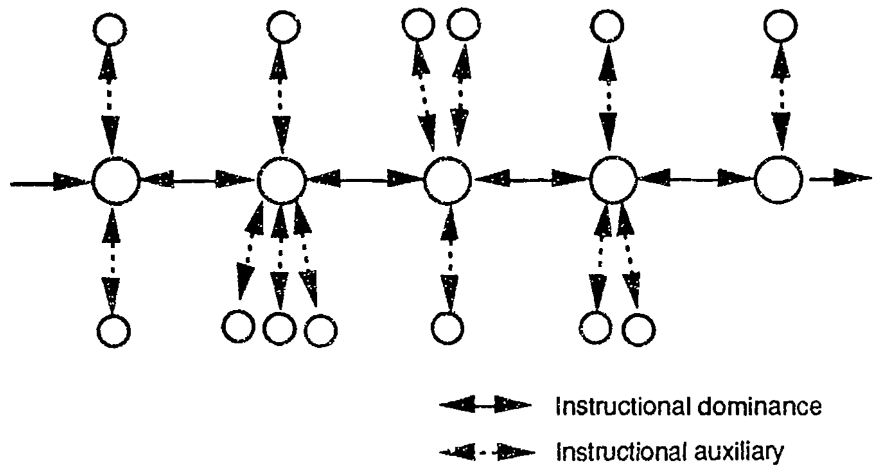


Figure 1. Instructional body centralized navigation schema

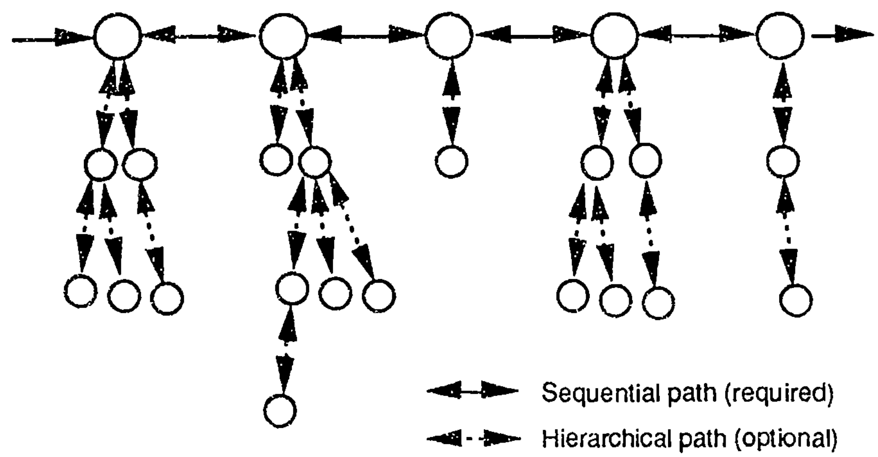


Figure 2. Instructional dominance consists of sequential and hierarchiocal navigation paths

There are two major characteristics of this approach. First, it conforms to the research finding that learners in learner control treatment have regularly learned less than learners those in treatment controlled by the instructor or an adaptive instructional design (Jonassen, 1986; Hannafin, 1989). Second, it effectively utilizes hypermedia technology through which learner is able to obtain the information that aids his or her learning. Balancing between system control and learner control to maximize the benefits and reduce the risk of using hypermedia for instruction is the purpose as well as the end result of this approach.

Project Examples

In this section, I will present two projects in which the strategies discussed above were applied in the two different hypermedia application areas. They should serve as the examples to support or elaborate the discussion. The table below presents general information about the two projects. More description is provided as follows.

In the first project, information access is the type of hypermedia application. The system provides the user with the information about the library materials, library services, computerized systems, etc. The information is independent one from another. Users don't need any specific prescribed path or sequence because they access the information based on their own interests. Paths and transparent interface strategies were applied in authoring the system. Linear, hierarchical, and backtracking path strategies were used to organize the information,

Project Name	Type of Application	Strategies Applied	Authoring System Used
Library Information System	Information system that allows the user to access the information about the university library such as circulation, reference, document, map, computerized catalog (LUIS), indexes, subject headings, services, materials and locations, etc.	Transparent Interface • Tour Map • Footprints • Zoom Facility • Fisheyes View • Landmark Paths • Linear path • Hierarchical path • Backtracking path • Conditional path	HyperCard 2.1
SLC - An Introduction	An instructional system that teaches the basic facts and concepts of the Systems Life Cycle (SLC) methodology that is used for developing and maintaining information technology systems.	Instructional lesson centralized navigation schema that provides the learner with a guided tour on the prescribed instructional path and sequence. At the same time, the learner is allowed to access other components relevant to the instruction such as glossary, course map, course orientation using hypermedia as long as he or she stays in the predominant path.	Authorware Professional 1.7

and at the same time, to facilitate the navigation. A map that has the features of footprints, zoom, fisheyes view, and landmark was built into the system. It provides users with an instant help regarding where they are, where they have been to and where they can go in the system.

In the second project, instruction is the key. The system was designed to teach the basic facts and concepts of the methodology. The learner, instead of the user, is expected to achieve specified learning objectives upon completion of the instruction. Based on the task analysis, it was also believed that certain learning path and sequence are important to the learning. In order to meet these requirements, two major navigation schemata were applied using hypermedia technology. One was the instructional lesson centralized navigation. The other was the combination of linear and hierarchical presentation. The first creates a predominant path for the instruction, avoiding its content cohesion deficit. The second makes it possible that information can be presented in either a sequence or a optional manner, so that the presentation can be more effective and efficient.

Conclusion

The biggest strateg} for effectively utilization of hypermedia is to differentiate between instruction and information access and differentiate between task-oriented learning and situated learning. There is no fundamental problem with using hypermedia for information access. User's hyperspace disorientation and cognitive overhead can be overcome through the integrated devices of orientation. However, there is a fundamental problem with using hypermedia for instruction. It is the instructional content cohesion deficit. Although an unknown theory may help interpret hypermedia learning better and solve the problem, the practical and effective solution to the problem is to lead the learner to a predominant navigation path in which the instructional body of the system is centralized.

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Selected Abstracts for the

Special Interest Group for Management Issues (MISIG)

Considering Organizational Culture in Selecting CBT Development Software

Robert C. Fratini, AT&T National Product Training Center

There are a handful of software best-sellers for applications such as word processing or spreadsheets. However, a recent issue of CBT Directions lists will over a hundred authoring languages and systems for use in the development of computer-based training (CBT). Why so many, with new ones coming on to the market every year?

The hypothesis explored in this presentation is that the level of satisfaction with a piece of software that is experienced by an organization (specifically, an organization involved in the development of CBT) depends on how closely the functionality expressed in that software matches with that organization's values.

During the presentation, based on discussion and input from the attendees,k I will discuss how major areas of software functionality expressed in CBT development tools can be assessed against such values of an organization's culture as:

-Individual need for control
-Level of trust of others
-Attitudes towards the systematic instructional development process
-Attitudes towards organizational standards
-Attitudes towards the place of "entertainment" during instruction
-Reviewers' feelings of autonomy prior to the general release of instructional materials
-Attitudes towards student or user control during training delivery

Attendees will be able to determine the level of consistency between functionality expressed in current and potential CBT development software and the culture and values of their developers.

Lifelines for the Struggling Multimedia Developer: Living on Multimedia's Bleeding Edge

Jeanne Gleason, New Mexico State University

Even during financial crisis and programmatic cutbacks, effective multimedia presentations can be developed.

This presentation will cover how to:
--cope with limited funding for equipment and personnel,
--deal with unrealistic administrative expectations,
--develop clear, attainable goals,
--know when to play it safe and when to take a risk,
--build strong design and development techniques,
--increase productivity by building "ownership",
--turn deadline pressure into creative energy, and
--effectively implement and market the outcome.

Examples will be drawn from The Natural Resource Extravaganza, a multimedia presentation for public environments developed in 90 days with extremely limited funds and student assistance. The speaker developed a model, called ADOBE, to manage activities. She will share her development tricks to keep the project on track, and how using development templates can build administrative support while guiding parallel development.

This system was developed for the PC environment, using touch screen input, a laser disc, computer graphics, and the IMSATT programming language. The presenter is currently developing additional systems using Macintosh systems for The Smokey Bear Center, the USDA, and the Navajo Indian Tribe.

Selected Formal Papers from the

Special Interest Group for Management Issues (MISIG)

Quality Improvement Cycle (QIC) and Computer Supported Learning in administrative organizations. An observation through some experiments.

Gianpiero Bussolin
University of Torino (Italy)

The discussion concerns the nature and above all the experimental issues resulting from models, systems and projects in progress by the Author for the Computer Supported Learning . The methodology of Quality Improvement Cycle (see Total Quality Management) is considered in order to improve and enhance the existing processes of learning about problems of an administrative nature (see also management education). H.A.Simon's ideas are a starting point for many observations . Further references shall be given in the paper and during the oral presentation (*).

Preface

This paper contains some key words which require a particular explanation.

The word "experiment" will often be used to indicate that the projects and systems discussed are to be considered in their experimental nature, in order to draw from them a "corpus" of empirical observations and comments upon their factual results. These results and these observations may serve to reinforce more general theories and scientific principles, or may be of a controversial nature as regards these very principles and theories mentioned above.

The word "system" will often be employed in order to indicate a " set or arrangement of things so related or connected as to form a unity or organic whole " (see Webster's New World Dictionary of the American Language), and ,we say above all, having a "purpose" which plays the important role of molding this arrangement during the process of its construction. (H.A. Simon, 1978 , "Preface").

This term is often used in our everyday language even though it has a rather vague nature with a rather weak meaning. In this paper this term will be used to indicate that this arrangement of things is considered both in its projectual condition and in its state of supporting practical applications and results. This arrangement of things will obviously include not only projectual activities but also hard and software , such as information technology may offer with its computers, languages and programs. The word " model" will be used in its definite meaning of representation and design.

The paper is divided into two parts. Part I contains a short explanation of some systems concerning , in some ways," computers and learning " ; Part II contains some observations upon these systems, in their experimental aspect as previously made clear.

Part I

a) The first experiment, from an historical point of view, has as scenario or outline of the organizational and administrative context, a project for a computer-based system in a worldwide company . This project concerns the planning, manufacturing and distribution of its outputs.

We are in the 60's and the computer-based Management Information System has the main purpose of integrating the administrative functions above mentioned , with a particular regard for the distribution function of products over the home market (peripheral warehouses) and the foreign markets. We might also say, with the use of an up-to-date concept, that the goal is " total quality" in terms of its attributes, namely that concerning customer service. The essence of this short description, is necessary for two main reasons: the highly complex nature of this project, and the organizational change entailed in the project itself.

The generation of new information technologies (new products of hard and software) has always played a role of change within administrative organizations,

(*) Experiments b) c) d) and the theoretical research into the field of the Sciences of the Artificial has found support from the Italian "Ministero della Università e della Ricerca Scientifica" and "Consiglio Nazionale delle Ricerche".

imposing a new form of information processing. The success and often the failure of these computer-based MIS's has strong links with the administrative knowledge of those individuals involved in the project itself.

We use the expression "administrative knowledge " to recall a complex problem where it is difficult to disentangle concepts like: communication, learning, education, skill and expertise, behavior, etc. (H.A.Simon,1961,Chapter VIII "Communication") . This project of computer-based MIS has been studied in the light of this administrative knowledge and therefore in the light of administrative education, arriving at the construction of a model of computer-based simulation for the administrative individual involved in the MIS project itself. This MIS project was so complex that an attempt was made to draw from the design of the project that form of "integrated knowledge" which the administrative individual had to possess in order to master the MIS successfully (Bussolin, 1974).

The skill and expertise of this individual are supposed to be enriched through computer-interactive learning upon hypothetical situations generated by the simulation. This simulation model (Bussolin,1967) may be considered a base for a computer- supported administrative or management education project contained within the broader MIS project. At the core of the theoretical design of this model there is a so-called "logical unit of discourse " for the representation of the product which is increasingly and dynamically enriched with logical attributes on the assembly lines of manufacturing and on the lines of distribution by truck transportation to the peripheral warehouses. This "logical unit" may be considered as the smallest brick of the design in order to represent dynamically what may happen to the output through the operation of the proposed MIS .

This model reproduces a shape of parallelism of administrative processes superimposed on physical processes (assembly lines of manufacturing and transportation lines). The source code for the computer programs was COBOL . We should not forget that we are in the 60's . Today , with the conceptual tools offered by Artificial Intelligence and object-oriented languages, we might design and realize in a more sophisticated manner these very models for education. This kind of models do not exhaust their function in a pure representation of physical or administrative facts, but they must possess an interface of communication with the individual who must learn through a computer-interactive human activity. (Even if dealing with a different kind of knowledge base, for this basic idea of "interface" for the "learner" see Polson-Richardson ,(1988) ; and one of the first and fundamental theoretical discussions in Simon,(1978)Chapter "Understanding the natural and the artificial world ").

Within this model we have a shape of "dynamic representation" which allows the learner to make his decisions at a given point in time and to observe the state of affairs of his system after a supposed interval of time. This process is obviously repeated , is recursive, along the course of simulation.

The nature of learning of this administrative education which may be allowed by these tools is basically different if compared with traditional tools. The "integrated" administrative knowledge descends from the fact that the learner is allowed to master a wider span of administrative situations , and if the experiment is carried on in a cooperative team, this form of learning may reach deep within the individual. The technological support of computer networks has (see further experiments) wide potentialities in this last sense.

b)The project of point a) has not been implemented in a real context of learning, and our research regards simply the design of its model. On the contrary, for this next project (Bussolin, 1979), we may report on some results deriving from its application in a real human context of university- level classes for industrial administration teaching.

This new model employs Forrester's methodology of" level and rates equations" and the source code of the computer program is FORTRAN . It does not use the compiler DYNAMO . In fact , the model under discussion does not reflect the philosophy set forth by various applications of Forrester's methodology . The use of this methodology consists in the representation of given phenomena (for instance concerning economics) and the related study of the system 's behavior for a given interval of time. On the contrary, our model has an educational purpose , i.e. the teaching of basic concepts of industrial administration, and this purpose correctly molds the whole design.

In this project, each group of students makes decisions about its company and may observe their results. Of course the cognitive process is recursive in its feed-back, in the sense that we have: decisions-results,decisions-results, etc. The same mentioned feature of learning in an evolutionary context by interactive computer simulation mentioned in the model of point a) is contained in the model under discussion.

The administrative system is subdivided into subsystems like : finance, production,market,etc. linked by channels in which flow various kinds of units : money, investments, products, etc. A kind of simultaneity occurs in the dynamic flowing of units into the various channels, similar to what we have discussed in point a). The learning process of the student is therefore like that illustrated at point a) where we have dealt with an "integrated knowledge". We might also say that the learner acquires a "process knowledge", i.e. a knowledge of the "how's" rather than a knowledge of the " what's" . The first form of knowledge concerns "how" administration processes are carried on , and the second deals with "what" these processes are (Bussolin, 1974,1986).

It has been possible to compare these two forms of knowledge in a human context of teaching administration matters to students at university levels, the first one being much more highly motivating for further investigations on the part of these students. The "role playing" of the individual belonging to a group of studen : and "the role playing" of the group as a unit is a stron :ason for enhancing all the attributes which conce. learning.

It is important that the designer of the model be also the teacher who uses this very model for educational purposes. In fact , if the design is module-based it should be easy to redefine the module of user interface according to the background of the student and the educational purposes. We all know how expensive it is to modify a computer package , and often it is convenient to redesign the whole model if it is not module based .

Competition among students is very important in the cognitive process of student learning. It has been possible to note that the more intense this competition, the less will be the learning in depth , particularly with regard to the learning of interrelations among variables of the system being simulated. We might also say that different human values may be transferred according to the greater or lesser intensity of this competition . The model under discussion does not contain a high degree of competition in that the behavior of each company does not influence the behavior of the other partners of the market. Nevertheless a certain degree of competition exists among groups , in that the set of companies at the beginning of the educational process has the same resources and the same mechanisms governing their responses to decision-making.

c)The model under discussion (Rosso-Vaglienti,1989) concerns cooperative learning for the operation of a bank system. This model has the purpose of stimulating decision-making activities of the individuals in a real context of cooperative behavior with the technological support of a local area network of PC's dedicated to the various teams. Each group of decision makers has the task of operating one of the branches of the bank and the coordinator of the learning experiment is also the headquarters general manager of this bank-branches network . This coordinator,through his PC, determines and supplies to the PC's of the branch offices, the flows of transactions (interchange of flows of debit-credit items) which create an information input for the decision making of each branch within its local market. Each team makes decisions based on its flows of items (views on the current accounts files of its own branch) while the central coordinator has the information support of the global database of transactions. The decision-making process of the set of teams is not simply carried on through a transmission of data via the network communication channels (such as the electronic mail process) but also and above all through a complex human process of coordination in which are combined competition,conflict and sharing of purposes (Malone and Crowston , 1990).

d) The last projects to be dealt with are research projects in progress and they concern Intelligent Tutoring Systems (ITS) for the teaching of Accounting and Hyper Text applications for the teaching of Industrial Administration problems .

The approach for the first research does not imply the use of a hard support like a text book of Accounting and the PC is not used to verify the level of skill of the learner . On the contrary , this research aims at developing in the learner a manipulative ability in book-keeping and balance-sheet generating. The word "manipulative" is here employed in an abstract sense and in a positive sense , i .e. in the sense of operating and controlling skillfully a set of accounting transactions with the purpose of arriving at a correct input into the accounts and a correct construction of the balance reports. The standard and normal applications of CAI are based on external and hard copies of text-books of Accounting and their purpose is to verify the levels of "what" has been learnt, through a variety of instructional frameworks (see, for example, the methodology of the so called "drill and practice") . On the contrary, the central idea in our research is that the learner has a series of more or less complex cases from the PC , and through a tutorial support given by his system , the learner can manipulate his transactions in order to accomplish the purposes suggested by his PC.

Among the variety of problems to solve, we have to face the question of "how" the human expert may create the knowledge base and to "what" extent reasoning ability has to be assigned to the computer expert.

Research into Artificial Intelligence seems to be improving and to lay even more stress on the computer expert , while the computer-based educational approach seems to reaffirm (this is our philosophy) the importance of the human teacher in his educational process. We might remember at this point of the discussion the idea of "bounded rationality" (Simon , 1961, Chapter IV "Rationality in Administrative Behavior"). The correct answer lies.... in the "contingency" situation, in the approach of the "hic et nunc".

As regards the research projects carried out on the hypertext software for creating educational support in the teaching of industrial administration matters at university levels, we are at the very beginning. We have encountered the obstacles of "which" textbooks are to be chosen, "how" to use this technology for different courses in different universities etc. The choice of subjects to be taught and learnt is an extremely important choice, especially when the scientific community has various approaches, various and controversial point of views ,etc. These subjects are quite different from subjects like Geography.... As we will note in Part II, the educational computer- based approach is "organization driven", we also have to consider the messages coming from the environment and we have to define the strategies to develop these projects.

Part II

As previously said in the "Preface" , in this "Part II" some observations and comments will be given regarding the experiments of "Part I" and their related scientific theories and principles . These observations and comments do not claim to be exhaustive .

a)The expressions " Computer-Aided Learning" , "Computer-Supported Learning" and the like, point to a wide scientific area of Education where the information technology participates in various manners and degrees. We do not intend to give a scientific solution to these problems of computer-supported education but certainly we have to face an interaction among different disciplines concerning behavioral sciences, decision-making, psychology, computer science. And we cite only some examples.

A project for an educational system must always take into account the organizational environment within which this project is to be carried on. Within this environment we have to fulfill the definition of purposes of the project, the cost-benefit analysis,the time interval for the development,etc. If the environment is of a more definite administrative nature like that of a profit-oriented company or that of a state agency, we should not undervalue that "learning","communication", "education", are "premises" to the "decision-making" of that organization, and not the only ones. Sooner or later we shall have to take into account other premises like "authority", "the criterion of efficiency" , "loyalties and organizational identifications" etc. (Simon,1961). In other words, the purpose of an educational project within an organizational environment plays a role of premise to the decision making (it does not matter whether at the instructional level,for training purposes, or at the higher indoctrination level) and it is quite difficult to disentangle this premise from the other ones previously mentioned.

Furthermore let us remember how the educational function is ever more acknowledged in modern organizations and this function is often carried out by an organizational unit of high level in the organizational line. These educational projects have some analogy with the Management Information Systems as regards the variety of experts who participate in these projects. Within these teams we find the same premises , above mentioned , for the decision making concerning the project.

The state of affairs does not vary if we consider an educational project for an organization like a school or university. A class of students or a staff of teachers participate in an organization where it is difficult to disentangle those elements like authority, communication, efficiency, etc. as previously said.

The role played by information technology in this state of affairs is not easy to define. From the historical point of view, this technology has played the role of powerful change in many areas of Science. If we observe this role within an educational project , we may observe influences of various nature.

b) Information technology evokes a sense of efficiency potential, of improvement of the educational system and, generally speaking, of enhancing the organizational development. One might say that the "quality" of the educational system and particularly the "quality" of the learning processes receive this benefit. The conditions that allow this benefit are often undervalued or not well analyzed.

The theme of quality of products , or better the theme of the so-called "total quality" has received particular attention for a long time . Let us remember some pioneers like Deming , Juran and Feighenbaum , and that the Total Quality Management (TQM) movement has evolved into a whole philosophy of management (Kleindorfer-Kunreuter-Shoemaker,1992) . This philosophy has strong links with the Japanese economic development.

"How do you make quality happen?" Deming asks (Anjani Jain,1992) and then answers this question as follows . The enterprise must , he says: 1) Create new and improved products. 2) Create new and improved processes. 3) Modify and improve existing products. 4) Modify and improve existing processes.

In our investigation we are not very interested in "products" but certainly in "processes", and among these let us focus upon educational processes. Many leader enterprises have paid and pay much attention to the educational processes (indoctrination, instructional activities, etc.) . Nevertheless, it does not seem that particular care is devoted to models, tools, etc., let us say by a statement ,to the "how's" of this administrative learning We might also say " particular care regarding the conditions for improving quality of learning processes ". The "how" of a process concerns the "quality" of the process.

c) Among the TQM methodologies we find the Quality Improvement Cycle (QIC) for improving processes and products (Kleindorfer, 1992) . This cycle may be explained by the following loop : 1) Select improvement area. 2) Identify outputs and customers. 3) Determine customer expectations. 4)Describe current process. 5) Focus on improvement opportunities. 6) Determine root causes. 7) Trial and implement solution. 8) Hold the gains. 1) Select.... 2) .... It is not difficult to apply this cycle to the improvement of learning processes. As an example, at points 2) and 3) , replace the word "customer" with the word "individual" who benefits from the learning process. At point 5) the word " opportunities" may indicate a technological support; ....etc. This cycle is loop-like in that administrative activities have a repetitive nature.

d) Points 1) , 4) and 5) of the above mentioned QIC , cannot be undervalued. We must select a new organizational area , describe the learning process and project a new one !

On this subject let us mention some key -attributes affecting the quality of learning processes. It is interesting to note how for each of these attributes one can find an information technological support. Let us remember a short list of these . 1) Number of learners , level of conflict-cooperation to be carried on . See the experiments b) and c) . The use of a local area network may enhance, even if not necessarily, this kind of learning . 2) Form of language used in the user interface : traditional or through images, colors, or even sounds . 3) Kind of events flowing . In experiment c) there is an alternating of electronic messages and human messages among teams of learners . 4) More or less strong reinforcement of the message, of the communication . This attribute is particularly important in experiments like d). 5) Evaluation of learning , more or less explicit and specific. See experiment c) as an example of not explicit evaluation, and experiment d) as an example of explicit and specific evaluation. 6) Form of knowledge and skill to be reached . In experiment a) , the integrated and process knowledge was the focus of the model . 7) The nature of concepts and the level of abstraction , the realism of representations . See experiment a) in which the simulation of processes takes into account their simultaneity, the analysis of the system arrives at the elementary unit of products, etc. In Computer Science there are specific methodologies for representing data in order to create data bases (see entity-relationship model). By analogy we may use methodologies for representing objects belonging to administrative processes in order to create computer-based educational systems . Languages of logic programming belong to this kind of considerations.

The above detailed list of attributes affecting the "quality " of an educational process is obviously not exhaustive . As regards the "essence" of computing in the educational process , and therefore a way of considering this kind of attributes for their educational quality , see Taylor,1991.

We have exposed this non-exhaustive list of arguments affecting quality of computer-supported educational projects in order to make clear "how" the technological support , both hard and soft, may enter into the design of these projects.

Problems concerning the effectiveness of these computer-based educational projects have not been faced (for a study concerning effectiveness evaluation of ITS see, as an example, Legree and Gillis ,1991) . Even if this kind of problems is important from an empirical point of view , we believe we have implicitly demonstrated how these computer-based educational projects are strongly connected to the purpose which "molds" the system. The variety of solutions suggests a different approach strictly connected to the design research.

Conclusions

When we have to deal with educational projects in which information technology has more or less weight, we discover that we have to deal with artificial phenomena where " the contingency has created doubts as to whether they fall properly within the compass of science" (H.A.Simon ,1978,Preface), where the system is molded by its goals or purposes which in their turn connect or link this system to its environment .

Our main attention has been to the area of design research, and we have not faced the problem of whether we have to deal with affairs of Science or Art, but we have simply discussed some elements which participate in the linking process between the goals or purposes ,on one hand, and , on the other , the organizational environment within which the educational project is immersed. In doing so we have not undervalued the fact that our investigations on learning fall within the compass of the individual, within the compass of his inner being.

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Selected Abstracts for the

Special Interest Group for Music (Music)

Object Oriented Music Theory Courseware

Paul E. Dworak, University of North Texas

This showcase demonstrates to the viewer the advantages of developing courseware using an object oriented language. The freshman ear training text used is *Basic Ear Training Skills*, written by Robert Ottman and this author. The accompanying courseware was written in C++ using MacApp, an object oriented development system for Macintosh applications.

In this presentation, the viewer will see how the object oriented environment encourages an intuitive software design based on defining the courseware in terms of functional units that correspond with activities actually carried out by students in completing an ear training exercise. This presentation will demonstrate objects used in this courseware. Although the presentation will not explain the object hierarchies, it will give the viewer a basic understanding of how these objects function and will suggest how such objects might be used in courseware developed by the viewer.

Selected Formal Papers from the

Special Interest Group for Plato Users Group (PUG)

CREATING COURSEWARE CATALOGS: THE MARRIAGE OF DATABASE TECHNOLOGY TO CBI SYSTEMS -- AN INSIDER'S VIEW

Presented by:

Elizabeth C. Miller	**and**	**Pamela T. Hess**
Senior Consultant		**Seniorr Systems Analyst**
Control Data Corporation		**Control Data Corporation**

1.0 Introduction

1.1 Purpose

Throughout the U.S., hundreds of people in the commercial, government, and academic communities have been developing CAI courseware for more than 20 years. Because people were not aware of previously developed courseware these efforts have been duplica·ed time and time again. In an effort to eliminate this duplication, the Joint Committee on Computer-Based Instruction (JCCBI) members voted to collect, organize, and catalog all CYBER based courseware. As a result of this, the JCCBI teamed with the Training and Performance Data Center (TPDC) to produce a catalog composed of over 3400 entries which represent more than 5000 hours of CAI instruction. This CATALOG is not only valuable to the JCCBI but also to other courseware developers who can access it either by hard copy or interactively in real time.

1.1 Project Scope

The CATALOG project contains the following information:

- Rationale for developing the Joint Service CYBIS Courseware Catalog
- Major tasks/milestones performed during the project
- Methodology used in compiling the Department of Defense (DoD) courseware information
- Description of the catalog organization and associated data fields
- Planning and Development of an automated CYBER application (CBT lesson) which would allow JCBIS users to access the CATALOG in an orderly fashion -- the CATALOG operates like the Control Data Corporation SHIFT-F CATALOG.
- Documentation of the CATALOG database and application to accommodate future modifications
- Documentation of courses that are available for American Council on Education (ACE) college credit recommendations are also called out in the CATALOG.

The basic approach taken for this project was to produce a CATALOG database for the long-term, update the data fields based on a user survey, develop the CATALOG application, and establish the CATALOG on the JCBIS computer systems.

The following activities were conducted during this project:

- Kick-off Meeting and JCCBI Briefing
- Database Design and Convention
- First Questionnaire Development and Circulation
- First Database Update and CYBER Upload
- On-line CATALOG Modifications
- Final On-line CATALOG Modification & Documentation

1.2 Catalog Design

The major portion of this report is the CATALOG of Joint Service Courseware. This portion contains computer-based instruction identified into major training/education categories. These categories include:

- Aviation
- CYBIS Utilities
- Data Processing
- Engineering
- Foreign Language
- General Education
- Job Skills Education Program (JSEP)
- Management
- Medical
- Military
- Technical Training

1.2.1 Catalog Category - Aviation

The Aviation Training Category in the CATALOG is composed of the following sub-topics:

- Airways Facilities Maintenance
- CARDION DMEFA-9783
- Communications Maintenance
- Data Communications
- Flasher System FA-9989
- Helicopters
- High Intensity ALS
- ILS
- Maintenance
- Navigation Aids
- Pilot Training
- RADAR
- VASI

- VORTAC
- Visual Landing Aids

1.2.2 Catalog Category -- CYBIS Utilities

The PLATO Utilities Category is divided into the following sub-topics:

- Character Sets
- Datasets
- New User Training
- Notefiles
- Test/Quiz Generators
- Utilities

1.2.3 Catalog Category -- Data Processing

The Data Processing Category in the Joint Service Catalog is composed of the following sub-topics:

- Computer Hardware
- Computer Literacy
- Computer Software
- Data Processing
- Programming Languages
- Programming Languages: Ada
- Programming Languages: C
- Programming Languages: COBOL
- Programming Languages: FORTRAN 77
- Programming Languages: TUTOR

1.2.4 Catalog Category -- Engineering

The Engineering Category in the Joint Service Catalog is composed of the following sub-topics defined by USAES:

- Analytical Bridge Design
- Bridge Design Fundamentals
- Concrete
- Construction Management
- Drainage Design
- Drainage Facilities
- Engineering Miscellaneous
- Equipment Utilization
- Geology
- Hasty Bridge Design
- ICAM
- Materials Quality
- Road Construction
- Road Design
- Road Design Simulation
- Roads and Airfields
- Utilities

1.2.5 Catalog Category -- Foreign Language

The Foreign Language Category in the Joint Service Catalog is composed of the following sub-topics:

- Arabic
- Chinese
- Czech
- Egyptian
- French
- German
- Greek
- Italian
- Japanese
- Korean
- Latin
- Miscellaneous
- Polish
- Portuguese
- Russian
- Serbo-Croatian
- Spanish
- Syrian
- Turkish
- Vietnamese

1.2.6 Catalog Category -- General Education

The General Education Category in the Joint Service Catalog is composed of the following sub-topics:

- AFCT/ASVAB
- BNCOC
- BSEP
- Broadcasting
- CLEP
- Career Development
- Education Services
- GED
- GRE Exam
- GT
- Journalism
- Learning Center Staff Training
- Mathematics
- Photography
- Statistics
- Training and Development
- Vocabulary

1.2.7 Catalog Category -- JSEP

The Job Skills Education Program (JSEP) is an on-duty, computer-based curriculum that provides job-related instruction. JSEP lessons develop the soldier's basic education skills couched in a relevant Army context. These basic skills were selected for inclusion because they are much more likely to generalize across Military Occupational Specialities (MOS) and job tasks. The lessons in the JSEP curriculum are clustered according to the requirements of the 94 most populous MOS. The goal of the JSEP effort is to improve soldier's general skills, thus enabling them to meet the requirements of their jobs more completely, and to learn new tasks more efficiently.

Under the JSEP Category the following sub-topics have been defined by Florida State University:

- Addition and Subtraction
- Algebra
- Angles and Triangles
- Degree Measures
- Editing
- Flow Charts
- Forms
- Fractions/Decimals
- Gage Measures
- Geometry
- Graphing in the Coordinate Plane
- Illustrations
- JSEP Graphics
- Learning Management
- Learning Strategies
- Linear, Weight, and Volume Measures
- Lines
- Multiplication and Division
- Note-Taking
- Numbering and Counting
- Outlining (Topic and Sentence)
- Planes
- Precautions
- Procedural Directions
- Process Combinations
- Recognition
- Reference Skills
- Report Writing
- Schematics
- Solids
- Spatial
- Supplemental Topics
- Tables/Charts
- Terminology

- Time-Telling Measures
- Trigonometry
- Vocabulary

1.2.8 Catalog Category -- Management

The Management Category in the Joint Service Catalog is composed of the following sub-topics:

- EEO/AA
- Finance
- Managerial Training
- Money Management
- Office Administration
- Production Control Management
- Safety

1.2.9 Catalog Category -- Medicine

The Medicine Category in the Joint Service Catalog is composed of the following sub-topics:

- Administration
- Anatomy and Physiology
- Behavior/Psychiatry
- Cardiology
- Clinical Medicine
- Community Health
- Course Management
- Dental Science
- Dermatology
- Emergency Medicine
- Endocrinology
- Ethics
- Hygiene
- Infectious Disease
- Laboratory Technology
- Medical Readiness
- Medical Terminology
- Medicine
- Mental Health
- Miscellaneous
- Neurology
- Nursing
- Nutrition
- Obstetrics/Gynecology
- Oncology
- Optometry/Ophthalmology
- Orthopedics
- Patient Records
- Pediatrics
- Pharmacology

- Physical Therapy
- Public Health
- Pulmonary Medicine
- Radiology
- Safety
- Security
- Surgery
- Tests/Quizzes
- Typing
- Urology
- Veterinary Medicine
- Wellness

1.2.10 Catalog Category -- Military

The Military Catalog in the Joint Service Catalog is composed of the following sub-topics:

- Administration
- Armor
- Drill and Ceremonies
- Drug/Alcohol Abuse
- First Aid
- HAWK
- International Relations
- Leadership/Command
- Logistics
- Map Reading
- Military
- Military Terminology
- NBC
- Promotion
- Security
- Tactics
- Technical Orders
- TOW

1.2.11 CATALOG Category -- Technical Training

The Technical Training Category in the JCCBI Catalog is composed of the following sub-topics:

- Automotive Mechanics
- Basic Electronics
- Hydraulics

Selected Abstracts for the

Special Interest Group for Academic Computing (SIGAC)

Examples of Instructional Empowerment Using ToolBook

Carol Dwyer and Morris Weinstock, Penn State University

ToolBook by Asymetrix Corporation is an interactive multimedia development tool for the IBM Windows environment. ToolBook combines buttons, text, and graphics on the "pages" of interactive "books".

Faculty from Penn State University are using ToolBook to develop instructional software and interactive classroom presentations with help from the staff of the Teaching and Learning Technologies Group. Products include "SPECS: Selecting Production Equipment with Computer Simulations," developed with a faculty member from Hotel, Restaurant, and Institutional Management, and "Computerized Glossing of Literacy Texts Written in French," developed with faculty from the College of Liberal Arts. In addition, with limited assistance from our staff, some faculty are creating interactive "electronic transparencies" for large class lectures in economics and statistics.

These products will be demonstrated, while discussing instructional problems, instructional solutions, as well as design and development issues. Participants will see high-quality design of screens, interactions, and pedagogical strategies. They will have the opportunity to visually inspect how instructional problems were solved through the integrated use of icons, animation, color graphics, etc.

We will begin with a brief overview of the mission and activities of our Teaching and Learning Technologies Group, how we solicit proposals for development projects from faculty, and how we work as a team to carry out the project. We will also engage participants in discussion about design and development issues and solutions.

The Student of Socrates Meets the Students of Kentucky PLATO(R) and Western Kentucky University

Kenneth L. Modesitt, Western Kentucky University

The problem: how to introduce <u>and</u> maintain effective use of computer-based learning on a significant scale in academia? The rapidly growing number of alternative hardware, communication, software, courseware and authoring systems can make for considerable confusion. Therefore, wise planning involves:

-key personnel at both faculty and administrative levels,

-active participation of a willing and highly-qualified courseware corporation,

-the choice of a "guaranteed success" in the formative stages,

-the involvement of respected "champions", and

-considerable ingenuity in determining financial feasibility, esp now!

The solution involves persistence in pursuing a plan to help students learn better so that they can become productive, self-sufficient and contributing members of society for the rest of their lives. The ingredients are: students, faculty, administration, tools, financial resources, and long-term vision and commitment, and a desire/ability to work with industry. Most universities have the first five ingredients, but are lacking the latter three.

Vignettes of the personal tales of traditional, under-prepared and non-traditional students will be interwoven in the presentation with recommending long-term strategies for success of significant reform in the university. The participant will be able to apply the knowledge that such planning can result in success, and will have additional evidence when promoting similar ventures at his own institution.

Reality-Based Strategic Planning for Computing in University-Based Schools/Departments

Ramona Nelson, University of Pittsburgh Medical Center;
Pamela Hepple, University of Pittsburgh School of Nursing

Higher education institutions are moving from a centralized main-frame environment to a distributed PC based environment. At the same time they are caught between tight budgets and rapid technological change. As a consequence there is a proliferation of approaches to hardware, software, and computer use.

This presentation explained how to develop a strategic planning process for computing in a school or department within a university. Using both theory and experience the presenters described a variety of realistic, effective approaches. An outline of the topics and issues covered follows:

Establish the planning team.
- -Who should be involved?

Identifying the purpose and scope of the planning process.
- -Are all constituents and their activities addressed?

Collect pertinent data.
- -What are the sources of data?
- -What approaches to data collection are useful?

Analyze the data.
- -How are past trends related to planning for the future?

Design an ongoing planning process and write the initial plan.
- -How does one design and organize a planning process?

Market the plan and the planning process to key decision makers.
- -How can a vision be connected to goals?

Implement the plan and the process.
- -How can implementation be flexible, yet effective?

Faculty Development and Support for Development and Utilization of Computer-Based Instruction: Experiences along the Continuum

Floyd K. (Rusty) Russèll, Stan Cohen, and Anne Nardi, West Virginia University; Carol Dwyer, Pennsylvania State University, and Charlotte Scherer, Bowling Green State University

Panel members will discuss how three different institutions are providing faculty development opportunities for learning how to develop and use interactive technologies for instruction. These efforts represent stages along a continuum of start-up efforts to advances support activities.

The session includes information about the CACHE incentive program in the West Virginia University (WVU) College of Arts and Sciences and information about faculty development workshops sponsored by the Office of Faculty Development in conjunction with the WVU Computer-Based Learning Forum. Content from the Penn State University segment includes information about the Teaching and Learning Technologies Group and the competitive awards program for supporting faculty in the development of computer based learning materials. Material about Bowling Green State University includes information about workshops, informal support in computer laboratories, and a long range plan for computerizing the College of Education and Allied Professionals by upgrading laboratories, providing computers in faculty offices, and networking the college. The discussion also includes plans for a high technology classroom building and its role as an incentive for faculty development of computer based instruction.

Focus areas for the session include 1) types of workshops and their content, 2) incentive programs for encouraging faculty development of materials, 3) design and production support, and 4) vendor support for development of materials.

Communicating Knowledge about LANs

Donald Scherer, Bowling Green State University

This presentation discusses three central problems of communication in the installing of an AppleTalk network in an academic department. The problems are the lack of a shared vocabulary between people in computer services and people in academic departments, the fragmentation of knowledge among people in computer services and differing computer interests and knowledge among people in academic departments. The presentation proposes procedures for minimizing each of these problems.

Multimedia Lectures: A Comparison of Some Macintosh Alternatives

Eileen Schroeder, Penn State University

New computer programs make it easier for instructors to recreate, restructure, and reinvent their lectures using computers incorporating graphics, text, and various types of media. Each program has its own special features but all are intended to simplify the process and remove the need for extensive programming skills. This session will review some of the options available to faculty members desiring to use the computer in lecture settings through an examination of the varying needs and abilities of faculty members, development of criteria for selecting tools to create multimedia lectures on a Macintosh platform, review of several currently available alternatives, and comparison of sample screens from comparable lectures using each of the tools. Programs such as Mediatext, Multimedia Annotator, Resource Navigator II and HyperCard with accompanying toolkits were reviewed for this project. Each program was examined for its ease of use, ability to access other applications, ease of accessing multimedia such as CD players and videodisc players, capability for handling a variety of graphics, audio, and text, use of digitized video, programming expertise required, flexibility, branching capabilities, adaptation for individual student use, and cost. A prescriptive matrix matching the programs examined with faculty needs was created.

Selected Formal Papers from the

Special Interest Group for Academic Computing (SIGAC)

The Design, Implementation, and Management of Lehigh University's International Multimedia Resource Center

Blair R. Bernhardt

Lehigh University

Abstract

After an extended period of planning, Lehigh University recently opened its International Multimedia Resource Center (IMRC). The IMRC consists of a multimedia-based microcomputer classroom for teaching foreign languages and world culture; the *World View Room*, in which international satellite transmissions may be viewed; and, the head-end room in which cable television signals are mixed with satellite transmissions as well as video from VCR's and videodiscs, and then placed onto a building-wide cable plant. All classrooms in the building housing the IMRC contain at least a VCR and overhead monitors while all offices contain cable television jacks. It is the intent of this paper to describe the design, implementation, and management of the IMRC.

Overview

The Lehigh University Department of Modern Foreign Languages and Literature (MFL), in conjunction with other departments on campus, had been working on the design of the IMRC for approximately two years when they requested assistance from the Lehigh University Computing Center (LUCC) and the Physical Planning Office. At that point, funding for the IMRC had already been established and it had already been decided that IBM microcomputers would be used for the IMRC. It appeared, at least superficially, that the *only* thing left for LUCC and Planning to do was to help MFL implement this plan. Now, after over a year of involvement, the IMRC is finally taking shape.

The Design and Implementation of the IMRC

Broadband versus Baseband

After consultation with other Lehigh departments, as well as with external consultants, the original MFL plan called for running individual strands of baseband cabling to all IMRC microcomputers as well as to all classrooms. This approach would have required additional wiring from each microcomputer, as well as from each classroom, back to a remote router (to change the channel) in the head-end room. It was felt that this approach would result in a better quality of video to these locations as signals from devices such as satellite receivers could be sent out directly without the degradation resulting from having to modulate the signal to put it on to a broadband cable and then demodulate the signal to get it off of a broadband cable.

Once LUCC became involved and examined the initial plan, it was noted that each of the microcomputers was to also be connected to a VCR. A number of VCR's would be placed in the head-end room and accessed from classrooms through the baseband cable. The VCR's would be controlled at the head-end room either manually (by calling up the on-duty operator on the phone), or via remote controls (hooked up to even more wiring). After consulting the local cable television company, LUCC was assured that with the use of commercial quality modulators any degradation to the signal to place it on a broadband cable and then remove it from the broadband cable would not be noticeable.

With these additional facts, a decision was made to run broadband cable throughout the IMRC and throughout the building. This decision greatly simplified the cabling plan and also allowed the use of inexpensive television sets for video display instead of using more expensive video monitors. Placing VCR's in classrooms provided the flexibility required for viewing prerecorded tapes.

Domestic versus International Satellite Receivers

The initial plan for the IMRC called for the installation of two satellite receivers; one dish for domestic reception, and one dish for international reception. Once it was determined that the roof of the building was structurally sound enough to hold it, the domestic dish was ordered and installed with no problem. The international dish was a totally different situation.

One of the reasons for getting an international dish was for reception of signals from the Russian satellites Gorizont 7 and Gorizont 12; both of which are low to the horizon from Lehigh's geographic position, and both of which are in less than stable orbits. While people familiar with domestic satellite dish installation are relatively easy to find, people familiar with international satellite dish installation are much harder to find. This made it difficult to determine whether signals from these satellites could even be received at Lehigh. While it was somewhat assumed that these signals could be received, it would require a rather large receiver dish to do so. As this dish would be significantly larger and heavier than the domestic dish, and would also be much more prone to wind stress, it was questionable as to whether this dish could even be placed on the roof of the building containing the IMRC.

Lehigh's campus basically straddles a mountain (at least by eastern Pennsylvania standards). One alternative which was considered for the international dish was to place it on top of the mountain and then send the received signals down to the main campus through either microwave transmission or via fiber optic cable. Both of these alternatives were rejected since both would have significantly increased the cost of the international dish. As a stopgap measure (at least until additional funding was secured), it was decided to subscribe to SCOLA. [SCOLA, the Satellite Communication for Learning network, is a service which receives foreign satellite transmissions (and video tapes) and retransmits them for reception via domestic satellite dishes.]

Design of the Multimedia-Based Microcomputer Classroom

The basic design of the multimedia-based microcomputer classroom was primarily a function of the triangular room in which it was to be placed. The microcomputers and associated peripherals were placed along two of the three walls with a doorway and a window (through which headphones and tapes could be checked out) into the head-end room on the third wall. Cabling from the head-end room was not a problem.

Computer Hardware and Software

The initial IMRC plan called for the use of microcomputers from IBM. IBM had already provided funding for the development of foreign language software to a number of institutions through its Foreign Language Consortium. A stated goal of this consortium was to enhance the availability of foreign language software, and it was the hope of MFL to be able to utilize this software while its faculty members were in the process of developing additional software.

Around the time that the specific computer hardware and software requirements were being finalized, IBM announced a new multimedia hardware and software bundle called the Advanced Academic System 2.0 or AAcS. This bundle consisted of a computer with an audio card, a video card, a CD-ROM drive, a hand scanner, and a full contingent of software to make these components work together and provide the tools for the development of computer-aided instruction. With the exception that the computers included in these bundles were slightly slower than those which had been planned, these systems met or exceeded all of the finalized requirements at a cost significantly less than anticipated. As cost had become a factor, fifteen of these bundles were purchased.

As is often the case when purchasing relatively new technology, a number of problems were encountered with these bundles. While institutions which were already in IBM's Foreign Language Consortium were supposedly using the same equipment, these institutions were actually using the prior releases of most of the hardware including the audio card, the video card, and the CD-ROM drive. To make matters even more interesting, in some instances the provided software did not work with the provided hardware. For example, while the software provided an option for digitizing CD-Audio, and while the CD-ROM drive was capable of playing CD-Audio, the software would simply go through the motions of digitizing and would result in a rather huge file filled with absolutely nothing of value. Upon taking apart the machines, it was determined that this resulted from the lack of an internal connection between the CD-ROM drive and the audio card.

Another problem resulting from these bundles was in that all of the software had been pre-installed on the hard drives and some of it was not supplied at all on diskettes. While this may have been perfectly acceptable for stand-alone systems, to protect these systems from student abuse they were to be placed on a local area network. Even though, with effort, the software probably could be installed on a LAN, some of the pivotal pieces of software required write-access to things such as device drivers. Since students do not have write-access to software on any LUCC LAN, by placing this software on a LAN the flexibility of the software would be limited in an unacceptable manner.

Laserdisc Players

Under normal circumstances, given the hardware and software which is to be used, picking a laserdisc player is a rather easy task; simply check which players are supported by the hardware and software. Unfortunately, just as mid-level players were to be ordered, the producer of the players announced a change in their product line, effectively removing the middle of their line and leaving nothing but a low-end model and a high-end model. Obtaining a source for fifteen players of a discontinued model was not feasible. In discussions with representatives of the company, it was determined that a new middle of the line model was to be announced shortly thereafter which, along with the video card which was to be used, would provide most of the functionality of their high-end player. At that point, an order for the new players was placed. Six months later, the players were received.

VCR's

In addition to a laserdisc player, each microcomputer also was connected to a VCR. The VCR was to have two basic functions:

to provide stand-alone playback for prerecorded tapes, and to function as a tuner to select channels from the broadband cable. As the video card was capable of accepting up to three different video signals at a time, it was assumed that it would be a relatively simple task to put together a simple program which would allow the user to select either the laserdisc player or the VCR for the video input. Unfortunately, the majority of the control program for the video card had not been included in the AAcS bundle. After discussions with IBM, a full copy of the control program was received which contained the necessary drivers for the development of a video source selection program.

While the video source selection program allowed video from a VCR to be displayed on the screen, it still required each VCR to be operated manually. A number of computer-controllable VCR's were purchased for developmental work, however, the cost of these devices was sufficiently high that little consideration was given to placing them at each of the microcomputer stations.

Microphones and Headphones

As audio experts are not typically found within foreign language departments, computing centers, or physical planning offices, it was basically assumed that it would be safe to purchase these items with some basic specifications from catalogs. By purchasing moderately priced professional quality microphones and headphones the supplier also assumed everything would be fine. This was not the case.

Unfortunately, the headphones turned out to be not quite professional quality, but rather medium-end consumer models. While the sound that the headphones delivered was acceptable, it was obvious that they would not hold up to the rigors of student use. After testing a number of other headphones, it was decided that the best alternative was to return the expensive headphones and buy a larger quantity of very inexpensive headphones instead. Also, any students who wish to are encouraged to simply supply their own personal-cassette player type headphones.

Microphones created even more interesting problems. First, professional model microphones do not come with connectors attached but simply with wires hanging out of the end. It is assumed that whoever purchases these models will have the technical expertise required to wire them and make them work. Next, there is the problem of the sound level which these microphones deliver. While the sound level is fine for the devices to which these low-impedance microphones are typically connected, it was insufficient for use with the audio cards which were expecting input from high-impedance microphones. This problem was resolved by placing an impedance matcher (with its associated connectors and wires) between the microphone and the audio card. Upon further testing, it was determined that this problem could have been resolved even easier by simply purchasing cheap replacement microphones (which are high-impedance) from any electronics store.

For faculty development use, the MFL department also wanted a number of headsets which combined headphones and microphones into one unit. These devices were also ordered from a catalog, also came without any connectors (but twice as many wires for the two devices), and also had the same impedance problem with the microphones. As if this wasn't enough, the instructions for wiring these headsets were written only in German.

Design of the World View Room and Classrooms

The building in which the IMRC resides is of the somewhat modern design which was popular in the 1960's. Form took precedence over functionality. Hence, like the microcomputer classroom, the World View Room and many of the classrooms are triangular in shape. For the World View Room, this shape actually enhances the design with a large screen projection television as the focal point in one corner of the room and chairs arranged radiating out from it. Another corner of the room contains shortwave radio monitors while the third corner contains foreign language reading materials. World maps line the walls. The television is usually tuned to SCOLA which provides broadcasts, either live or slightly delayed, from around the world.

The classrooms are supplied with either one or two televisions suspended from the ceilings (depending on the size of the room), and a VCR. As all of the classrooms are also supplied with connections to the broadband cable, this setup allows classes to utilize either live broadcasts from SCOLA, C-SPAN, or CNN, or any prerecorded video tapes. One of the larger classrooms is supplied with a projection system connected to the same type of multimedia-based computer system found within the computer classroom.

The Management of the IMRC

Daily Operation

The mission of the IMRC is to promote cultural awareness and to develop software for foreign language instruction. To achieve these objectives, a position of Director of the IMRC was established. The director handles the daily operations of the IMRC, including things such as programming the satellite dish and VCR's, scheduling of IMRC resources, and ensuring that all IMRC resources are functioning. It is the role of the director to not only handle daily operations of the IMRC, but also to provide training to MFL faculty (and others who may want it) in the use of the IMRC facilities and in the development of instructional software. On a part-time basis, a number of students assist the director by handling such tasks as signing out headphones, video tapes and discs, and programming VCR's.

The Computing Center, LUCC, is still actively involved with the IMRC by providing hardware and software assistance and by providing more advanced training to users of the IMRC computer classroom. With the arrival of new versions of software, there is an ongoing process of determining that all hardware and software continues to interact successfully. It is still a goal of this project to place all software on a write-protected LAN to ensure the integrity of the software.

Software Development

In order to make the lab functional as quickly as possible, LUCC developed a number of programs and templates which can be quickly modified for MFL use. Since the MFL department already had a large number of video tapes, the first LUCC-written program simply allowed the selection of which video source would appear on the computer monitor; VCR, laserdisc, or live broadcast. Without this program, even though up to three video signals may be arriving at each computer, only the text and graphics from the computer would appear on the computer monitor.

To facilitate courseware development, LUCC created a number of templates. The first two of these were for controlling laserdiscs; one for CAV discs and one for CLV discs. By simply entering titles in a field (column) and then editing laserdisc start and stop locations in a script associated with that field, a series of video clips can be created. Text pertaining to all of the video clips can be placed into a second field which will automatically scroll to the proper location when a video clip is selected. With these templates, MFL faculty members can create courseware for any foreign-language laserdisc with relative ease.

One of the primary functions of the old MFL language lab was the ability to continually listen to phrases and then repeat them into a microphone. To provide this functionality, and more, another template was created in which the student can see the phrase, hear the phrase and repeat it into a microphone, and then hear a comparison of the original phrase to the student's own recording of the phrase. All that the faculty member needs to do is to record the phrases the students are to hear, enter the text into a field, and then edit a script associated with the text field to enter the name of the files containing the recordings.

A number of templates were created for questions and answers utilizing multiple choice, fill-in-the-blank, and matching formats. Scoring is built into all of the formats. When text is entered into a field, an attempt is made to check for minor spelling errors so that answers won't be rejected totally.

The Future of the IMRC

The role of LUCC with the IMRC is increasing as the IMRC, along with the rest of the campus, moves from a combined analog and digital environment to a strictly digital environment. The MFL faculty have expressed a strong interest in integrating their own personal video tapes into the courseware they develop. This can probably best be facilitated within a digital environment. The testing of digital devices is already under way.

Conclusion

While establishing the International Multimedia Resource Center was not a particularly smooth process, it did prove to be a valuable learning experience. One of the most valuable lessons was to buy a single item or system for testing before buying in bulk, especially if the technology is relatively new or unknown.

Through the establishment of the IMRC, issues such as analog versus digital video, and what is the minimum acceptable resolution and number of colors for still images, are now being discussed. While superficial discussions regarding campus-wide video had been taking place for years, the development of the IMRC added an impetus to this planning and forced the University to more closely examine the integration of data, audio, and video on a campus-wide basis.

A Computer-Based Course in Programming Paradigms

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Abstract

This is a summary of an introductory programming course taken by pre-service teachers from a variety of fields. Course development, content, assessment, successes and failures, and student reactions are described. The first few weeks consists of an exposure to different programming paradigms (Imperative, Declarative, and Object-Oriented) and languages and their environments (Turing, Logo, Prolog, and Smalltalk), and programming principles. The remainder of the course consists of a student project, in which a computer system is specified, programmed, tested, and presented to the class.

Contents

Development

Clientele

The course was first developed by the author (also the instructor) in the winter term (January to May) of 1991. Two groups of pre-service teachers, about twenty in total, have followed the programme. The students are Bachelor of Education and Diploma in Technical Education candidates at the Faculty of Education at Queen's University who attend the institution from September to May. Admission to the Faculty is based on equal weighting of both academic and personal qualities of the applicant, and competition is intense to gain entrance. All students require a course in psychology, and there are minimum numbers of subject-specific courses needed for admission into B.Ed. subject specializations at the intermediate and secondary levels. Queen's can typically admit less than one sixth of all those applying, and in some specialities the ratio is even greater. These students possess great diversity in both academic and personal experiences. The mean age of students at the Faculty is over 28 years.

Students take several different courses, depending on their preferred teaching level (e.g., primary-junior, junior-intermediate, or intermediate-secondary). Some of these courses focus on curriculum in their chosen specialities, some deal with foundations issues such as psychology, philosophy, etc., others deal with professional skills including curriculum design, assessment, computer and media skills, and so on, and finally some courses are offered purely as electives. A total of nine weeks of practice teaching rounds is distributed over the year, typically in two-week stays at a school. During these times all courses at the Faculty are interrupted while student teachers and Faculty instructors work in the schools. Elective courses last one term in length, thirteen weeks of class time are broken up by practice teaching. The course described here is an elective.

Rationale and General Aims

No assumptions could be made about either student background knowledge, or their aims in taking this course. Student participants have come from such diverse areas as elementary education, music, physical education, mathematics, science, and computer science. Some students took the programming course to prepare them for later professional qualifying courses for the teaching of computer studies, some because they knew something already about programming and wanted to deepen their understanding for personal satisfaction, and others decided that this was a good opportunity for them to start to learn about programming.

The course was developed to give the students an overview of what programming a computer is about, but in a way that was quite different from many other programming courses. Most traditional courses focus on a single programming language and paradigm and treat them in some depth, to give students a knowledge and capability with that particular system. The syntax and structure of one programming system are experienced in detail. Given that most of these students will not go to more advanced courses, and that some will have never done any programming before, it was decided to provide a bird's-eye view of the area, rather than a pedestrian's. Granted, taking a helicopter ride up Mount Everest does not give one the same cutting-edge appreciation for the technical difficulties faced by climbers, but it does show the lay of the land in ways that cannot be effectively perceived by those following tortuous routes. The goal of this course was a forest-view, not a trees-view. This was deemed to be more attainable and beneficial for both programmers and non-programmers.

One component of the overview was a look at the expressive power of programming systems. A computer program is usually crafted to solve some problem. There is a two-step process at work. First, the problem in the real world is isolated and described in simpler conceptual terms. A transformation from the complexity of the real world to a distilled essence of the related ideas is sought. It is in this form that the problem is really solved in an algorithmic sense. Many generic tools can be brought to bear on the problem at this stage: features of the model, negligible factors, and above all, expression of the conceptual problem in mathematical terms and subsequent manipulation in this form. Much can go wrong in this process. Assumptions may be inaccurate or inadequate, the simplified concepts may not be capable of representing the problem fairly or completely, mathematical operations may be misused or abused.

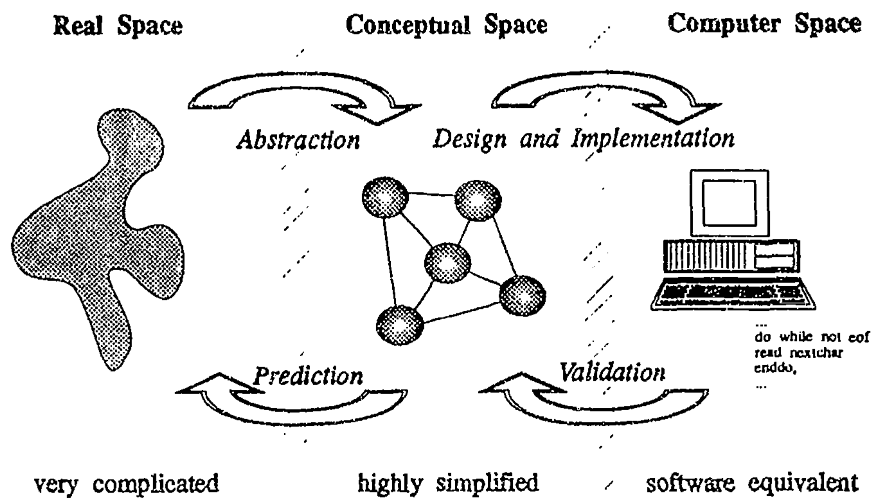

Figure 1: Problem Solving by Computer: A Two-Step Process

The second step in the process is the casting of the conceptual model into software that is executed by hardware. This is not always a trivial task. The representation in software must be valid with respect to the conceptual model. Most modern programming systems do include a host of mathematical operations that can carry out those required by a conceptual solution algorithm. Unfortunately, they do not always allow the freedom of expressiveness needed by conceptual models. How does the programmer capture the features of the conceptual data in a programming language? In most systems there is a still quite a narrow range of built-in data structures that can hold these data, but conceptual data of arbitrary complexity often has to be jammed into bizarre combinations of data structures. This alone can lead to errors. The conceptual data can be misrepresented in software. Program execution may mean using data piecemeal, which can lead to incorrect extractions of the required parts of the data, or unwanted side-effects when operations are performed. Finally, the software representation of the data is manipulated by operations specified by the flow of execution of a sequence of instructions. In many systems the data are separated from the kind of behaviour it should have; data are sent to procedures for some operation to be performed, and they are returned in some modified form. Representing the steps in a problem solution is not always easily embodied in a programming system.

The expressiveness of programming systems was sampled in two ways. One way was through the features of the language itself, especially with respect to the kinds of data that could be represented. Data included (in a general sense) numbers, text strings, graphics, and sound. Secondly, and more importantly, several programming paradigms were examined. A programming paradigm in this sense refers to the way in which a problem is redefined in software and the mechanism in which the created software arrives at a solution to the problem. Four languages (Turing, Logo, Prolog, and Smalltalk) and three paradigms (imperative, declarative, and object-oriented) were used.

Whatever programming system, issues of program specification, design, structure, modularity, and testing were considered to be important. Some key software engineering ideas were introduced as the course progressed. Mechanical considerations of programming environment were also significant features. A comparison of screen layout, editor operation, compiler or interpreter invocation and commands, debugging tools was included in the course.

For the sake of completeness, so that students could have some idea of the relationship between their programming and the execution of code at the lowest levels in the machine, basic ideas of the various components of a programming were briefly described. This involved no more than a summary of the relationship between editors, compilers/interpreters, machine-level code, and operating systems. This was only of passing interest to complete novices, and to more experienced programmers, but added some context to intermediate programmers who could now appreciate some of this terminology.

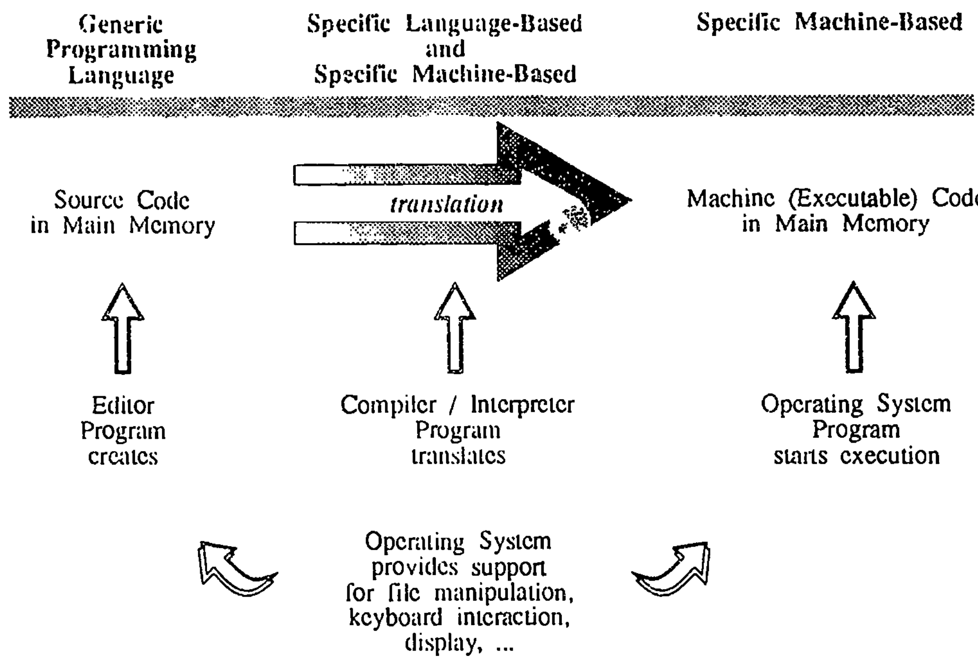

Figure 2: Components of a Programming System

Finally, it was critical that students appreciate the creative side of programming. Programmers do analyze problems. But the extraordinary intellectual pleasure of programming comes from the synthesis of a solution design, its implementation, and its execution. To experience the pleasure of seeing one's own creation drive a machine, which can be a tremendous mental lever, is to feel the power and joy of the human side of programming. Computing can be an awful lot of fun!

Key Elements: The Languages and Paradigms

The languages include Turing (a Pascal-like structured language that includes coordinate-style pixel graphics and sound) [Holt 92], Logo (a language that includes both Turtle graphics, sound, and Lisp-like data structure processing) [Papert 80]. Both these languages use the imperative paradigm, typified by Niklaus Wirth's dictum *algorithms + data structures = programs* [Wirth 76]. That is, the programmer must arrange a controlled flow of data through a prepared sequence of operations to have the program produce the intended result. It falls to the programmer to create the software that structures and contains the data for the ideas dealt with (usually something in the real world), and to know what operations to perform on these data and how to do achieve them. These are not trivial tasks, even when the desired outcome of program execution is clearly understood. Turing is very much a "conventional" programming language in its form, but has a remarkably clean syntax (something like semi-colon-less Pascal). It has the usual data types. integers, reals (floating point), strings of characters, arrays, and records. Variables must be declared and as such there is strong type checking. Variables can have both global (system-wide) and local (within a procedure) scope, a common feature of this generation of languages. It can do pixel graphics in multicolours based on standard coordinate geometry with an origin in the lower left-hand corner of the screen. Music is easy to add by a frequency/duration specification. There is a small vocabulary (ca. thirty) of reserved words for Turing commands. Turing programs are written by using these primitives within a sequence of short one line commands, and by grouping sections of these into named and callable procedures. Each of these programming systems use a different user interface for execution and development. While both incorporate editors that are integrated with the system, Turing provides syntax checking before run time (Turing code can be compiled) that will not allow escape from the editor until such errors are corrected. Programs are created and modified, then run, by a separate command from within the editor. The programmer does not need to know that the code is checked, and that library routines may be linked, all by the "run" command from within the editor. After execution the system returns to the editor. Edited code can be saved or retrieved in files from within the editor.

Logo is best known for its "Turtle graphics" in which commands are given to a conceptual Turtle object that drags a multicolourable pen across the screen (an abstraction of a real robot Turtle that moves along the floor carrying a retractable pen). Geometry is Turtle-centred and differential (for the most part). That is, command sequences used to create figures are centred on the Turtle itself, its final position depending on its initial position and orientation and the self-referencing commands to turn through an angle or take several Turtle steps, as compared with specifying a move to a Cartesian point on the screen. The basic data structure is the list, and Logo is very Lisp-like in how symbolic or mathematical procedures are implemented. Variables do not have to be declared in Logo, and strong typing is not required. Furthermore, variables can only have global scope (they cannot be declared local to a procedure). Some limitations of this feature can be overcome by using arguments when calling procedures. We use a version of Logo called LogoWriter [LCSI 86]. The LogoWriter editor is more rudimentary than that of Turing, but is more seamlessly connected to the system. Using the editor involves going to the "flip side" of the "page", in which all new code is written. The user must return to the "front side" of the LogoWriter "page" to call the code for execution. Logo code is not checked extensively on exit from the editor. LogoWriter pages can be saved in files for later recall or editing in another LogoWriter session. Logo also possesses an immediate-mode execution facility from which users not only invoke program execution but write and execute short "one-liners" for investigative purposes. There is again a small vocabulary (ca. thirty) of reserved words for Logo commands; Logo programming consists of extending the language by creating new "words" that invoke combinations of the primitive operations or other previously-defined procedures.

Since both languages rely on the flow of execution control they can illustrate features of structured programming and modularity. Structured programming is an approach to restricting flow of control to three main types: the sequence, the conditional test (if ... then ... else) and the loop (do ... while ..., or repeat ... until ...). Structured programs are easier to understand and maintain than those that are not, particularly those that contain "goto" statements which can redirect flow arbitrarily. Modular programming encourages the packaging of code segments into a group of code devoted to a particular operation. When the operation is required for execution the control passes to the module and its contained code, and then returned to the part of the program that called it.

The other programming systems used in the course are Prolog and Smalltalk. Prolog embodies the declarative paradigm espoused by Kowalski: *algorithm = logic + control* [Kowalski 79]. The name of the language comes from *pro*gramming with *log*ic. In this context, the role of the programmer is to specify the relationships between data that must satisfy the solution, then let the Prolog inference mechanism (built in to the Prolog system) direct control until the data are massaged such that the solution is found. That is, the programmer need not know *how* to reach a solution in a procedural way, only the constraints that must be satisfied by a solution. Of course, it isn't quite that simple. The programmer must understand how the underlying control mechanism works to arrange the facts and rules that comprise the program so that they will generate the necessary data modifications. The algorithm, or sequence of operations, is a result of the program (database) of logical statements combined with the built-in control mechanism. Prolog is not a system that is well-suited to number crunching, and since it is not structured inherently for control it does not lend itself to structured programming methodologies. However, the database of facts and rules can be modularized to encourage low coupling of components of the overall logic, which enhances readability and reduces maintenance problems.

The paradox that the code is specified declaratively and yet executed procedurally is the characteristic of the system that confuses most beginning Prolog programmers. Prolog has a small set of primitives. Prolog programs are databases of facts and rules that augment and call one another and the basic system primitives. The programmer cannot simply "read" Prolog code sequentially, as in an imperative language, because execution order is based on the inferencing mechanism that directs the flow of control at run time. The best that the programmer can do is to create the necessary, self-contained facts and rules that target a specific outcome (usually two or three short lines). It is the entire database of these clauses that makes up the elements of a working "program". There is no integrated editor with most versions of Prolog, though the system can be set up to invoke an external editor from an internal call to the immediate-mode interpreter. The editor is simply a text editor operating on an external file; when it starts up Prolog relinquishes all control to it until it is exited. On exiting the editor the programmer returns immediately to the Prolog system. To some extent, these shifts are transparent, but they are awkward. It is also possible to edit Prolog files completely independendy of the system and later file in the database without recourse to an editor call. To add to or modify the existing database of facts and rules Prolog must be given a goal to consult the previously edited file. On reading the file Prolog will declare certain syntax errors that it cannot parse.

In the version of Prolog that we use, Wisdom Prolog [MIT Press 1991], there are three screen windows. The windowing environment is entirely text-oriented, not graphics, and is written in Prolog. One is a general "console" that permits the user to solve problems and give directives directly to the Prolog interpreter. It is used to consult files of facts and rules (to bring them into the system database of all facts and rules) and to give the interpreter goals that it must solve. Another window can be used to create "one off" databases of facts or rules for testing purposes, though it is not recommended as these data cannot be subsequently saved to a file. Finally, there is a trace window that will track each fact and rule call made by the inference engine during execution. This can be useful for debugging.

Smalltalk is an object-oriented language in its purest form [Goldberg 84]. In the object-oriented paradigm problems are solved by creating software structures (objects) that contain the state (data) and behaviour (procedural code) of the components and then allow them to interact through message sending and responses among themselves. In a sense, object-oriented programming is *problem solving by simulation*. Object-oriented systems also make use of the idea of classes of objects which are templates from which specific instances objects can be created, but which contain the executable code for them. Moreover, classes are arranged in a hierarchy so that related classes of greater specificity (subclasses) can inherit state and behaviour from those of greater generality (superclasses). Smalltalk is a big system. In the version that we use, Smalltalk /V 286, there are over one hundred classes and about three thousand "methods" (procedures) associated with the basic system [Digitalk 88]. Programming in Smalltalk is done by extending and specializing existing classes or creating new ones, and by reusing as much existing system code as possible.

A typical "program" execution is started by asking Smalltalk to create and initialize an instance of some class, and sending it a start-up message. Execution proceeds by a subsequent barrage of message sends (usually many hundreds) to various objects in the system such as text windows, etc. Much of the low-level complexity is hidden from the programmer, who only has to know the "external" protocol that an object responds to. With so much reuse of code, and the organization based on a class hierarchy, "programs" in Smalltalk are usually distributed throughout the system. Thus the programmer cannot "read" Smalltalk code very easily, as it is broken into separate, very small, behavioural chunks for the objects for which they are written. Rather, the programmer browses and augments the various components of behaviour in small chunks. Smalltalk permits the building of a class of object of arbitrary complexity, so there is no restriction at all on data types, though many variations are built in (integers, reals, collections - including bags, sets, arrays, ordered lists, and strings). Smalltalk is not strongly typed, as variable binding occurs at run time, when the message is sent. Global and local variables are permitted.

The Smalltalk environment is built entirely in bit-mapped graphics. All "programming" is done by interacting with graphics windows and the mouse, cutting, pasting, augmenting and browsing system code. Nearly all the Smalltalk system is written in Smalltalk, and the programmer can see and modify any of it; there is no operating system, as such, with

Smalltalk. There is a window-based dynamic debugging facility built in to Smalltalk that permits inspection and modification of objects during execution.

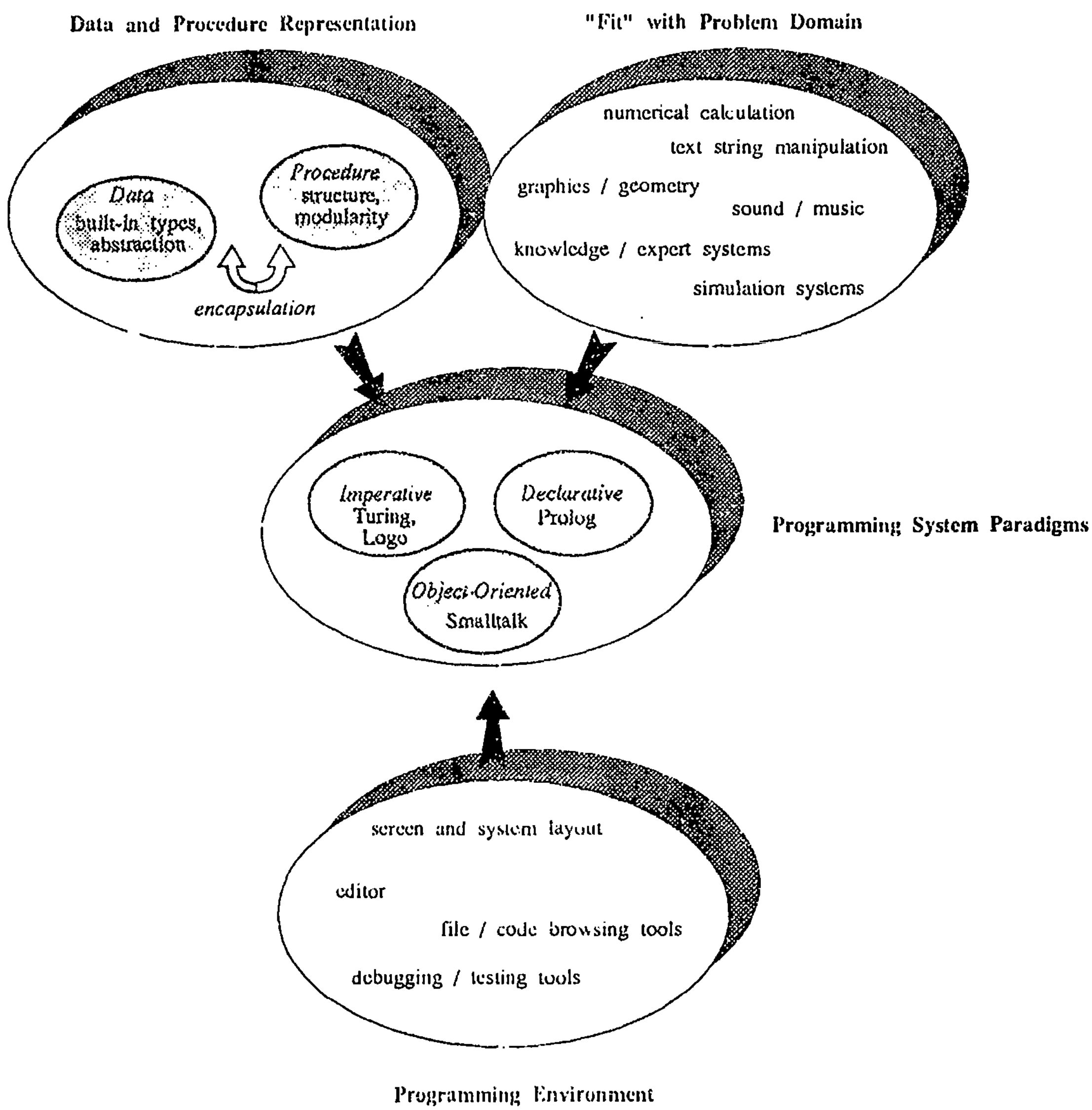

Figure 3: Programming Paradigms and Languages

Just as there are many different kinds of problems that can be approached through computer programming, so goes the difficulty of finding a single language or paradigm that will allow the programmer to solve all problems with equal facility. Some languages have numerical, string handling, graphics representation, or sound generation features that make them more suitable for some problems as compared with others. That is not to say that one could not attack any problem in virtually any programming system. It is a question of the ease with which one can map features in the problem domain into software. The expressiveness of a programming system depends on more than just language syntax and structure, though that is part of the difference. Turing and Logo can both do superb graphics, but Logo Turtle graphics is more suited to differential geometry than Cartesian-based pixel graphics. A singular difference among systems can be seen in the paradigm of computation: how data are represented and interact. Prolog handles expert system construction and certain constraint problems much more easily than an imperative language, simply because of its separation of the knowledge and facts from the engine that drives the reasoning. Smalltalk offers uninhibited design of any data structure coupled with operations on that data structure (encapsulated, so that the internal implementation can be hidden from other objects). Smalltalk objects are "active data", which respond to messages sent them depending on their programmed behaviour. It allows the programmer to concentrate on capturing the essence of the world in software objects that relate intimately and directly with their real-world counterparts. There is no need to divide complex things and jam them into a few data structures offered by the programming system. Smalltalk is especially suited to simulation and modelling of large systems of complex objects.

Programming in parallel systems and connectionist computing, while interesting and different paradigms of great significance in their own rights, are deemed to be beyond the scope of the course.

The general aims of the course are summarized by the following general objectives, as given to the students.

The student will be able to:

1. describe the (i) process of programming
   (ii) major programming paradigms (and an example of each)
   (iii) importance of programming environment features
   (iv) fundamental concepts of good program design

2. design, implement, debug, and present a programming project in the student's language/system of choice (in agreement with the instructor)

Topics

The first half of the course consists of an exposure to different programming paradigms (three) and languages and their environments (four), and program design principles. The remaining part of the course consists of a student project, in which a problem is specified, programmed, tested, and presented to the class. The project is chosen in mutual agreement with the instructor. Times shown are for in-class sessions, at the keyboard, of which three hours are scheduled each week. Often, out-of-class time must be added as well.

Week 1: Introductions. Overview of programming paradigms, languages, and environments (1 h total). The Turing language (5 h total): environment, variables and types, input and output, processing, assignment, if/then/else structures.

Week 2: Touring Turing: loops (counted and conditional exit), random number generation, character strings, modules (procedures and functions), graphics and sound. Assignment #1: Turing.

Week 3: The LogoWriter language (4 h total): introduction, environment, turtle graphics, repeat loops, state transparency, modules (procedures, procedures with inputs), top-down and bottom-up design, if/then/else structures.

Week 4: The last of LogoWriter : recursion, numerical procedures, list processing (including strings and sentences), music. Assignment #2: LogoWriter. The Prolog language (4 h total): introduction, environment, database of facts and rules, closed-world assumptions, inference engine, unification and instantiation, numerical calculations, recursion, search, sound.

Week 5: Completing Prolog: generate and test, list processing, expert systems. Assignment #3: Prolog. The Smalltalk language (4 h total): introduction, environment, objects, messages, classes, encapsulation, inheritance, programming by simulation, code fragments.

Week 6: Saying goodbye to Smalltalk: data abstraction, class libraries, magnitude, collection, and graphics classes, model-view-controller paradigm, creating a small counter application, investigating and modifying a complex simulation. Assignment #4.

Weeks 7 - ...: Program design issues. Discussion, choosing of projects, work begins. Project work is mostly independent. We save the last couple of classes for student presentations of projects.

The course was thirteen weeks long.

The aim of the project portion of the course was to give practical experience in designing and implementing a program to solve a problem that was of interest to the student. They chose any programming language and any computer for their project. Some effort was devoted to learning a new system, or gaining other information that enabled the solution of the problem. The students verified that their projects were satisfactory in terms of degree of difficulty; i.e., limited enough in scope and complexity that they could be done in a reasonable length of time, yet involved enough to stretch their abilities.

Previous student projects have included: a spreadsheet application with macros in tracking basketball statistics, HyperCard (Apple Macintosh system) stacks in social activities (P.H.E.) and biology, Toolbook (a hypermedia program for the IBM PC family) programs in history, health, biology, chemistry, physiology, face reconstruction, a Turing version of the game of Life, and a hyperspace graphics generator, a Logo graphics/music player, a Prolog fuzzy-logic investment counselor, a garden planner, and an automobile diagnosis expert system (partial), and a Smalltalk network planner and complex number class.

Delivery

There were no lectures. Aside from a brief introduction to the general properties of the programming system being sampled, there were no formal class discussions. Students worked almost exclusively at the keyboard, in pairs or alone. A comprehensive set of notes guided them through examples, concepts, problems, and explorations. Reference manuals were kept in the computer lab at the Faculty of Education; sometimes they were signed out on an individual basis, quantities permitting (we had more students than computers and programming systems, and we remained within licensing limits). Students were usually present during scheduled class periods, but not always, . Attendance was not a requirement except for project presentations. Some students worked at home on their own computers, if they had them; they purchased their own copies of Turing at a very low price, and our site licence for LogoWriter allowed them to use the system at home while they were students at the Faculty of Education. A couple of students also had their own copies of Prolog (Turbo Prolog). No student has ever had Smalltalk on their own computer. The instructor was available at each scheduled class meeting, and often outside those hours, for assistance. This was seldom needed, as there was usually peer consulting going on within the group about how to get past particular problems. The instructor's main activity was to unobtrusively join the programmers and eavesdrop, commenting on the thinking that was going on, or suggesting alternate ways of approaching the difficulty. The instructor was not the problem solver or the resident expert who would dispense shortcut solutions and clever hacks. The instructor was a mediator in analysis, design, and debugging.

Besides these meetings, there was little formal interaction between instructor and student. At the scheduled end of the time allocated to each programming system instructor and students would mutually agree on a due date for the assignment. Assignments would be handed in, then commented upon and marked by the instructor, and returned promptly by the next class meeting.

There was a class meeting to discuss the project, its assessment, and show examples of previous projects. After that point students worked whenever they wished to and consulted the instructor on an *ad hoc* basis. An extended class was scheduled for the last meeting, at which students presented their programs to the group. This celebration was the culmination of the course.

Assessment

All assignments and projects were handed in as both hard-copy and machine-readable form (on disk). The assessment

Four given problem/programming assignments (one on each language: Turing, LogoWriter, Prolog, and Smalltalk)	40%
Programming project: Design, program, documentation = 40% Class presentation = 20% (partly student assessed)	60%
Total Mark	100%

scheme was given out with each assignment or project.

Assignments were handed in on mutually agreeable due dates. To allow quick turnaround of assignments, to avoid needless procrastination, and to be fair to those who complete work on time, late assignments had the total possible score reduced by 20% per late day.

We used the following grading system, based on student preference: Pass (No Honours)/Fail. The breakdown would be based on:

Pass	50% < Total Mark
Fail	Total Mark < 50%

(Occasionally students will choose an Honours/Pass/Fail system.)

A typical assignment in Turing and LogoWriter consisted of designing, implementing, and testing four different programs. Of the four, one was usually based on numerical calculation, one on some control feature of the language, one of some form of data type or structure, and one on graphics or sound (usually there is a choice). The Prolog assignment usually consisted of databases already given the student for modification or augmentation to another purpose. For example, a generate and test program was modified, and a tiny expert classifier system was created (facts) using a shell given. The Smalltalk assignment consisted of browsing the system, finding and explaining code, and extending some existing application classes.

Each assignment was assessed according to the following criteria:

All programs should contain documentation that includes:

- Name of programmer
- Title of program, and the date
- A general comment on what the program does and how it does it
- A list of variable names and what each variable represents
- Comments sprinkled through the program.

Programs are evaluated based on:

• *Program Design*	
clarity	10
correctness (meets specifications)	5
efficiency	5
• *Program Documentation*	
name, title, date, general statement	5
meaningful variable names and description	10
general comments	5
• *Program Execution*	
correctness (meets specifications and runs)	10
• *Total*	*50*

The aim of the project portion of the course was to give practical experience in designing and implementing a program. The project deliverables included a description of the problem, a summary of the approach that was used to solve it, and what tools (programming languages or hardware) and algorithms were brought to bear on the problem (and why). They also included the program or system code. Finally, the students presented their problem and its demonstrated computer solution to the class in a time-limited (15 minute) session at the end of the course.

The marking scheme for the project is shown below. Students are involved in assessing their colleagues' work for part of the total score.

Overall:

Creativity and originality: Is it a good problem, suitable to solution by computer, and can you see why someone would find it interesting? 10%

Degree of difficulty: Did the problem stretch the author's (not your) problem solving and intellectual capabilities? (The solution may fall far short of perfection, but it may have been very challenging to the author) 10%

Effort: Did the problem represent substantial effort on the author? (It may have been a fairly simple intellectual problem, but a tremendous effort went into an outstanding product.) 5%

Success: Was the problem solved completely and effectively by the program? 10%

Documentation and Programming:

Problem statement: Is it clear, and unambiguous, and does it define the scope of the work? 5%

Description of approach: Were the choices of platform and programming system / language reasonable, and were the algorithms suitable? 10%

Program clarity, design / structure, appearance, commenting: Is the program understandable? Does it break down complex problems into smaller ones? Are meaningful variable names used? Is the program readable? 20%

Program correctness: Does the program do what it is supposed to do? Does it trap common errors? 10%

Presentation (15 minutes):

Clarity: Is the problem clearly stated? 5%

Completeness: Is the presentation complete, in that you can see how the demonstration of the computer program solves the problem? 5%

Motivation level: Is the presentation motivating; would you like to see and hear more about this problem and program? 5%

Timing: Is the presentation well-timed; does the presenter move effectively from one topic to the next within the overall time limit? 5%

Resources

Different computers have been used in the course, including Unisys ICON II, Apple Macintosh, and Zenith IBM PC 386 compatibles. The platform of choice has settled on the PC, mainly because there is a small lab of eight machines that can be devoted to programming use by the students during their class periods, because there are other PC compatibles more readily accessible, and because it offered a slightly more uniform screen and keyboard interface to the programming systems used. The lab was reserved for these students during their class times and was accessible to them for much of the day (when they enjoyed an elevated priority of access, as compared with students that wished to use the machines for, say, word processing). The PCs that we used were 80386-based, 25 MHz, with 1 MB to 4 MB RAM, usually a 40 MB hard drive, VGA colour monitor, and mouse.

The programming systems used focussed on Turing [Holt 92], LogoWriter [LCSI 86], Wisdom Prolog [MIT Press 91], and Smalltalk /V 286 [Digitalk 88]. Queen's University has a site licence for Turing (as it is used in undergraduate computer science courses), so it was available at no cost to the Faculty of Education. It also offered a low cost, full-featured version (including manuals) to students who order the product (CDN$40.00). LogoWriter is also site-licensed at the Faculty of Education, and the agreement allows for student use at home. We keep LogoWriter manuals on site. We chose Wisdom Prolog because of its low price and its compliance with the Edinburgh standard. Its documentation is totally inadequate for

anything more than syntax definitions and special features, so we have made sure the library h

anything more than syntax definitions and special features, so we have made sure the library has several books of varying complexity on Prolog. Smalltalk /V 286 was chosen because it is an inexpensive, full-featured implementation of the Smalltalk language. It is specific to the PC environment, requires extended memory, and it is different from the original Smalltalk-80 standard [Goldberg 84]. However, it runs on the machines that we have (it is tight on machines with only 1 MB of extended memory). A DOS version exists at half the price, but its debugger and features are not nearly as good. The Windows version is too costly for us. Educational institutions receive a 60% discounted price when ordered directly from Digitalk, Inc.

Reactions

Student reactions have generally been positive. One frequent comment was that the course was a lot of work. Many students found the pace to be just about the limit of what they could cope with, and appreciated that an in-depth knowledge of the programming system was not required. The transition from one language to the next caused the usual discomfort in just learning to get around the system; the editor, file saving, and so on, was different. The shift to a new paradigm was more jarring. Students had to step back from the way they had been programming for the past few hours to critically evaluate what was different about what they were now doing. This caused very interesting and penetrating insights about how a programmer tries to capture a particular problem in a programming system. They questioned the differences in the geometry bases of graphics, why sounds were generated with different syntaxes, why declarations were important in one language and not in another, why some systems were good at number crunching and others were not, how data could be stored and why (e.g., lists, arrays, collections), and generally how program flow of control was different.

The most significant evidence of this thinking was that, in selecting their projects, most students first analyzed the problems and what must be done to solve them, and then sought a programing system that would offer them the best fit to their conceptual representations. For many, this meant learning yet another programming system. Few were bothered by this, as they had just had the experience of sampling four systems in six weeks! In several cases the choice was related to their professional interests, and they used a multimedia system such as HyperCard or Toolbook. A few were excited by the possibilities of languages that were unfamiliar to them (Prolog and Smalltalk) and chose to explore these more, creating a problem that would be suited to their abilities and those of the system. Finally, several students decided they could make better progress using more conventional systems (Turing and LogoWriter) and chose problems that were appropriate to them.

Some students felt intimidated by the presence of colleagues that were more experienced programmers than they were. More often than not, those with more expertise were peer teachers for the group. Paradoxically, only a few of these pre-service teachers recognized that such diverse heterogeneous groups would exist in their own classes in the schools, that peer teaching would be an important and virtually uncontrollable asset in them, and that they would frequently encounter students with more knowledge and expertise than their own within some narrow area. This has much to do with their image of a teacher as a font of knowledge, a dispenser of wisdom, a leader of a harmonious band. It was also interesting to see their reactions to the rapid overview provided by such a concept-rich and technically-oriented subject area. Some loved it, others felt constantly on the edge of confusion. Again, few students recognized that this would be the range of reactions to much of the material that they would be teaching, whatever the subject area.

The project was a particularly heavy workload, mainly because the students set much loftier goals and standards than the instructor. The students were advised on how to prototype their work and develop it incrementally. In doing so the projects were more manageable and "grew" to a state of completeness that everyone could be satisfied with.

The instructor was pleased with outcomes of the course. Some students who returned a year later said that they had worked very hard in the course and that the real knowledge of what they had learned was just beginning to dawn on them. Students exchanged programs after the presentation and felt genuine pleasure and pride in what they had accomplished.

Allen Brown, Queen's University

Future Directions

There will be a formal 15 minute introduction at the start of each new paradigm. This will include an anthropomorphized example of giving instructions that must be followed according to a preset pattern. This should set the tone for a shift (rather, a break) in the thinking modes needed for the next paradigm. The class notes will continue to be revised, to reflect greater emphasis on graphics, sound, and possibly multimedia, which are underutilized dimensions of programming at present. The instructor will also informally emphasize the types of learning that are occurring in the class and ask students to reflect on these observations in the context of their own teaching and learning.

Although the atmosphere is quite convivial during the project presentations, a concurrent pizza party is also planned!

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Using the Authoring System QUEST to Implement Courseware in Computer Science

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Abstract

This paper describes the process of development of courseware for teaching compilers in Computer Science programme using `Quest` (Allen Communication) authoring system.The compiler course is particularly difficult to teach, because it uses ~ny theoretical and practical concepts. For this reason, the computer-based presentat... is ideal for this course. We demonstrate how these essential features could be implemented in `Quest`.

Introduction

Early in the history of computers, their potential for instructional purposes has been recognized. In the 1960's and 1970's much research in this area was done, but the practical results were limited by the hardware available. Since the development of affordable and fast personal computers in the 1980's and 1990's, the situation has changed dramatically.

The oldest, and yet still most widely used medium for the presentation of information is the book. Since CBT [Ale91] is often based on a book metaphor, courseware should be at least as good as the conventional book. To this end, courseware should support the following tools, which are available to anyone reading a book. The user should be able to *move* to any page at any time and start reading. The *position* in the courseware of the reader should be apparent. Some type of *notetaking* capability, either global or margin notes, and *highlighting* should also be supported. A *table of contents* and *index* are also necessary. Courseware also should make use of text and graphics. Besides these standard book features, courseware has the capability to go beyond the book by providing more advanced tools. Perhaps, the most important capability is the use of hypertext. *Hypertext* [Woo91] is text organized as a directed graph, rather than a linear sequence of phrases. It permits the rapid and efficient access of further relevant information. In addition, the power of the computer can be used in courseware to provide for *animation* and *simulation*. These two tools are powerful visualization techniques that go beyond the capabilities of a book. Finally, courseware should *interact* with the student. The student can be asked questions, and the courseware should be able to analyze the response and judge if it is correct. Immediate feedback on these questions helps the learner discover which areas require more study. One last feature that an authoring system should also provide for is support of student management, or *computer managed instruction* (CMI). CMI is used for the maintenance of student records. Student records should be available based on performance criteria, the number of courses completed, and others. Registration of students to specific courses and keeping separate records for each student registered should be available.

The development of books into their present form has taken over thousands of years, whereas courseware is still developing and has many issues that remain to be resolved. The most important issue revolves around the instructional strategy used. Most current courseware is based on the Branching Programmed Instruction Model [Mer85]. This model organizes instruction into the following sequence of events: students are presented with information, asked a question, feedback is provided based on the student's response, and then the cycle is repeated. There is much debate over whether this strategy is sufficient, or if another should be used.

There are three main ways to create courseware. A general purpose programming language, like Pascal [Coo87] or C [Ker78], can be used. This method requires experienced programmers and considerable development time. Using a general purpose language is very flexible, however, and provides the best speed of execution. Second, a special purpose authoring language can be used. An *authoring language* is simply a programming language with additional functions that make the creation of courseware simpler. This has advantages over the first approach in that the creation of courseware is easier because of the added functionality of the language. Its main disadvantage is its complexity. For each new function added to provide for courseware development, the author must learn how to use this function. The third method is the authoring system. An *authoring system* has three main goals: minimize or eliminate programming, provide student management support, and include instructional templates. Unfortunately, authoring systems are inflexible for the author who wants to perform a task outside the scope of the system. Most authoring systems use the Branching Programmed Instruction Model for instruction, and they lock the author into using this model.

The primary goal of this paper was to implement courseware for teaching compilers in Computer Science programme. This course is particularly difficult to teach, because it uses many theoretical concepts and also requires a considerable practical experience. Thus, the teacher has to often *refer* to concepts introduced earlier in the course, or covered in other courses. At the same time, the teacher has to *show simulations* of various tools, such as finite automata, scanners, parsers, etc. For these reasons, a computer-based presentation is ideal for the compiler course.

We assumed that the created courseware should have all the essential tools described above. We also took into consideration the fact that courseware for computer science is designed for a special audience, namely for the computer science students. We decided to use an MS-DOS based authoring system and chose `Quest` (`Quest` is a registered trademark of Allen Communication, Inc.).

Our paper is organized as follows. In Section 2, we describe requirements for courseware for teaching compilers. Section 3 provides a short introduction to `Quest`. Section 4 describes the compiler courseware that has been implemented, and Section 5 is on implementation of this courseware. In particular, we discuss the implementation of various features for which `Quest` is not really suitable; for example multiple windows and support for hypertext.

We assume that the reader is familiar with the basic terminology. For more details of our project, see [Low92].

2 Requirements for Courseware for Teaching Compilers

Designing courseware typically requires expertise in at least two fields. One expert is required in the field specific to the course being created and another is required to actually create the courseware. This second expert is usually a computer programmer. One of the goals of authoring systems is to eliminate the need for the computer expert by allowing a person to easily create courseware, without any specialized computer skill. Authoring systems hide the internals of the creation process by allowing the designer to work at a very high level of abstraction. Unfortunately, the authoring system may not provide all the tools the author requires, and there is little recourse for the author who wishes to perform some task that the authoring system does not support.

When courseware is being created for computer science, the course expert is a computer expert. The computer science author who is familiar with programming is not restricted to the highest level of the authoring system but can choose to switch to a low level, for example, programming in the C programming language, if required. In addition, the author of computer science courseware can benefit greatly from the level of the students. For example, it can be safely assumed that the majority of the students will be familiar with computers, their basic operation, and terminology used. Such knowledge can free the author from having to give lengthy tutorials on the basics. It should be noted, however, that computer science students are demanding users and therefore courseware for them must be particularly well designed and implemented.

Besides the standard support required for computer based teaching, courseware for computer science has some specialized requirements. Perhaps the most important of these is communication with outside programs [Mül91]. The student should not be required to exit the courseware to conduct experiments or to use examples. An excellent example of the need for communication is courseware for teaching programming languages. In order to provide for the best teaching environment, a link to the appropriate compiler is necessary to allow the student to compile and execute examples while remaining within the courseware. There are different methods for this communication. The most primitive one is through the use of files. One program can leave information in a file, where another can read it. File communication is available regardless of the environment, but it is slow and cumbersome. A better solution is to use available tools within the environment. Programs running under Microsoft Windows (Windows is a trademark of Microsoft Corporation) can communicate with each other through Dynamic Data Exchange (DDE) [Nor92]. This type of interprocess communication is a significant improvement over the use of files, but it is not always available due to the requirement of the environment. Microsoft Windows specific programs are required to take advantage of DDE; non-windows programs cannot use this communication method. The underlying operating system and environment are important aspects of authoring systems. For many authors, MS-DOS does not provide enough support for courseware. In the case of designing courseware for teaching compilers, there is a need for links with various compiler tools that are discussed, for example LEX and YACC.

Courseware for computer science also requires sophisticated judging facilities. Simple judging capabilities like word or number matching, which are present in most authoring systems, are insufficient. Analyzing computer programs is a very difficult task and frequently involves using some artificial intelligence techniques. A link to the compiler is useful to the student to see if the program compiles, but program correctness cannot be determined. A student's program may compile, but this does not ensure that the program answers the question correctly. Determining the correctness of programs still requires a human marker. A fully complete courseware package for computer science would include this capability.

In the next section, we briefly introduce `Quest`.

3 Introduction to `Quest`

`Quest` is an MS-DOS based authoring system and it aims to provide all the necessary tools required to create multimedia presentations. Since `Quest` runs under MS-DOS, it suffers from the communication limitations of that operating system. `Quest` is frame based, meaning that each lesson consists of a number of frames that may be considered as pages in a book. Each screen of information presented to the student on the monitor is one frame of the lesson. Frames can be easily constructed as `Quest` provides several different types of objects that can be placed in frames. Many of these objects are similar to the objects that may be found in a drawing package, such as text, circles, and rectangles. Others are more sophisticated such as branches, audio, video, and answer analysis (judging). Frames are entirely composed of these objects. All of these objects enable the author to present information and to question the student without any specific knowledge of programming. In order to create complex effects and operations however, the author must resort to writing programs.

There are many different types of `Quest` objects; they are separated into the following groups: text, graphics, shape, image, display, performance, branch, event, video, audio, conditional execution, `Quest` Authoring Language (QAL) program, and group. Branch objects allow the author to connect frames. There are different types of branches, for example Unconditional branch (UBR), similar to a goto statement in Basic. `Quest`'s performance object gives authors a wide set of answer analysis or judging capabilities. The author can supply varied and direct feedback based on the answer the student provided.

An aspect of `Quest` that allows the author to go beyond the usual functionality of an authoring system is QAL objects. QAL is a Pascal-like programming language with a large set of these functions that mirror the capabilities of the other objects. For example, there are graphics functions to draw circles and squares, as well as to change fonts or colors. Although QAL provides these functions, they are easier to implement using more appropriate objects. For instance, it is simpler to create a rectangle using a rectangle object rather than to write a QAL program. The advantage of QAL lies in the functions it provides that cannot be performed with the other objects. For example, QAL provides for file I/O, as well as mouse control. Also available are memory functions such as peek and poke and a BIOS/DOS interrupt interface. One example of the use of QAL is to combine mouse and keyboard input. QAL is not the only way the author can integrate a program into the courseware. Using a Call Program branch, (PGM) `Quest` can call other programs, which may be written in another language. The author could write a program in C, or any other language, and then use a PGM branch to run it. The advantage of using QAL instead of other languages is that QAL can communicate with `Quest` through global variables, while programs written in other languages cannot. In addition, a QAL object is actually inserted into the frame. This means that the QAL program need not be physically present on the disk when the student uses the courseware. This is not the case when a PGM branch is used, because in that case the program must be present on the disk. The disadvantage of QAL is its simplistic structure, without such features as recursion, external procedures, or separate compilation.

4 Description of the Compiler Courseware

To design our courseware, the test and exam questions from previous courses on compilers taught at Acadia University were categorized, and it was determined that most of these questions were based on the areas specified below. The other possible lessons; for example on type checking were left out, due to time constraints.

The course is divided into the following lessons and sections:

- **Introduction**
  - Using the System
  - Introduction to Compilers

- **Lexical Analysis**
  - Regular Definitions
  - Transition Diagrams
  - LEX

- **Syntax Analysis**
  - Context Free Grammars
  - Recursive Descent Parsers
  - Table Driven Parsers
  - Shift Reduce Parsers
  - YACC

The *Using the System* section provides students with information on how to navigate through the courseware and conventions used, for example the use of hotwords. The *Introduction to Compilers* section is a brief overview of the entire course.

The *Regular Definition* section presents the following terms: alphabet, language, regular expressions, and regular definitions. It also explains regular expressions and regular definitions and how tokens are represented using regular definitions. The section

Transition Diagrams demonstrates how to create transition diagrams from regular definitions and the code for the scanner from these diagrams. The *LEX* section gives an overview of how to use LEX and some of its important features. This section makes considerable use of examples. Regular expressions and definitions are used extensively in LEX, so ideas presented in the first section are used.

Context Free Grammars explains the use of CFG's in describing a grammar and introduces some important terminology. *Recursive Descent Parsers* presents a recursive implementation of top-down parsing. It illustrates the steps necessary to constructing a recursive descent parser, including left factoring and eliminating left recursion. An interactive example of the latter is given. *Table Driven Parsers* presents a non-recursive implementation of top-down parsing. It explains the construction of the sets FIRST and FOLLOW, as well as the parsing table. This lesson also presents an interactive example on the construction of both sets and the table. The concept of a LL(1) grammar is introduced. Another interactive example of the parsing algorithm is then shown, using the previously generated table. The section *Shift Reduce Parsers* explains the difference between top-down and bottom-up parsing and then proceeds through a lengthy interactive example of parsing a string given the algorithm and parsing table. The section on YACC (a bottom-up parser generator [Aho86]) gives the basics for writing YACC programs and provides several examples. It demonstrates how to use LEX and YACC together to create a complete front end of a compiler.

In our courseware, students are not required to follow any fixed path; they can jump between lessons and sections at will. Students also have control over questions. The courseware does not force them to answer questions correctly or at all nor does it keep a score of correct or incorrect answers. This type of student control was used primarily due to the nature and level of the students (the upper level university students). Another reason for this design was the goal of the courseware; it is not meant to be a replacement to the actual course but rather as an additional tool for students to use. It is designed to be a better book. At the beginning of the course and each lesson, a menu is displayed allowing the student to make choices on where to begin study. The student can make choices using either the mouse or the keyboard.

Question frames are meant to drill the student on the topics previously covered in the tutor frames. The purpose of question frames is to reinforce knowledge through interaction the recent information assimilated. There is no score kept for incorrect or correct answers, and the student is not required to answer correctly or even answer at all. The student is immediately informed about correct and incorrect answers and is also allowed the opportunity to continue answering, as well as to see the answer. Another type of frame is the interactive example frame. The student can move back and forth through the example, easily seeing exactly what is taking place at each step.

Window frames are used to implement some of the important functions such as the index, margin notes, and help. The windows appear on top of the current screen and restore the original screen when they disappear. All the window frames can be dismissed by pressing the Esc key or by clicking with the mouse in the upper left corner of the window. This area of the window is called the window dismiss box.

Students may encounter, on certain frames, words or phrases that are displayed as blue text on a white background. These are known as *hotwords*. The student can click on hotwords with the mouse to obtain more information, so these words form electronic links to this information. In some cases, a list of pages where there is additional information related to the topic is available. The student can jump to a listed page by selecting it.

The student is provided with a variety of essential tools that can be invoked via *icons* located along the bottom of the screen. These tools implement the important functions necessary for courseware: global notes, index, goto with table of contents, page history, linear traversal (backward and forward), and exiting. Icons can be selected with the mouse or the keyboard, using a special key combination. They are available at all times at all frames, except the *Using the System* section where the icons are introduced. Below, we list all the essential icons:

- ***Quit*** icon quits the student entirely from the course and saves the frame where the student is in the lesson. When the same course is entered, `Quest` will restore the student to that frame.

- ***Escape*** icon takes the student back to the nearest menu screen. At the top level menu screen, *Escape* will exit the student from the courseware in the same manner as the *Quit* icon.

- ***Shell to DOS*** icon allows the student to spawn a command shell. The student can return to the same page where the shell was started by typing exit at the DOS prompt.

- ***Goto*** icon opens a pop-up window which allows the student to enter a page to jump to. Alternatively the student can click on the *table* button, which will present the initial table of contents window. The table of contents consists of several windows which present the student with a complete list of the lessons, sections, and individual pages within the course. The first window contains a list of the available lessons from which the student can select a lesson. Then a window with a list of the sections within that lesson appears. By selecting a section from this list, the student will activate a third window, which is a list of the individual pages in the selected section. If the student then selects a page, a jump is performed to that page. At any time the student can press the ESC key or click in the window dismiss box in the upper right corner to dismiss a window and return to the previous one.

- ***Back*** icon gives access to the page history, a list of the previously visited pages. A student can cycle through this list by repeatedly invoking this icon. Using the icon once will move the student to the first page in the history; each successive usage will move to the next page in the history until the history is exhausted. To go back from the keyboard, the student can use the home key.

- ***Book*** icon allows the student to invoke a text editor for the purpose of taking notes. These notes are saved in the student's own file. Notes are global, that is, they are not associated in any way with the current frame but with the entire courseware. Margin notes, associated with the current frame, have also been implemented although they have not been fully integrated into the courseware due to time constraints.

- ***Index*** icon presents the student with the user modifiable index (see Figure 4). The student can delete, enter, and modify entries in the index. All students have their own index; modifications one student makes will not affect the index of another. The deletion and modification of index entries are done by first highlighting the desired entry and then clicking on the appropriate button. Students can also use the Delete key on the keyboard to delete entries. The student can insert entries by clicking on the *insert* button and then typing in the desired entry.

- ***Previous*** and ***Next*** icons return respectively to the previous and the next page.

5 Implementation

The implementation was influenced by the design decisions made during the initial design phase of the compiler courseware. The main decision was to combine keyboard and mouse input as much as possible. This resulted in the eventual decision to use QAL as the main implementation tool. For this reason, much of the implementation is non-standard, and QAL programming was unavoidable. In particular, tools like the modifiable index, require QAL.

Global variables provide for communication between `Quest` and QAL programs and are available in `Quest` by using embedded statements. Embedded statements are simply statements in text objects, placed in frames. Since frames can only communicate through global variables, a large number of them are used in the compiler courseware. In particular, global variables were used to implement the index and history feature. For the entire index facility there are four separate frames. The main index frame reads the entire student index file into memory, storing it in a global variable. The add, modify, and goto frames can access this global variable and perform their actions on the data in memory rather than in the file. Without the global variable, these frames would have to either read the file into their own local variable or be included into a large QAL program in the main frame. Another use for the global variables is the page history, which is stored in memory as a global array of strings.

Hypertext is an important and powerful tool for courseware. `Quest` does not support in any way the use of hypertext, and this is a serious drawback. The author must resort to using QAL to implement links, a difficult and time consuming task. In order to follow an electronic link, the student is usually required to click on a certain screen region. Each link, therefore, must be manually coded in QAL, with the author responsible for maintaining the pixel region of the link. Any change to the structure of the frame, such as moving text, requires the author to update the pixel area.

Although using global variables to reduce the number of programs can be used in many instances, separate programs are still needed. For example, the continuous animation in the introduction to the *Lexical Analysis* lesson requires a separate program.

Navigation in `Quest` courseware can be done in several ways. The author can assign special student keys to forward and backward movement. This method was determined to be too restrictive for the compiler courseware, mainly because of the lack of mouse support for many of the functions. All the icons could have been implemented using the student keys, but the students would have been restricted to mostly keyboard input. Since mouse input was available only for a small subset of all the functions, each frame in the compiler courseware has a QAL object followed by a performance object as the last objects in the frame. The QAL program polls the keyboard and mouse, waiting for events. When the student performs an action that requires a branch, the QAL program sets the answer variable to the appropriate string. For example, clicking the *quit* icon sets the answer variable to the string "quit". The performance object then performs an answer analysis and executes a specific branch based on what the answer variable is. A performance object is necessary because many different branches are needed. For example, `Quest` treats branches within a lesson as different from branches to other lessons, so anytime there is a branch from one lesson to another a different branching object must be used. Another method to branch to different frames is to use the Expression branch. This branch is inadequate because it does not allow branches to other lessons.

Every frame in the compiler courseware shares the same structure and is specified as a no-erase frame. The frame first displays its information, then it waits for student input. Since the student input expected is the same for most frames, once the frame information is displayed, an automatic branch is executed to a common *image* frame. This image frame contains only the QAL and performance objects; it does not display anything. Each available function has a corresponding answer and performance sequence. Adding more tools to the courseware can easily be done by minor modifications to the performance object and the QAL program (by adding another answer). Since these objects are in only one frame and used by all the other frames, the changes are quickly integrated. It has been noted that some frames require special QAL programs; these frames also require a special performance object and so cannot use the global image frame. The use of image frames serves two purposes: it keeps the implementation of the functions in a single place making modifications easier and it also increases execution speed. If the student selects a function that displays a window, this window saves the screen area where it is displayed and then restores the screen area when dismissed. If the window returned to the original frame, the entire information of that frame would be redisplayed unnecessarily. Instead, all the window frames return to the image frame when dismissed. Since nothing is drawn on the screen in the image frame, this speeds up execution of the courseware.

Mouse operations were implemented using QAL. The usual method of controlling a mouse when using a programming language is with MS-DOS interrupt calls. This was not necessary with QAL however, since it provides for basic mouse operation through special functions. Using QAL enabled complete control over mouse functions. For example, mouse button clicks from any button could be trapped. The drawback to this method is that the program is now responsible for all mouse operations. `Quest` cannot be used to control any of the functions of the mouse. One of the implications of this requirement is that absolute pixel coordinates must be checked whenever the mouse button is clicked. The program continually polls the keyboard and mouse waiting for events. When a mouse click occurs, the coordinates of the mouse pointer are compared with a coded list of screen areas. Each of the icons encompasses a rectangular region of the screen. For every icon, the position of each of the four corners is known and is coded into the program. This is a rather difficult and error prone approach. For example, let us examine what happens when a student clicks on an icon. When the mouse is clicked, the QAL program then obtains the mouse pointer coordinates in absolute pixels. The coordinates of the mouse are then compared to see if they are within the boundaries of one of the icons. If the mouse pointer was not within any of the icon boxes, the program ignores the mouse event and continues. However, if the pointer was within the box delimited by an icon, the function represented by that icon is started. Typically, when the icon is depressed, the answer variable is set to the appropriate string and the program exits. The performance object then analyzes the answer variable and performs some type of branch based on its value. The buttons and icons in the compiler courseware actually move; they depress when the mouse button is depressed and return to normal when the button is released. This three dimensional effect was implemented using two shapes for each button or icon: an up shape and a down shape. Originally the up shape is displayed, but when the student clicks on the button or icon, the down shape is displayed as long as the mouse button is depressed and the pointer is within the icon or button box. When the button is released, or the mouse pointer is moved out of the delimiting box, the original shape is displayed. All of these shapes are stored in the shape library. Another approach to signify mouse events is to cut an image of the screen and then paste it back in reverse. This approach is used for list selections, menu selections, and the window dismiss box. This cutting and pasting technique is also an excellent way to highlight areas. The original image can easily be restored by pasting the cut image in normal mode, rather than reverse.

In `Quest` there are three ways to use mouse input: QAL, position answer analysis, and `Quest` student keys. Of these, only QAL is acceptable for all our requirements. By using the position answer analysis method, screen areas can be associated with certain answers. This is what the QAL program does; mouse clicks in certain screen regions cause the assignment of different strings to the answer variable. It would seem, therefore, that the position answer analysis approach is satisfactory, but it has some restrictions. Its most significant drawback is that keyboard input is not accepted in the normal sense. The arrow keys can be used to move the pointer to the screen areas; the Enter key is used to activate the area. In this way the keyboard is used to simulate a mouse. This was not the kind of keyboard input that was desired because it is very unnatural. One of the benefits of assigning certain key combinations to functions is that these key combinations are typically faster to use than the mouse. Simulating the mouse with the keyboard actually makes keyboard input slower. Another disadvantage is that the mouse cursor changes to a crosshair while it is normally an arrow. The second method, of using `Quest` student keys, allows for the normal use of the keyboard and the mouse, overcoming the limitation of the previous technique, but it also is not sufficient. In addition to being able to assign certain keys to functions, some of the functions can also be assigned screen areas. The main disadvantage is that these functions are fixed and do not provide enough capability for the compiler courseware. The following functions may have screen areas assigned: moving forward and backward, exiting, a table of contents, help, and a glossary. For other functions, such as hotwords or taking notes, a mouse cannot be used. A significant problem that plagues both solutions is that the function is activated when the right button is pressed. This is not a button click, since the generally accepted definition of a button click is a press and release. The other buttons on the mouse cannot be tracked at all.

In `Quest`, there is no internal concept of icon, and these icons are completely implemented using QAL and stored in the shape library, which allows for easy modification. Since the shapes in a frame are dynamically linked to the library, changes made to the library shape immediately change the shape in the frame. This feature is very useful, especially with respect to icons. The color, size, and appearance of the icons need only be changed in one place. Following is a description of the implementation of one of the icons, the *Quit* icon. When the student selects this icon, the `Quest` answer variable is set to the string "quit". Then, the answer analysis performs an Unconditional branch to the frame `ooga', a non- existent frame. Branching to a non-existent frame causes `Quest` to exit the course and save where the student is in the lesson. The next time the student enters the course, `Quest` will restore the student to the nearest bookmarked page. `Quest` recommends not bookmarking all pages, since this slows down the system, but it has been our experience that this has a negligible effect. In addition `Quest` saves the values of all embedded statement variables. This is a very useful feature. For example, the history stack will be restored to the same state it was when the student exited. Each of the following icons is implemented in the same fashion. When the particular icon is selected, the answer variable is set.

Conclusion

Designing good courseware is difficult, requiring the author to invest a large amount of time and effort on the project. On the basis of our experience using `Quest`, we believe that the requirements of the project demand more than a single designer. Although authoring systems attempt to reduce the number of experts necessary to create courseware, we are convinced that this is not feasible. Authoring systems can allow authors who are not computer literate to construct courseware, but there are many other areas that must be addressed. The use of colors, graphics, and animation all require some deal of expertise in these areas. An authoring system may provide the tools necessary to create quality graphics and animation, but the author still must have some knowledge of their proper use. In fact, these tools may make it easier to create ineffective or even counter-productive, rather then beneficial, courseware [Mau92].

Our project shows that the ability to use QAL in concert with `Quest` is essential. For example, using QAL, we simulate pop-up windows and hypertext. The power of a programming language is almost limitless, even a rather poor language like QAL. The problem with using QAL is that it essentially reduces `Quest` to an authoring language. `Quest` can not be considered a totally complete authoring system, since some important tools can only be implemented using QAL. Despite this, `Quest` can still be used by non-programmers to create some useful courseware, especially if input is limited to the keyboard.

Although we attempt to provide many of the features of a complete package, there are some items that could be implemented in future work. There needs to be a considerable increase in the interaction of the courseware. The feasibility of communicating with LEX and YACC from within `Quest` should also by studied. This communication would have to be implemented using files and QAL.

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Making a limited budget work: The development of a multipurpose multimedia lab.

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Abstract

In an era of high cost technological equipment and educational budgetary belt-tightening, many institutions are finding the cost of keeping pace with current technology prohibitive. Many institutions find it necessary to make due with existing, often outdated, equipment for use in their existing labs as well as in the development of new multimedia labs. This paper discusses the development of a multimedia lab without exceeding the constraints imposed by limited funds. The discussion includes construction of the lab, the challenges encountered, and a brief description of current research and development efforts.

Introduction

In an era of high cost technological equipment and educational budgetary belt-tightening, many institutions are finding the cost of keeping pace with current technology prohibitive. Many institutions find it necessary to make due with existing, often outdated, equipment for use in their existing labs as well as in the development of new multimedia labs. At the University of Northern Colorado the approval of a new doctoral program in Educational Technology made it necessary to establish a multimedia development laboratory. To meet this need, the Educational Technology faculty proposed a multi-year plan which would provide the hardware and software needed to bring the technical part of the program to a level roughly equivalent with many corporate development operations. While the cost of the proposal greatly exceeded the available funds, the need for a multimedia development laboratory to support the new doctoral program remained. This paper discusses the development the multimedia laboratory without exceeding the constraints imposed by limited funds. The discussion will include construction of the lab, the challenges encountered, and a brief description of current research and development efforts.

While on the surface it seems that the function of the multimedia laboratory is to support the courses in the Educational Technology program, the limited resources at the university require that the function of the laboratory be defined in more concrete terms which can be defended in budget meetings. Therefore our laboratory is designed to serve four primary purposes, to be phased in over the next several years:

- interactive technology research
- development of marketable products
- training for graduate students, faculty, and staff in the use of interactive technology, and
- technology testing.

Research

Interactive technology research requires the ability to run existing courseware, develop courseware, and conduct tests of the courseware. Further, it requires a facility having enough in common with other facilities on campus to allow collaboration with programs from across the campus. This collaboration is necessary to provide content (and context) for study, subjects for study, and an avenue to begin the transformation of the educational process across the campus to one which maximizes appropriate use of technology, which can only be done through a focused research effort. (The effort to transform the educational process is an underlying goal of the institution, and was part of the justification for beginning the development of the laboratory.)

The use of the facility for research was the beginning point for addressing and defining the needs within the laboratory facility. For example, the need for some commonality with facilities across campus, as well as the need to provide some leadership, defined one of the dimensions considered in the design of the laboratory. The need to run existing courseware and the need to be able to develop our own courseware defined another dimension. (Development requires more capable hardware and software than does running existing courseware, in general.)

Development

Development of courseware for research purposes is a starting point. However, facilities such as the multimedia development lab require more funding than available through normal budgetary processes. Since the lab is not a general access student lab, it is not eligible for funding through student fees. Yet, the demand for constant upgrade must be met in order to remain a viable resource for the program or institution. Therefore, alternative funding must be sought. Building on the research base, the goal of commercially viable products is one method that can be used to obtain some revenue specifically for the laboratory. While this is one purpose of the laboratory, it will not be implemented during the first several years. There are a couple of major reasons for the delay. First, there are not enough people (students, staff, faculty) with the required expertise to produce commercially viable products at this time. As the laboratory is increasingly used in support of research and coursework, the necessary expertise will be developed. The second reason is that the financial details and intellectual property right details have not yet been clearly defined.

Training

In order to meet the goal of transforming educational practice, or even to be able to develop and use courseware, people must be trained. The training function of the multimedia lab falls into three categories. Training of students and faculty active in the development and research efforts centered in the lab was begun concurrent with the planning and implementation of the lab. It began with a small group of students and one faculty member and was conducted within the context of doctoral level courses dealing with the development of courseware. This approach accomplished the goal of producing a core group of trained individuals who can conduct the next level of training without the additional expense of outside training.

The two remaining categories of training are training students to use the technology to support their classes and training faculty to develop course materials and use the technology to support class presentation. Student training began with a pilot study during the Summer 1992 semester. Training for faculty began with the Fall 1992 semester.

Testing

Once a critical mass of both students and faculty have been trained on the existing technologies and have begun to effectively implement the laboratory, additional technologies will be evaluated for possible inclusion into the existing system. This testing of the new equipment and technological advances for compatibility and effectiveness are a goal for the near future

Hardware and Software

The design of the lab required consideration of hardware and software already in place both for research and instruction. From that base, consideration of the direction of current and future research and development efforts, as well as the course requirements for the new Ph.D. lead to the specification and development of a multi-platform (two at this time) laboratory with a balance of software tools including high level programming languages, software development environments, authoring systems, graphics and image processing tools, and desktop publishing tools.

With the limitations of a small budget, it was decided that the initial hardware emphasis would be MS-DOS and Windows based hardware. While more multimedia software development tools are available for the Macintosh platform, the Intel based hardware provides more raw processing power for the dollar. We were able to purchase three additional 486 based computers and equip them with a minimal set of software tools within our budget. The 486 computers were produced by a local company which had won the low bid for computing equipment for the university. While the computers were very inexpensive, there were some compatibility problems. The new computers, and to some extent the existing hardware, were modified by the faculty to include third party (and inexpensive) multimedia components, including audio boards, CD-ROM drives, and graphics overlay video boards. In making the purchases, we did not ignore the Macintosh platform. We added a new Macintosh IIsi to the laboratory, allowing the use of existing Mac specific peripherals.

The software tools provided for both platforms included software development environments (HyperCard, ToolBook, Borland C++), authoring systems (early version of AuthorWare, Challenger), graphics tools (Draw and Paint software), desktop publishing (PageMaker), and presentation software (PowerPoint). All products were available with substantial educational discounts. While the available software and hardware tools are limited, they do allow the construction of some very sophisticated products and can be used for both research and production of commercial grade materials. With this balance of resources, the lab accommodates the widest possible mission.

Existing equipment included one '286 and one '386 pc with audio/video modification, one Macintosh IIsi, 1 Pioneer 6000 laser disc player, 2 gray scale scanners for Macintosh, 1 gray scale scanner for PC, three Hewlett-Packard re-write optical drives, one LaserJet II printer and three Deskwriter printers. New equipment included two IBM compatible '486 computers which were upgraded to multimedia personal computers (MPC's), a Pioneer 8000 laser disc player, an additional audio amplifier, a color scanner, an NEC PC-VCR, a color scanner, and a '486 IBM compatible to be used for the File Server.

At this time, we have a reasonably equipped and functional multimedia development laboratory capable of supporting the research efforts of faculty and students. It is also capable of supporting the training purpose within courses and for faculty on the small scale permitted by five work stations. During the next year, several additional workstations and more software will be added, improving both the capabilities and balance of platforms available in the laboratory. The additional stations will allow fully implementing the training purpose and the beginning of the materials development purpose.

The Network

Because of the diverse user base, Novell version 3.11 was chosen as the network operating system. Four levels of users were defined using Novell's file and directory security -- Administrators (full access), Researchers/Developers (read/write access to group directories), Trainers (read only rights) and Students (read only rights). The Research/Development group includes faculty and doctoral students; the Trainers includes anyone evaluatng or instructing with training materials, primarily masters students and certain undergraduates; and the students receiving training are primarily undergraduates.

Shared access to certain directories on the server are granted to the Developers so that work can be shared and critiqued by peer developers. Students are given somewhat more limited access, while General Users are restricted to the execution of software only. One exception to the above is that any user granted a personal account is given his own "home" directory for personal storage.

Other reasons which contributed to the choice of Novell included: A copy of version 2.15 was available for upgrade, which saved on the cost; Novell is the de-facto standard on the UNC campus with 11 Novell servers supporting various labs and offices; third-party support is more readily available for Novell, including specific software for CD drive sharing; and more brands of hardware are supported by Novell, enabling the project to be assembled from lower cost components.

The diverse user group also led to the use of twisted-pair ethernet topology. Because of the general use, high traffic operating environment, cabling can be damaged more easily, and twisted pair isolates errors to single workstations rather than "downing" the entire network. Twisted pair also cannot be dis-connected incorrectly when equipment is moved within the lab or to a classroom. Ethernet was chosen over token-ring because it performs well in a small network situation and ethernet adapters are readily available at lower cost.

The sharing of devices and directories contributes to the co-operative feeling the lab hopes to promote, and the total cost of the lab was reduced by networking. Peripheral devices, including CD drives and printers, are shared by all workstations and do not need to be duplicated at each computer. Sharing of CD was accomplished using "Map Assist" by Fresh Technology. Novell's own print services were used for printer sharing.

Pitfalls

The development of a multimedia lab intended to serve multiple levels of users is always accompanied by problems. Some of the problems we encountered were the result of serving multiple levels, some were the result of implementing the laboratory within the constraint of the limited budget. For example, an (apparently) inexperienced user erased several files on one workstation. In the early stages of implementation, it was not uncommon to find that someone had "cleaned" the lab and misplaced or discarded important manuals and original disks. (At one time both copies of the booklets providing technical information for the network cards were lost.) In addition, students and faculty using other equipment located in the same area as the lab frequently moved or disconnected the cabling. The disconnects were most likely accidental, since the cabling was frequently exposed, though outside of the normal traffic pattern..

Equipment failures were also problematic in creating the lab. A faulty hard drive controller in the server was replaced by the computer retailer with a different brand not recognized by the Novell software. A delay of several weeks was experienced in locating Novell drivers for the new controller. (These drivers are normally supplied with the controller card, but the retailer did not forward them to us.) Once the server was working, it was discovered that the network cards supplied were not compatible with the '486 computers, even though they were supplied by the same retailer. It was determined after several hours of phone troubleshooting with the network card manufacturer that the cards were unable to "keep up" with the '486 bus speed. Another delay of several weeks was experienced while troubleshooting and testing other network interface cards. Finally, Intel brand cards were selected, allowing the network to operate normally.

Equipment failures and people problems merged in several cases as the lab was created. Due to the limited funding, no tape or optical back-up hardware was available and system back-ups were limited to floppy-based back-ups of critical system setups and files. While this did afford some protection, it did not prevent many hours spent reconstructing systems following a system crash due to human errors.

Training

Training is a key component of the implementation. Faculty and graduate student users include researchers, developers, evaluators, and end users. Different levels of training are required for each type of user, since each type requires a different level of access to resources. For those more familiar with another operating environment, training is being developed to facilitate the transfer to Windows or Macintosh based systems. However, only limited training more in the form of apprenticeship is being conducted at this time.

Although there is an insufficient number of personnel with the prerequisite skills to implement commercially viable products at this time, there is a program in place to change this. Most of the training has occurred for doctoral students and in class. Classes have included the use of authoring and programming languages as well as the implementation and management of interactive video and instructional systems.

An important component of the training is the use of graduate students in training others. Two graduate assistants and two graduate practicum students were assigned to learn the network and basic operations of the multimedia tools. Their training is being provided in part by the university computer center (on the network) and by faculty (on the multimedia tools). The remainder is self-teaching. These students are in the process of creating job aids for others involved in the lab. These aids will eventually include the multiple levels of instruction.

Current projects

Currently projects are being developed within classes, for dissertations, and for the Taliesin Project, a large research and development project (Smith & Westhoff, 1992). All are real world applications that are expected to outlive the academic assignment that launched them. In addition to class time, faculty have worked with students outside of class to support several research projects. Many of these projects were initiated within courses and continued the following semester. Several of these are described in the following paragraphs.

Munson and Smith (1991) developed a hypermedia model that investigated two different navigational schemes, icons and concept maps. Although this series of studies was initiated before the implementation of the lab, they were of major concern in the planning and implementation of the lab. In addition, most of the actual studies occurred in the development lab. They tested these within a physics content with both education and physics students. Lightner, Smith, and Reed (1992) developed a hypertext program modeled after two different instructional theories that investigated differences in achievement by accounting students. Munson, Smith, and

Janson (1992) have developed a prototype of a model allowing students to explore animal symbolism and then create their own stories using a videodisc as an information resource. This project, called Wildlife Wonders examines the implementation of one portion of the Taliesin Project. They have submitted proposals to fund further development of this project.

Two additional projects were developed in conjunction with the development lab. The first project was developed for use in middle school science classrooms and provides students the medium to create and manipulate a database for classifications of animals. The student classification schemes used to organize the database were investigated in relation to the selection of the phylum, kingdom, class, habitat, and geographic location. The second project involved exploring the preconceptions and mental efforts of students when using computer assisted interactive video and instructional television.

An additional class project has evolved into a research project in which graduate students were used to train undergraduate students. This project was designed and developed to address the issue of preservice teacher technology training and to demonstrated the use of multimedia (hypermedia), desktop publishing, and analog video technologies within the educational environment. The research project teamed graduate students with undergraduate preservice teachers education majors to complete a project using one of the three technologies, with the graduate students responsible for the training.

An important facet of the research and development projects housed in the development lab is collaboration between programs. The business school has been involved in one project and several are currently at the inception stage. The major collaborating program has been the Kinesiology and Physical Education department. Three major videodisc projects have been locally planned, developed, and produced. After the discs were pressed, Educational Technology graduate students developed the software for the discs.

The first two projects were produced to train PE teachers to analyze motor skills in swimming (Mathias, 1990--developed prior to the lab, but used each semester within the lab) and tennis (Chung, Munson, Smith, & Phillips, 1992). The PE department is hopeful that these discs and others can be used outside of class to help them reduce the number of credits required by their students and increase quality at the same time. In a second phase, the tennis program is now being used with non-PE students to investigate the program's impact on personal tennis performance. A third project filmed in a basketball class was used with the physical education teacher assessment instrument to investigate the performance of the teacher in a classroom and identify teacher behaviors (Horton, 1992).

Recommendations

It is clear that the limited resources of the multimedia development laboratory are being used effectively. We expect the use to increase rapidly and begin to include desktop publishing and video production efforts as hardware and time are available. Indeed, we expect demand for the facility to shortly exceed availability. Despite the success, there are several recommendations for other institutions considering the installation of a multi-user development lab, based on our experience.

Cabling should be planned and routed carefully, even if fault-tolerant cabling like unshielded twisted-pair is used. Name-brand network cards will save a great deal of trouble shooting of the lan and cost only a few dollars more than "generic" cards. Name brand PC's should also be considered if not cost prohibitive, and name-brand, certified parts are a must (e.g. Adaptec SCSI controllers, etc.). Backup equipment and fault tolerance systems should be budgeted for as well (e.g. Uninterruptable Power Supply for the file server, tape backup unit(s), master software files under lock and key).

Graduate assistantship or other on-site lab administrator is recommended to assist with and oversee the lab, maintain inventory, and trouble-shoot problems as they arise. The location of the lab should be isolated from high-traffic flow where possible. And, access to the lab should be restricted to people already trained and working on development projects or people undergoing training. The lab should not be opened to casual use or general course support. With limited resources and high demand, research and development efforts must take priority.

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Selected Abstracts for the

Special Interest Group for Computer-Based Training (SIGCBT)

The Use of Computer-Based Instructional Simulations for Teaching Photography Skills

Charles F. Belinski, The University of Georgia

With advances in authoring systems and the ability to display photographic quality images on computers, computer-based instructional simulations can be created and implemented for a wider variety of instructional topics. This session will discuss the design, development, and implementation of a series of computer-based instructional simulations that were developed to assist in the delivery and instruction of basic photography topics.

Instructional simulations can be separated into two major categories. Simulations can either teach about a topic (informational simulations) or they can instruct how to perform an action or series of actions (operational simulations). The design and development of informational and operational simulations create special concerns. The amount of realism presented in instructional simulations directly influences the effectiveness of the simulations. Issues such as the application of various levels of visual and functional realism in relation to user experience and other topics need to be addressed when designing and developing an instructional simulation.

Demonstrations will be done of representative samples of both informational and operational simulations. Recommendations for the design, development, and implementation of computer-based instructional simulations will be discussed.

Designing Computer-based Assessment

James H. Cowardin, Precision Learning Systems

The field of automated training, if not the entire field of training, begs for a rigorous assessment measure to augment of replace the ubiquitous but weak score of percent correct. The straightforward answer is to adopt the concept of fluency, rate of accurate responding. This measure certainly applies wherever percent correct is appropriately used now, and it probably has even more potential. Rate of correct responding provides much more information than the correct/total ratio. Our experience shows that learners find fluency measures interesting enough to motivate them to persist in learning in as percent correct does not. Developing training or assessment based on fluency requires new thinking about instructional design. But the technique applies across media and strengthens CBT limited to ASCII text as will as video-disk interactive.

Fluency measures anchor a new and unique learning model, Generative Instruction, which states that higher level cognitive performance, such as problem solving, depends on many more basic level skills that are learned to fluency and called upon as needed, or recombined to meet the presented need. This technique adds emphasis on basic skills to the current tendency to presev[illegible]te on (imperfect) simulations of high level performance. Assessment keys Generative Instruction in providing navigational aids by which instructors can pilot safe passage for the learner. Fluency adds precision.

Are Software Quality Factors a Relevant Measure of CBT Quality?
Michael J. Hillelsohn, McDonnell Douglas

There is more to high quality CBT than just instructional effectiveness. If we treat CBT as a software application can we capitalize on existing software tools to describe the quality of our courseware? Quality does not have to be an amorphous concept, best described as "I know good quality when I see it!" Rome Air Development Center (R.A.D.C.) has been researching software quality factors for many years. The thirteen quality factors which are the basis of their approach, provide a consistent lexicon for communicating software quality requirements to developers, and then measuring the quality characteristics of the final product. Each quality factor has attributes and metrics associated with it, so that the quality of the application can be measured. In this session the quality factors and their attributes will be presented, a demonstration of a decision aid to prioritize the factors will be demonstrated and we'll discuss the applicability of such tools to assessing the quality of CBT programs.

Effective Screen Design for Computer-Based Training and Interactive Video
William D. Milheim, Penn State Great Valley; Brenda Bannan Haag, Penn State University

One area of particular importance for the development of computer-based training and interactive video programs is the issue of screen design, which can have a very significant impact on both the overall effectiveness and the learner appeal of a particular instructional project. The overall field of screen design encompasses a number of sub-topics including items such as color, balance, use of graphics and text, windowing, object location, button usage, and general learner control features, among others. Each of these items is important to the instructional design process for the production of an easy-to-use program that is effective, yet provides a comfortable learning environment.

Based on review of pertinent literature and the practical experience of the presenters, a number of screen design guidelines have been developed. These include:

- limiting screen information to relevant detail,
- using a limited amount of text on each screen,
- using standard, relatively large fonts for text-based information,
- using graphics instead of text when possible,
- using color where appropriate, with a limited number of colors per screen,
- using windows, tables, or other forms of partitioning to structure information on each screen, and
- separating instructional information from navigational aids in a systematic way.

Quality CBT - The Quick Way

Jeff Oliver, Castle Learning Systems Ltd.

The conventional theoretical model for courseware development has significant shortcomings when writing CBT for commercial clients. A practical methodology needs to overcome the limitations of paper-based designs, to consider implementation issues early in the design process, to keep the client happy and work within budget.

"The Practioners' Method" is an evolving, working methodology which has been applied successfully in a number of projects. The stages of the process involve:

-Minimising less productive parts, such as finely defined objectives.
-Extracting subject matter and producing narratives, not detailed layout forms.
-Creating a courseware prototype.
-Reusing well-tested elements to minimize bugs.
-Costing the script and adjusting the design to fit the budget.
-Importing text from word processed scripts directly.
-Producing intermediate versions of the courseware for review.
-Systematic acceptance testing.

The method challenges the notion that the programming part of CBT should be a mechanized inputting process but rather that the programmers should interpret the design script in a creative way. This presentation discusses the method in detail, with illustrations drawn from past projects.

Credentialing Courseware Developers: A Postgraduate Program in Computer Based Learning

Rod Sims, University of Technology, Sydney Australia

In 1992, the University of Technology Sydney (UTS) introduced a Graduate Diploma in Computer Based Learning (GDCBL). The program runs for two years part-time (one day per week per semester) or for three block (residential) weekends per semester. The program was developed as a result of changes in students requirements and legislative changes (Training Guarantee Act) for Australian business. In addition, there is now an industry-wide push for Competency Based Training (CBT), which has resulted in an emphasis on multi-skilling and award restructuring. Within this environment, the demand for training, and training alternatives, has increased - and programs such as the GDCBL are in demand. The value of the program can be emphasized in terms of four major factors:

Course Flow, designed to present individual subjects in a sequence which reflects the development methodologies for interactive training materials.
Delivery Strategies, providing both day and block (or residential) attendance patterns.
Assessment Strategies, incorporating techniques to integrate assignments into cohesive products.
Technology Change, such that new technologies are integrated into the program as required.

Meta-CBT 2: The Final Product

Rod Sims, University of Technology, Sydney Australia

The endeavor to produce effective courseware for high-order skills remains a challenge into the 1990's. While methodologies of Instructional Systems Design define the content structure, the creative ability to transform subject matter into performance-oriented instructional events is elusive. A strategy to involve the learner through integration with the content is proposed. The development of a meta-CBT course (CBT about CBT) provided the opportunity to create an environment in which the learner **actively participates** in the courseware development process, compared to learning **about** those processes. This strategy provides an alternative to traditional stimulus-response courseware structures and sets a new standard for learner involvement and interaction. The technique may also be viewed as creating a *virtual* environment in which the learner can explore the essential relationships of the focus domain. Of equal significance is the opportunity to implement such learner-integrated interactions using traditional frame-based authoring tools, demonstrating the essential contributions made by the human factor in courseware structures. This approach is now being applied in many interactive environments, and provides a model for future courseware development.

A HyperCard/Hypermedia Courseware Package Entitled: "Ticked Off! - A Resource for Tick Identification"

Wendy Snetsinger, Penn State University

Computer-based training offers wonderful opportunities for engaging the learner through the use of animation, unique graphics, appealing screen design, and other techniques. The learner can become an active participant through the courseware's personalized strategies and allowance for user control over options. At the same time feedback and guidance can be provided based on performance; thus CBT is ideal for independent learning.

A hypercard/hypermedia courseware package on tick identification is currently being developed by the Department of Entomology at Penn State University in cooperation with The United States Center for Disease Control, Ft. Collins, CO. This program is designed to address a growing health problem in the United States and throughout the world -- that of Lyme and other tick-borne diseases. Correct tick identification is crucial for the accurate diagnosis of these infections, since most tick-borne diseases are species specific.

Recognizing the broad range of experience and interest of the potential users, the courseware employs learning theory to customize needs and requirements to obtain various levels of mastery. Each unit has its own enabling objectives, and the lessons provide choices of how the material is presented -- through conventional strategies or through humorous metaphors. Microworld simulations are presented to challenge higher level thinking and problem solving, Interactive video materials and references are incorporated to provide general information on related material.

The Ford Experience

Timothy W. Spannaus and Laurie Diener, The Emdicium Group Inc.; Jackie Binkert, Ford Motor Co.

Ford Motor Company has committed to World Class Timing, a plan to accelerate product development as a way of improving competitiveness and profitability. Bringing about that dramatic change requires changes to the organization and culture.

A cross-functional team derived a strategy of using training as a key tool to bring about organizational change. We have built an unusually close relationship that can serve as a model to others in the same situation.

> **Needs:** An extended needs analysis, including focus groups, interviews, reviews of project data and documentation, determined that, in addition to training, needs included cultural changes and systems approaches.
>
> **Strategies:** The approach is to change organizational behaviors, through individual learning, organizational learning, process consulting, and a commitment to continuous improvement.
>
> **Processes:** We built a series of interventions, including mass communications, training, organizational learning, team consulting, and process documentation. Training included classroom and hypermedia, both designed to integrate product development processes.
>
> **Results:** Preliminary results are very encouraging. Individual and organizational acceptance is very good. Top management commitment to the strategies and processes, better definitions of product development processes, and successful startups of product development teams point toward better products.

Scoping a Program for Delivering CBT to your Users: A Hands-On Planning Session

Adele Suchinsky, US General Accounting Office

A wealth of excellent off the shelf computer-based training (CBT) and interactive videodisc (IVD) is available to business, government and academia for use in a self-paced training environment. Top management support, however, is not necessarily the only element required for you to ensure to successful implementation of a multi-media Learning Center or a distributed training program.

The initial challenge is to identify the place of CBT or self-paced training within the context of your training environment. Once the need for the program is established, the individual tasked with making the program a reality is faced with successfully addressing a number of critical steps in the implementation process. The key issues include budget, staffing, marketing, tracking, evaluation, facility, courseware selection, determination of need/correlation to existing curriculum, and design decisions for effective implementation.

This hands-on planning session will take you step by step through these elements and will assist you in identifying the issues, constraints, and alternatives for you to consider for implementing such a program within you organization. Through completion of prepared worksheets and interactive group discussions, you will identify and capture thoughts and ideas related to implementing a self-paced training program.

Selected Formal Papers from the

Special Interest Group for Computer-Based Training (SIGCBT)

Computer Graphics: Implications for Instructional Design

by
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Abstract:

Computer graphics in instructional materials support learning in various ways. They aid cognition by providing stimuli, retrieving prerequisite knowledge, encoding concepts, deciphering information, and sustaining motivation and interest. From a review of the literature, guidance for using graphics related to each of these cognitive processes will be summarized in the form of guidelines for graphic design. Examples illustrating how these guidelines can be employed with computer-based materials will be presented.

Introduction:

Researchers agree that the use of multiple representations facilitates the understanding of instructional content (Goldenberg, 1988). The need for multiple representations is that different learners have different capabilities for processing, understanding, and retaining information, and no single mode of presenting information works equally well for everyone (Taylor & Cunniff, 1988). Describing information or concepts verbally does not guarantee the learner's understanding of a concept or a fact. Graphics provide an additional representation to help learners comprehend the concepts that might not be understood through textual description.

For increasing motivation to learn, graphics have been widely used as an important strategy in designing instruction for various contents areas, together with various delivery systems. Learning is facilitated when instruction is appealing to learners (Keller, 1983; 1987a; 1987b; 1988). Including graphics in computer instructional materials can help learners develop positive attitudes toward reading. Graphics make learning become more pleasant, especially among young children (Samuels, 1970). Since learning requires considerable mental effort in relating, reasoning, and reconstructing information, the use of graphics may motivate learners to sustain mental effort in the face of difficult learning tasks. Used in conjunction with verbal materials, graphics also provide a more concrete representation to help learners conceptualize the information given. Learning becomes more interesting when comprehension is guided by concrete representations (Keller, 1983). Designing instruction that appeals to learners, encourages their active involvement and facilitates persistence in learning.

The use of graphics designed to complement texts can significantly improve student achievement of certain types in learning task (Hegarty, Carpenter, & Just, 1991). However, the specific type of graphics that will be most effective depends upon the student's abilities and characteristics, and the level of information processing required by a learning task (Dwyer, 1988).

The purpose in this paper is to examine how graphics can assist cognitive processing as viewed from the perspective of enhancing memory and motivation. The cognitive theories that support the use of graphics in memory and motivation are discussed. The empirical studies addressing the effect of graphics on learning are also reviewed. It is also the intent in this paper to provide prescriptions and guidelines for designing graphics for use in computer-assisted instructional materials.

Background for The Use of Graphics:

The use of graphics in instruction has been shown to support the following cognitive purposes: providing stimuli, retrieving prerequisite knowledge, encoding concepts, deciphering information, and sustaining motivation and interest. For providing stimuli, graphics are used for obtaining, sustaining, and directing a learner's attention to the important information (e.g. Levie & Lentz, 1982; Reynolds & Baker, 1987). For retrieval, graphics can be employed for metaphoric reasoning or for relating new information to information that students are already familiar with so that new learning can be achieved through a learner's own reconstruction (Kaufmann, 1985; Reed, 1985). For decoding, a picture can provide a concrete referent to explain an abstract concept and to guide students learning through visualizing the elements and the relationships between concepts (Reid & Beveridge, 1986). For encoding, pictures can help people rehearse to-be-remembered materials (Beck, 1987). An image also can be constructed by people through pictures or imagery instruction. The contrived image extracts the key concepts given from verbal information so that the information can be rehearsed and remembered easily (Alesandrini & Rigney, 1981; Morris & Hampton, 1983; Pressley, Cariglia-Bull, & Deane,1987). Providing graphics in instruction can stimulate emotional arousal, which may be helpful in encoding information (Levie, 1987). For sustaining motivation, graphics may stimulate learners' interests so that they gain enjoyment and generate positive attitudes toward the learning materials (Eisner, 1985).

Knowing how to use graphics effectively is important for instructional designers because of the key role graphics can play in motivation and learning (Faiola & DeBloois, 1988; Hannifin & Peck, 1988; Marcus, 1992). The role of instructional materials is to provide the external learning conditions that activate appropriate internal learning processes (Gagnè, Briggs, & Wager, 1992). Design techniques, such as grid systems, typography, color palettes and animation, or video capture capabilities, allow designers and developers to produce vivid graphics by using advanced technology. However, the merits of employing graphics rests mainly on their capability to enhance memory and comprehension during learning. The role of a graphic designer should be more than just to producing graphics that appeal to the eye. Moreover, a graphic designer should focus on applying design principles and research findings when developing graphic materials (Faiola & DeBloois, 1988).

The Psychological Effect of Graphics

Graphics can be presented in forms that vary from simple iconic objects to elaborate and realistic pictures. Graphics can be concrete or abstract and may convey analogical or representational concepts (Alexandrini, 1985). Graphics can also present information inferentially. For example, arrows represent directions, and so do pointing fingers. To be meaningful, people seeing such graphics must understand the inferences in the analogy. How well graphics benefit certain groups of learners depends on how well the graphics relate the knowledge and experience that learners already have and the knowledge and experience they are expected to acquire.

Meaningful stimuli are by definition the essence of communicating intended concepts. Although it is assumed that the more stimuli the representation can provide, the better it can facilitate the process of learning (Gibson, 1971), providing stimuli does not necessarily guarantee effective response unless they are meaningful to learners (Franzwa, 1973). Franzwa reported that pictures classified as highly meaningful were more easily learned than those receiving a lower classification in meaningfulness. The surface components of both verbal and pictorial stimuli should be relevant and coherent with the underlying concepts that the instruction is intended to provide (DeBeaugrande & Dressler, 1981). Learning from graphical information is not simply stimuli driven; it also involves relating learners' knowledge and the new concepts to be learned (Lindsay & Norman, 1977). Variations among learners might influence the process of interpreting graphic materials.

Supporting Cognitive Theories

The superiority of pictures over words in memory has been studied and addressed in several cognitive theories, such as dual coding theory, level of processing theory, and the sensory-semantic model. The dual coding theory (Paivio 1971, 1983, 1986, 1991) suggests that pictures and words activate independent imaginal and verbal codes. However, the availability of this dual code differs; that is, a verbal code for a picture is more available than an imaginal code for a word. Pictures are better than words because they are more easily dual coded (Paivio, 1983, 1986, 1991). From a level of processing view (Craik & Lockhart, 1972), when information is deeply or elaboratively processed, retention will be enhanced. Pictures used in instruction might induce a deeper encoding because a concrete, meaningful representation is extracted. Nelson (1979) advocated a sensory-semantic model. It was suggested that the picture code is superior to verbal. The superiority effect of pictures is attributed to a more distinctive sensory code; semantic judgements can be made more rapidly with picture than with words. Although these theories have different explanations and no theory provides an unassailable viewpoint concerning the phenomenon of picture superiority in memory, existing theories agree that the use of graphics facilitates memory and learning.

Motivation & Attention:

Learning from graphical information is an interactive process of perceiving, integrating, and reconstructing information from the given materials (Fitzerald, 1989). How knowledge is constructed depends upon how information interacts with learners' expectations and intents, and their motivation to learn. Emotion affects how information is attended to, stored, and retrieved (Langhinrichsen & Tucker, 1990; Lehmann & Koukkou, 1990). Since perceiving information involves selecting and filtering the elements from given stimuli (Pettersson, 1989), the learners' interests and expectations play an important role in extracting information and reconstructing their understanding. Viewed from the perspective of dual coding theory, motivation refers to the arousal and goal-oriented aspects of behavior that accompany the verbal or nonverbal memory system (Paivio, 1983, 1986).

Rogers (1983) considers emotion as a third cognitive code in addition to verbal codes and imagery codes. He argues that how people feel is related to how people can learn and remember information. What makes information learnable is largely a matter of coherence to one's beliefs and desires. Implied from Rogers' interpretation, the emotional effects that graphics can provide are highly related to how pictures are processed and how they interact with learners' internal mental states. As proposed by Rogers (1983), affective reactions to graphic information is part of the encoding process in the cognitive system. He assumes that when affective responses are activated, retention is enhanced. A positive attitude toward learning materials motivates learners to operate on and to organize the given representations.

Research findings suggest that graphics create memorable impressions and have an emotional impact that might affect people's attitudes toward the information described in the printed materials (Samuels, 1970; Swell & Moore, 1980). In computer-assisted instruction materials, still or animated graphics are often used for purposes of gaining attention and appeal (Rieber, 1989a). The instructional intent, however, is not just to provide enjoyment, but also to encourage cognitive curiosity and learning involvement. As involvement is enhanced, it becomes easier for students to acquire concepts from verbal materials provided in the instruction (Rigney & Lutz, 1976).

Given that affective reactions to pictures ordinarily occur more quickly than to words (Paivio, 1986), more precautions and considerations should be taken in relating what is perceived by learners and what is desired to be perceived from the intended objective. Fitzgerald (1989) argues that the use of pictures needs to be guided by the properties in the pictures relevant to establishing intended belief and desires from learners. Because different people have different experiences with graphics, when a picture is used to communicate, consideration should be taken regarding whether the picture can encourage learners to relate desired reactions. For example, the use of red color in a drawing might create a warm feeling. However, red color might also represent a warning or wrong response. The design decisions about integrating specific graphic attributes, such as color, format, or animation, depend not only on which attribute to choose to present to learners, but also how to use it properly, and when to use it to meet intended purposes.

Empirical Findings of Graphic Effects:

Empirical comparisons of graphics with non-graphic instruction, or one format of graphics with another, have been conducted. To test the effects of graphics in computer assisted instruction, Alesandrini and Rigney (1981) compared all-verbal to verbal-graphics presentations in a program with 96 undergraduate participants. The results favored the verbal-graphics presentation. Another experiment in the same study was conducted to test the effectiveness of the pictorial review task compared to a read-twice control. The results from post-test showed that the pictorial review condition facilitated performance more than re-reading, and produced more favorable attitudes as well.

It has been reported that information presented with graphics facilitates comprehension and enhances learning of science concepts (e.g., Arnold & Dwyer, 1975; Rigney & Rutz, 1976). Reid, Briggs, and Beveridge (1983) suggested that the readability of textual materials should be related to the content of pictures accompanying the texts. To examine the effect of pictures upon readability of a specially written science topic, a study was conducted among students in reading biology materials. The findings supported the use of pictures as a factor in the long-term understanding and recall of the text.

Although evidence has been provided by some research that graphics increase learning, the support for using graphics in instructional materials is inconsistent. In a reading comprehension study, Edyburn (1982) indicated 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 study (1985) showed that a graphic treatment was not significantly better than a non-graphic treatment. In math learning, Caputo (1981) concluded that graphics enhanced the learning of math skills. In spelling learning, Surber & Leeder (1988) reported that provision of graphic feedback in CAI materials did not enhance either achievement or motivation. From the inconsistent results among those studies, it appears that related variables such as variation in learners' abilities, differences in the nature of the learning tasks, and design quality might need to be considered in the assessing the effectiveness of graphics.

To examine the instructional value of different types of graphics in facilitating learners' achievement of different educational objectives, Berry and Dwyer (1982) studied subjects of different levels of ability. Graphic treatments included: one control group viewing instruction with no visual illustration, one treatment group viewing instruction with black and white shaded line drawing, another treatment group with realistic colored shaded line drawings, and another treatment group viewing non-realistic colored drawings. Analyses indicated that subjects of different levels of ability profited differently from identical types of visualization and that identical types of visualization were not equally effective in facilitating subjects' achievement of different educational objectives.

To determine the effect of pictures on learning to read, Samuels (1970) found that there was no difference in learning between picture and no-picture conditions for better readers. However, among poor readers, the presence of pictures influenced learning a sight vocabulary. He assumed that the less able readers were using a strategy of looking at a picture as a cue when having difficulty identifying a word. This finding suggests that students' ability is an important consideration in determining the value of graphics.

Reid and Beveridge (1986) studied the relationship between picture facilitation, children's ability, and text difficulty. Learning for picture and non-picture groups was measured by a criterion-referenced objective test. The results indicated no general motivational effect of pictures on the learning of text. With students of higher ability level, pictures are beneficial, while with less able students, they distract. Apparently higher-ability students can extract appropriate information from pictures more easily than less able students. Although this finding contradicts Samuel's conclusions (1970), the importance of the students' ability in the content area and their general reading ability were addressed in both studies.

In a multifactor analysis of the instructional effectiveness of self-paced visualized instruction on different educational objectives, Dwyer and Parkhurst (1984) studied the effectiveness of different types of graphics when supplementing programmed instruction. They were interested in how students' reading comprehension level influences their ability to profit from visual instruction. The results of this study indicated that different types of visualization used to supplement programmed instruction were not equally effective in helping students master different objectives. They also found that the achievement of the high reading comprehension group improved as the degree of realism in the graphics increased; whereas, the achievement of students in low reading comprehension groups decreased as realism in the graphics increased. A similar conclusion was reached in Parkhurst and Dwyer's study (1983) when they assessed students' IQ level and their ability to profit from visualized instruction.

The effects of graphics in assisting learning might vary when the formats of pictures are different. In teaching wave motion, Gage (1989) used three different formats of computer graphics among three treatment groups. The three treatment groups include the most realistic graphics, intermediate level realistic graphics, and the least realistic graphics. The results showed that the treatment with the least realistic visuals materials had the highest gain. Realism of the graphics materials did not add to learning in this study. An important implication for designing computer graphics is that the main function of graphics is to help students to differentiate the relevant cues in a graphic display. Realism may actually interfere with the transmission of information because irrelevant cues might also be activated in processing the information.

In a study designed to evaluate the instructional effect of realistic and non-realistic graphics (in both the presentation and retrieval of information) and students' levels of dogmatism, college students received a dogmatism pretest and were then assigned to different graphic treatment groups. Results indicated that a significant interaction was found between students' relative level of dogmatism and their ability to learn from different color cued visual materials (Berry & Dwyer, 1983).

From the studies cited here, it can be seen that individual differences in ability and learning experiences interact with different types of visual illustration for specific instructional objectives. To design effective graphics used in computer assisted instruction, it is necessary to investigate the ability level and characteristics of learners, and match graphics with learning tasks and objectives. For example, should visual displays be simple or more complex, what colors and cues should be used, and in what sequence should these graphics be presented. Additional questions related to students' cognitive abilities and to learning outcomes should be addressed in the design and use of graphics.

Computer graphics have played an important role in the way learners interact with electronic texts (Reinking, 1992). Especially in designing science or mathematics instruction, mandatory viewing of static or animated graphics becomes necessary to perform intended learning tasks. How well students can learn from graphics might be determined by how well students can interact with the graphic materials. In problem solving programs, Thomas (1989) used computer graphics together with problem-solving activities for improving student achievement, their attitudes and motivation in learning functions and transformational geometry. One of the objectives of the study was to evaluate the effects of graphics problem solving activities on the achievement and attitudes of secondary mathematics students. It was found that students who were allowed to select a picture to work with throughout the activities resulted in higher levels of motivation than students who were allowed to change goals throughout the activities. It was implied that providing different access conditions for allowing interaction with pictures might influence the level of understanding of the concepts presented through the graphics. To facilitate deeper processing in learning from graphic information, the instruction should also provide opportunities for sufficient interaction.

Four experiments involving 180 undergraduate students were designed to evaluate the effectiveness of computer graphics when learning algebra word problems (Reed, 1985). The purpose of the study was to explore the conditions under which computer graphics could be used to improve students' estimates of average-speed problems. It was observed that effective use of graphics required learning by coaching, especially for poorer achieving students.

Learning physics usually requires learners to visualize the motion and trajectory of objects in order to construct concepts. To study how animated graphics interact with learners and assist learning, Rieber and his colleagues conducted various animation studies among different grade levels of physics students (Rieber, 1989b, 1990a, 1990b; Rieber, Boyce, & Assad, 1990; Rieber & Hannafin, 1988). As expressed, animated presentations help students visualize those physical laws which involved changes in speed and the path of travel. However, the optimal use of animated graphics is related to practice activities. Although pictures might promote deeper levels of mental processing during encoding, the absence or ineffectiveness of practice might provide little facilitation of memory. The effective use of computer graphics depended upon supportive instructional activities.

Design Implications:

This review of the literature suggests that the effective use of graphics depends upon student's cognitive ability, differences in learning tasks and objectives, and other supportive instructional strategies. These estimations can guide decisions about when to use graphic information and how to use it. These design decisions may influence how learners interact with the graphics. They also influence how learners understand and retain concepts extracted from the representations. Prior to designing instruction, analysis of the intended cognitive tasks and the cognitive ability of learners becomes an important task.

From reviews of the various graphics research studies, several principles for guiding graphics use can be tentatively stated. The principles are predicated on the notion that to design effective graphics, carefully considering the learners and what they are to learn is needed in addition to considering the graphics themselves. Some guidelines can be summarized as follows (examples for each guideline are provided in Appendix 1):

1. Graphics should be used to guide learners to the important information rather than distract learners to focus on irrelevant information.
2. Graphics should be relevant to the learning objectives and the ideas to be communicated in the text.
3. The graphic objects used should be concrete and meaningful, with consideration of learners' familiarity in specific area.
4. The use of graphics should consider how learners interpret the graphics given, and their ability to peruse the materials for performing the required interactions.

5. The use of certain graphic objects should encourage learning interests of specific learner groups, and be appropriate to their characteristics.
6. The level of graphic realism required usually depends upon what types of information need to be conveyed, how much information is to be given, and how much time is provided for conveying the information.
7. The design format should be concrete and explicit for the concepts. When an analogy is used, experiences with the analogy used must be considered.
8. If too much information is included in a picture, it is necessary to break it into smaller or simpler units and present one unit at a time.
9. If graphics contain concentrated information, it is necessary to provide visual cues, such as colors, labels, or arrows, to emphasize the important information that should be focused upon.
10. The use of graphics should encourage positive learning attitudes.

Summary:

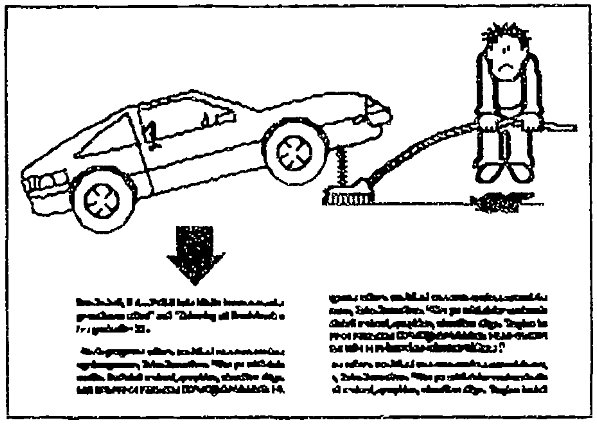
There are a variety of sound reasons to use graphics in computer-based instructional materials. We have reviewed some of these reasons from the cognitive and affective perspective by looking at existing theory and research. Rapid advance in computer technology has made possible an increasing array of sophisticated and appealing computer graphics. Design trends should reflect not only the interest of graphic artists but also the needs of learners. Adding aesthetic dimension to designing CAI can substantially encourage people's active involvement in learning materials. However, designers need to be cautious about the individual differences in observing, interpreting, recalling, and encoding information. Different kinds of pictures facilitate learning in different ways. The use of graphics should not just be based on a designer's intuition. Instead, how viewers interpret the pictorial information, and what can be done to bridge the gap between what learners know and what learners need to know should be a primary concern.

Guidelines based research findings are limited in current research on graphics. Most studies are done in a specific field. Instead of investigating a narrow range of application, future studies on graphics area should consider a wider range of variables and application. To ensure that designers use graphics more effectively, guidelines must be generated from an understanding of cognitive and affective phenomena.

Appendix 1: Examples of Design Guidelines

1. Graphics should be used to guide learners to the important information rather than distract learners to focus on irrelevant information.

   The graphic in this example is used to obtain attention from viewers about the problems that might happen to their own cars. The information follows when the graphic is displayed.



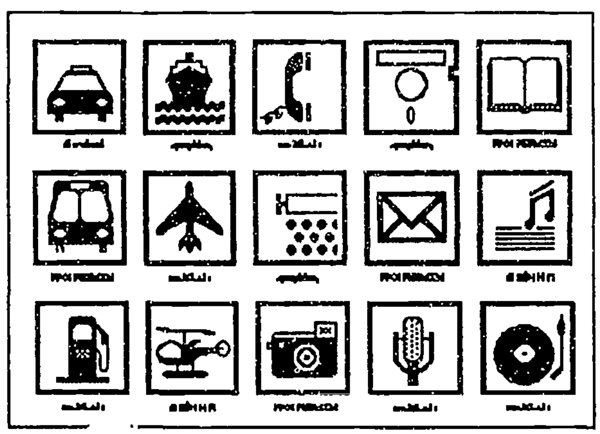
2. Graphics should be relevant to the learning objectives and the ideas to be communicated in the text.

   The graphic in the example represents the job of a veterinarian. The holding hand in the graphic infers the meaning of "protecting" which captures the role of a veterinarian.

Veterinarians are responsible for the welfare of our nation's food-producing and companion animals, a role crucially important to maintaining public health.

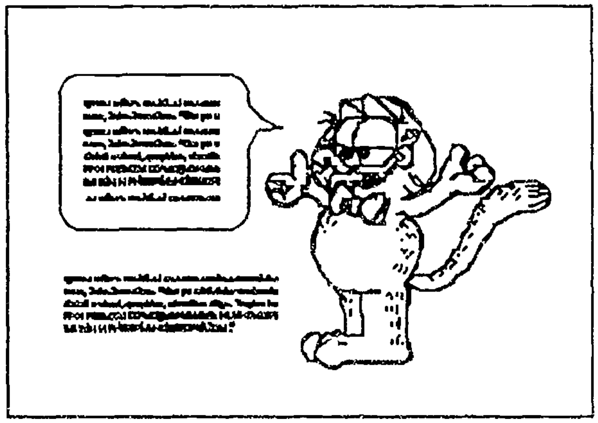
3. The graphic objects used should be concrete and meaningful, with consideration of learners' familiarity in specific area.
4. The use of graphics should consider how learners interpret the graphics given, and their level to peruse the materials for performing the required interactions.

   When simple line drawing symbols are used, labelling them with what they represent might help to avoid confusion or misunderstanding.



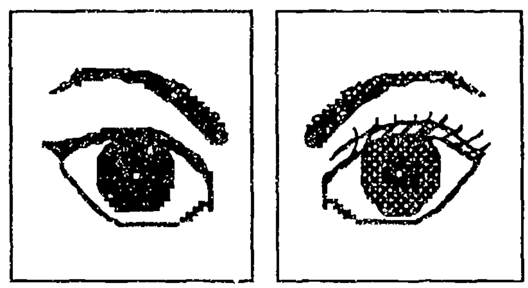
5. The use of certain graphic object should encourage interests of specific learner groups, and be appropriate to their characteristics.

Graphics that use cartoon characters might interest young learners. However, whether cartoons provide the same interest for older learners should be carefully considered.



6. The level of graphic realism required usually depends upon what types of information need to be conveyed, how much information is to be given, and how much time is provided for conveying the information.

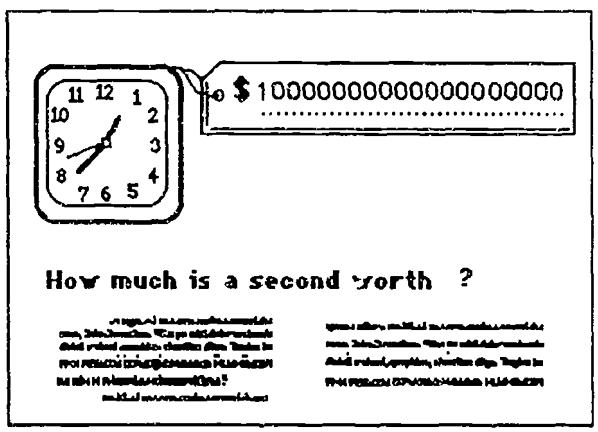
The picture on the left might be sufficient for achieving objective 1: Identify the eyeball. However, it might not be detailed enough to help achieve objective 2: Identify the pupil, eye lid, and eyelashes



Objective 1 Objective 2

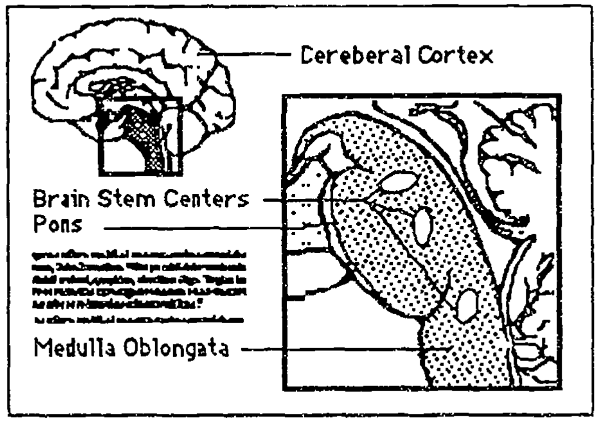
7. The design format should be concrete and explicit for presenting key concepts. When an analogy is used, considerations about learners' experiences with the analogy are required.

The graphic example tries to communicate that time is not what money can buy.



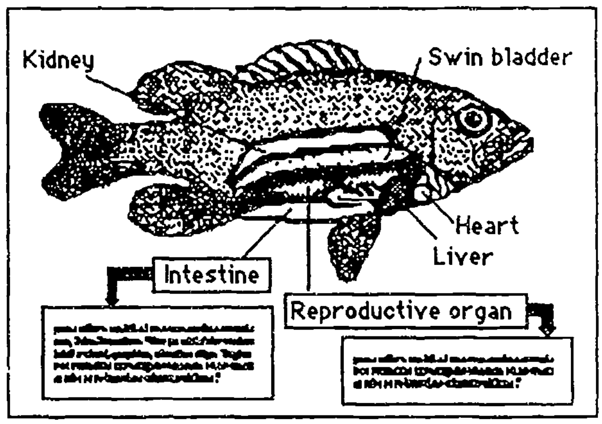
8. If too much information is included in a picture, it is important to dissect it into smaller, simpler units and present one unit at a time.

   For example, in teaching physiology or a related content area, dissecting the information into digestible pieces is necessary. It might also be helpful to show the part and whole relation through the use of a cropping technique.



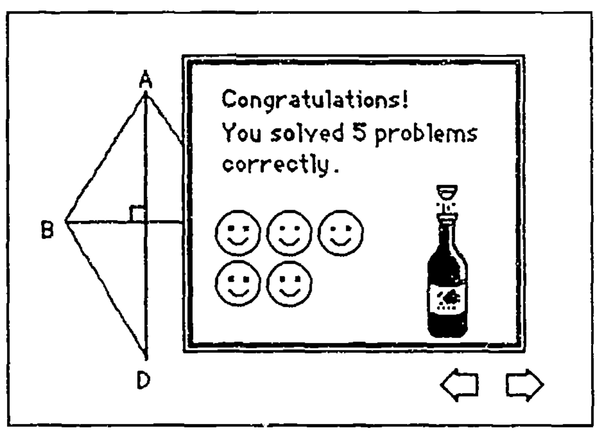
9. If graphics contain concentrated information , it is necessary to provide different visual cues, such as labels, colors, or arrow cues, to emphasize the important information that should be focused upon.

   In the example, the label cues and arrow cues are used to identify the portions that need to be described in details.



10. The use of graphics should encourage positive learning attitudes.

   In the example, the graphic feedback is to encourage learning interest.



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COURSEWARE EVALUATION: TECHNIQUES FROM INSTRUCTIONAL DESIGN THEORY AND COGNITIVE SCIENCE

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Introduction

The computer, like any other tool, is only as valuable as the software and the skill and knowledge of the user allow it to be. It is important then that we have good programs to use on our schools' computers. However, There is a widely felt concern about the quality of courseware available for schools (Allesi and Trollip, 1991; Hannafin and Peck, 1988; Krendl and Williams, 1990; Price, 1991; Venezky and Odin, 1991). In our efforts to improve the quality of courseware it would be useful to have a tool to describe instructional systems without reference to media or theory. Such a tool would be valuable for two reasons. First it would give designers a way to see clearly what they have created and help catch many problems at an early stage. Second it would give the consumer a powerful tool for obtaining information for evaluating courseware. With this information the consumer would be able to make judgments about what program to buy that would be based on the instructional qualities of the programs.

This paper explains some components of a taxonomy that is being developed at the Center for Systematic Courseware Integration, Design, and Evaluation (C-SCIDE) to describe instruction for use in evaluating educational software (Hoskisson, 1991, 1992a, 1992b). The elements of the taxonomy that have been developed so far include:

- an objective classification system
- terminology for describing instruction
- a method of mapping instructional interactivity

This paper will briefly discuss the objective classification system and then do a more in-depth explanation of some parts of the terminology to describe instruction.

Objective Classification

In order to design, study, or evaluate instructional systems it is helpful to know what the objective is. If a comparison study is being done, it is necessary to know what the objective of each system is to see if they have the same objective and to measure their success. When we evaluate instruction we must know what the intended and actual objective are. Determining the objective is one of the first steps in designing instruction. Therefore we need a way to classify objectives according to learning outcomes. There are many schemes available (Bloom, 1956; Gagné, 1985; Kyllonen and Shute, 1987). The choice of taxonomy is somewhat arbitrary. I have chosen Merrill's (1983) taxonomy (see Figure 1) because I find it is easy to use without losing accuracy. The taxonomy consists of two dimensions, performance and content.

The performance dimension has three levels:

- *Remember* is a level that asks the student to reproduce or recognize some item of information from memory. This is the only level that deals with facts. Therefore the *find* and *use* levels for facts are shaded in Figure 1.
- *Use* is the level that asks the student to apply an abstraction to a particular case.
- *Find* is a level that requires the student to originate or invent a new abstraction.

The second dimension consists of four kinds of content:

- *Facts* are pieces of information that are arbitrarily connected such as proper names, dates or events, the names or symbols of places, objects, or events.

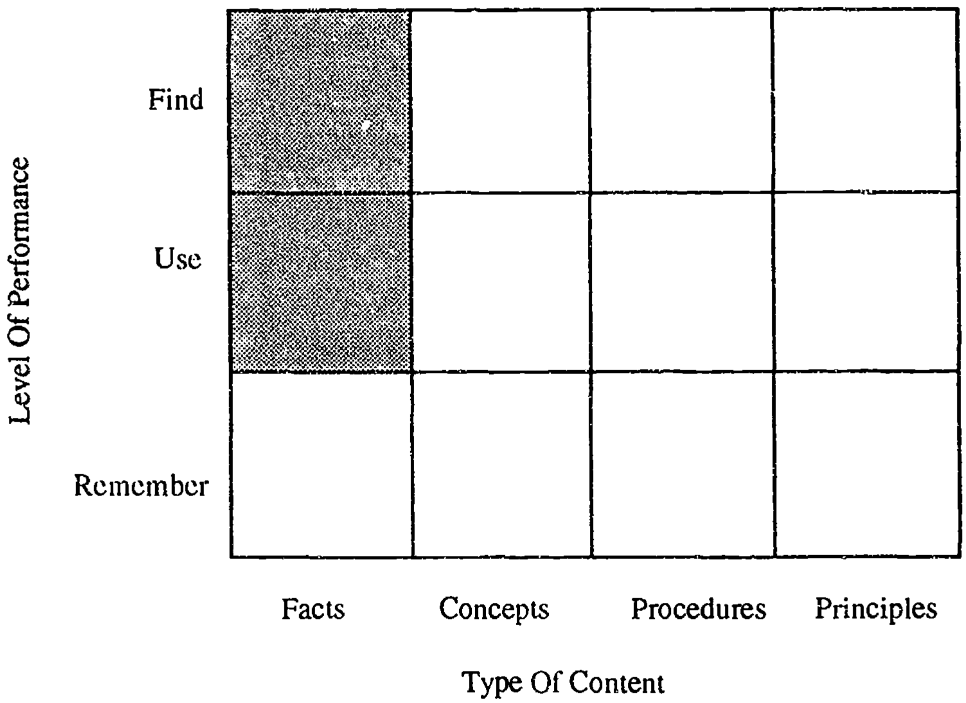

Figure 1. Objectives classification

- *Concepts* are groups of symbols, objects, or events that share common characteristics and the same name.
- *Procedures* are organized sequences of steps to accomplish a particular goal.
- *Principles* explain or predict why things happen. They represent causal or correlational relationships that interpret events or circumstance

A fuller explanation can be found in Merrill, 1983.

Terminology to describe instruction

Merrill (1983) has developed a set of primary and secondary presentation forms or instructional characteristics. We have adapted these for the taxonomy. The primary forms consist of two levels of specificity and two modes of presentation. The two levels of specificity are general and instance. Material can be presented as a generality such as an explanation of the commutative property of multiplication using x and y. Material can also be presented as specific instances such as using the word church to demonstrate the digraph "ch."

The two modes of presentation are expository or telling and inquisitory or asking (Merrill, 1983). The levels of specificity and the modes of presentations are combined into expository generality (EG), expository instance (Eeg), inquisitory generality (IG), and inquisitory instance (Ieg).

The secondary presentation forms includes most of Merrill's original set (1983) and several others we have added. Those secondary presentation forms that we have retained from Merrill are

- feedback (correct answer)

- representation (present information in alternate representation)
- mathemagenic help (underlining, bold type, etc.)
- mnemonic (memory aids)
- prerequisite (help recall prerequisite learning)
- context (place the new information in context)

We have added several others based on the work of West, Farmer and Wolf (1991). They are:
- chunking
- concept mapping
- advance organizers
- analogy/metaphor

Their are two two types of chunking or organizing strategies that can be used in instruction. The first type is linear/spatial strategies. This type includes spatial, sequential, procedural, and logical. The second type is classification which includes taxonomies, typologies, and multipurpose sorting.

Spatial strategies organize knowledge according to relationships in space such as dividing the states into western states, states east of the Mississippi, or the Great Lakes states. Sequential strategies organize knowledge according to relationships in time such as the break down of communism in Eastern Europe or the events of the Kennedy assassination and the shooting of Oswald. Procedural strategies organize knowledge according to relationships of stages such as a recipe or the steps to dry-mount a picture. Logical strategies organize knowledge according to relationships that can be logically induced or deduced such as proof for a theorem.

Taxonomies are used to organized knowledge that can be described by logical, law-like relationships such as instructional objectives or the animal kingdom. Typologies show less logical order but, never the less, are based on easily observed, obvious features such as color, size, or personality type. Multipurpose sorting can be done according to cause-effect, similar-different, form-function, or advantage-disadvantage.

West, Farmer, and Wolf (1991) describe concept mapping as a "way of graphically displaying concepts and relationships between or among concepts (p. 93)." The map is a visual portrayal of how the concepts are related to each other. A learning hierarchy could be displayed as a concept map as could an instructional design system model.

Advanced organizers serve as a bridge or connecting link from known information to unknown information. The connection is the similarities between the known and the unknown. An advanced organizer is a brief prose passage that recalls the known information and the aspects that are similar to the unknown information. The similarities are explicitly stated and the new information is outlined. A statement recalling the Yankee reasons for the Revolutionary War and outlining how they are similar to those of the wars for independence in South America would be an advanced organizer for a unit on the South American independence movement.

Metaphors, analogies and similes are another type of bridge or connecting link from known to unknown. They are figures of speech that create a comparison of two unlike things but which have some characteristics in common. Comparing an instructional objective to a target is a metaphor.

Application of the Taxonomy to Two Sample Courseware Products

We have been using the taxonomy for a year now and have found it a valuable tool in our evaluation of courseware. We use several methods of recording the descriptions of software. One method is a checklist of the instructional characteristics of a program. Figure 2 shows the results of using the checklist to describe "The Great Solar System Rescue" from Tom Snyder (1992). The instructional

Name of Program	Type of Program	Subject
Great Solar System Res	game	Astronomy/solar system
Tom Snyder Prod.	Objective: Use/concept Students use given information to determine where an object is in the solar system.	

Presentation forms

EG	
Eeg	y
IG	
Ieg	y
Representation	
Mathemagenic help	
Mnemonic	
Prerequisite	
Context	

Chunking	y
Concept mapping	
Advance organizers	
Analogy	

Figure 2. Checklist for Great Solar System Rescue

characteristics of the program are uncomplicated. Information is presented in an expository (Eeg) manner and a question (Ieg) is asked. The information is chunked to help in applying it. All of this is embedded in a game format the characteristics of which are not shown on the checklist.

Figure 3 shows a checklist for "The Puzzler" from Sunburst (1986). The checklist shows that this is a simple program. The program presents (Eeg) a story fragment and asks the learner to make predictions (Ieg) based on the fragment. After the learner makes one or more predictions the program presents another fragment of the story and repeats the process. There is no correct answer provided because it is intended to be an open ended exercise and allow students to fully develop their own thought processes.

These analyses done with the taxonomy are not complete by themselves. There are many qualities of the programs that are not captured. How all these characteristics interact with each other is not shown.

Name of Program	Type of Program	Subject
The Puzzler	drill/practice	reading comprehension
Sunburst	Objective: find/concep Students need to use given information to make predictions about aspects of a story.	

Presentation forms

EG			Chunking	
Eeg	y		Concept mapping	
IG			Advance organizers	
Ieg	y		Analogy	
Representation				
Mathemagenic help				
Mnemonic				
Prerequisite				
Context				

Figure 3. Checklist for The Puzzler

Neither is the sequencing shown. For these and other needs we have developed additional elements of the taxonomy (Hoskisson, 1991, 1992a, 1992b).

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Computer-based Tools for Methodology teaching

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Abstract

In this session, we address the problem of the training of company employees in project culture, and especially in the use of methodology. At first we present MEDOC, a whole life-cycle methodology that may be applied in the management of projects in various domains of the software industry. The structure of this methodology is suitable for instruction through a computer-based training tool. Such a tool is METHODMAN I, which represents the commercial version of an Intelligent Tutoring System for basic methodology training. METHODMAN I had originally been developed as a prototype aimed at testing the efficiency of a certain padagogical approach in teaching methodology. To meet the user requirements that emanated from METHODMAN I usage, we are currently developing GEPRIAM, a highly-interactive Authoring Environment supporting the construction of intelligent methodology-teaching, computer based applications. GEPRIAM, in order to improve system modularity, uses a *methodology expert system* and a *pedagogical expert system*, which assist the user during application construction and execution. Finally, the current status of GEPRIAM development is evaluated, and some considerations for future upgrade are presented.

1 Introduction

Since technological progress and innovative technologies, and the associated benefits for all levels of modern enterprises [Gurbaxani, 1991], are usually available to or accessible by all enterprises, the difference lies in the degree of adaptation of the enterprise to the new technologies, or in the rate of adoption of the new technologies by it; these both depend critically on the people that will introduce or use the new technologies.

Therefore, both personnel and managers' development and training are two of the key issues in todays bussiness world [Friis, 1990]. Personnel is a very important parameter in competition. Capable project managers may develop products correctly and within budget [Sommerville, 1989], but in order to develop advanced products that use innovative technology yet are beneficial for the investor, well-trained project managers are needed.

As managers and industrialists develop an appreciation of the significance of training people in the use of methodologies, the production and dissemination of products for methodolody education and training is rapidly gaining ground. The current situation is that training disciplines rarely include education in *project culture*. Such an education should include the introduction both of a project-type organizational structure (responsibilities, knowledge, controls etc) and of the use of methodology, and sessions in risk management (technological, human, etc). This lack frequnetly causes the failure of innovative projects and also hinders the dissemination of new technologies.

Up to now, people were trained in courses controlled and carried out by other people (the experts). This practice involves a high cost in time, money and spirit, since the trainees had to be moved to the training site and the expert had to be constantly in his best shape, in order for the training session to maintain a standard level of quality. Apart from depending on the expert's mood, success of the training also depended on the capability of the trainees to absorb information. Usually, the weaker trainees determined the pace of the session. Finally, it is clear that using this practice it is almost impossible to massively train a large number of people efficiently.

Consequently, the traditional training practices can hardly meet any of the current training requirements, which include [Menu, 1990]:

- rapid development of student's skills, in accordance with his needs and time schedule, and of course, at his/her location
- adapting the sequence and pace of training to student's personal requirements
- preparing and assisting the student before and during the session
- enhancement of the training environment and of the communication between student and tutor

Thus, new technologies had to be used, and especially computers, which proved very successful in this field due to their capability to process information very quickly, and to "customize" themselves to people's particular needs. Computers proved very efficient especially in fields where human knowledge was already coded in a structured and "logical" way; such was the case with methodologies.

In the next section, we present the characteristics a methodology suitable for computer–based training should have. Such a methodology is MEDOC, which is also briefly presented. Then, we analytically present METHODMAN I, a computer–based tool that teaches the adaptation of MEDOC in software project management. METHODMAN I had originally been developed as a prototype aimed at testing the efficiency of a certain padagogical approach in teaching methodology. To meet the user requirements that emanated from METHODMAN I usage, GEPRIAM, a highly interactive Authoring Environment supporting the construction of intelligent methodology-teaching, computer-based applications is currently being developed; GEPRIAM is briefly presented in the next section, and the current status of development is being discussed.

2 Methodologies suitable for computer–based teaching

Although a human tutor could probably teach any methodology, this sadly is not yet true for computerized tutors, mainly because methodologies are developed by humans to be used by humans. Keeping in mind, however, that it is humans who will construct the computerized tutors, we can state a set of characteristics that a methodology should have in order to be possible to effectively codify it into a computerized tutor:

- *internal structure*: it must be composed of well-defined phases and subphases, each of which is an integral task, with well-defined "execution" semantics (people involved, actions to be taken, output to be delivered etc), and a well-defined set of preceding and succeeding tasks. Phases or subphases may also have an internal structure. This decomposition may continue until trivial phases or tasks are reached.
- *well-defined goal approaching steps*: every methodology is applied to solve some kind of problem. The procedures that solve all problems must be well-defined, in the sense that every step taken must be justifiably goal-approaching. This does not mean that there must not exist alternative solution paths for a certain problem; it means that the structure of methodology should be able to "justify" the correctness of the path.
- *solution and procedure documentation and justification*: apart from being self-justifiable, a methodology must be capable to adopt domain-dependent explanation for the procedures and tasks it contains, so that the easy justification of the solution reached is possible.
- *generality and domain independence*: it should be possible to apply a methodology to similar problems over several domains, although the way and the means of application may be different. If this is not possible, then an attempt to extract a more general methodology should be made.
- *flexibility and capability to evolve over time*: a methodology should be flexible in the sense that, if needed, it could be customized (to a certain extend) to meet personal requirements without losing its structure or effectiveness. In other words, different people could have different understandings of the same methodology, without this fact affecting the methodology at all. In addition, a methodology should evolve over time to capture the new cases that may be added to the set of cases it can deal with.
- *successful application*: if a methodology has been successfully applied to several domains, then its procedures and tasks will have become as efficient as possible.

The first three characteristics relate to the procedures a methodology adopts, and the capability to justify them. This will permit the effective monitoring of learner progress, and the capability to present and justify the correct answers. The fourth characteristic leads to formal clarity [Clancey, 1987] by permitting the separation of domain knowledge from teaching strategies. Especially, the second and fourth characteristics relate directly to the two levels of structure that knowledge has, namely *surface structure* and *deep structure* [Yolles, 1991] (which result to the acquisition of surface and deep knowledge, respectively). The fifth characteristic tries to ensure that a computer tutor will not become obsolete after a short period of time (at least due to causes inherent in the methodology). The final characteristic has to do with the expertise transfered to the computer tutor compared with the expertise needed to obtain a successful result.

2.1 MEDOC

MEDOC is a general methodology for project management with a well-defined internal structure. It divides the project management process in a number of *phases* [COMETT, 1991]. Each phase is composed of *task-content* and *task-control* activities. The former define the steps that must be carried out by the project manager in order to complete the phase, while the latter define the phase terminating activities (usually carried out by the inspectors). The project manager must take some *action(s)* to complete an activity. The project, as well as the activities and the actions that make up its phases produce or consume *information products*; these have the meaning of inputs (prerequisites) or outputs (objectives), respectively, of the action or activity (for example, documents, reports, meetings, interviews, etc). The sequence of phases is strict. Each phase forms a subgoal, which may be achieved by following the activities it contains. The sequence of activities may or may not be strict. This is not the most flexible structure one could find, but it is a working one.

MEDOC can be (and has been) applied to various domains, where project management tasks exist. Although the names of the phases or activities may change, the structure in effect remains the same. This allows for easy justification of actions, or sequence of activities or phases. MEDOC is in use for several years now, and its procedures have reached a point of high effectiveness. Its general structure permits the adaptation of the methodology to all the problems of software project management that may come up.

In the application of MEDOC in the domain of software project management, the project management process is considered to be made up of a sequence of six phases:

1. Starting the project
2. Functional Analysis
3. Internal Conception / Design
4. Implementation of the modules
5. Integration
6. Testing / Acceptance

Each of these phases is made up by a sequence of task-content activities and is ended by a task-control activity. All these activities entail one project manager action, that is why the notion of actions is not explicitly used in this adaptation of MEDOC.

3 METHODMAN I

METHODMAN I is a CAI tool which aims at teaching the MEDOC methodology for project management; in particular, it teaches the adaptation of MEDOC in the domain of Software Project Management.

As is the case with most computer tutors, METHODMAN I is composed of a set of *content files* and a set of *support programs*. The latter are used to present the former to the user, and in general, these make up the invariable part of the application (invariable in the sense that if a different METHODMAN-like application was to be constructed, these programs could be reused, while a new set of content files would have to be produced). Execution is commanded by a *driver* *program*, which reads a file with the teaching strategy. In METHODMAN I, the teaching strategy is "prewired" in the driver program, and thus the sequence of execution of the programs used to display the various content files cannot change. This was a design decision aiming at relieving the pedagogical burden from the authors and permitting them to concentrate only on the application contents.

3.1 Pedagogical issues

METHDOMAN I uses the Crampes learning cycle [Crampes, 1991] as its pedagogical basis. The Crampes learning cycle (figure 1) overcomes the problems reported in [Cunningham, 1990] and is particularly appropriate for complex learning material [Yolles, 1991]. It adopts a mixed program control method (part of the course is learner-controlled, and part of it is system-controlled), which is currently regarded as the most effective teaching strategy [Bolton, 1991], and describes a learner in a learning process that first passes through a *discovery* voyage, identifying the nature of the learning material and determining its form and structure. Then the learner examines the content and explores the meaning of the learning material through an *exploration* stage. Finally, *evaluation* may be self-determined or objectively done by the system; it may consist of a set of tests or a form of simulation. If evaluation demonstrates a satisfactory result, then the cycle may end. Otherwise, it may lead to:

(a) a poor assessment which itself can encourage or demand a re-evaluation of the learning material and continuation of the cycle, or

(b) extended discovery, particularly in more complex learning domains which have more than one level of perception or understanding.

The adaptation of the Crampes learning cycle to the needs of training in software project management, as they were implemented in METHODMAN I, led to a course composed of four distinct stages [COMETT, 1990]:

1. **Discovery**, where the trainee is presented with the phases and the activities and is asked to order them correctly (i.e. to *discover* the correct evolution of a project). During this phase, the methodology expert system included in METHODMAN I is monitoring the trainee's performance and guides him/her by indicating both the correct answer each time he/she makes two mistakes in a row, and a list of suggested library topics that he should consult. In addition, the trainee has free access to the library and the glossary of management and informatics terms.
2. **Exploration**, where the trainee is asked once again to correctly line up the phases and each phase's activities of the project life-cycle. He can still access the glossary and the library, which now contains tests next to the topics. When the trainee successfully passes a test, he is awarded some EKUs (Elementary Knowledge Units), the number of which depends on the type of the test and the times he has taken it. Needless to say that every mistake is paid in valuable EKUs.
3. **Evaluation**, where the trainee passes a number of (admittedly) difficult tests, with his EKUs score decreasing with every mistake. If the score reaches zero before the stage is over, the

trainee is thrown back to the previous stage and is asked to study the topics more carefully. If he manages to finish the stage with a positive EKU score, he is considered to have acquired the basic methodology in software project management and is awarded a password that enables him to enter the final stage, which is the free consultation stage.

4. **Free Consultation**. The trainee (now an acknowledged project manager) can now review all the tests, together with the correct answers, as well as the library topics. Note here that most of the answers to the tests are not available until this stage.

3.2 Architecture

The functional architecture of METHODMAN I is depicted in figure 2. The general idea behind METHODMAN I is to incorporate the teaching strategy in the support programs, so that the au 'or would concentrate on the structuring of the content to be taught. This content is structured in icture, text and test frames. There exist interpreters that display each of these types, and also ma..age user-system interaction. The pedagogy of the application is incorporated in two types of stages (each of which is used twice, resulting to a four-stage application); the order of stage execution is standard.

The overall execution of the program is controlled by the *driver*, which reads a *command line* from the *script file* that represents the pedagogical content of the application. Depending on this line, the driver activates the appropriate *stage monitor* program with a set of appropriate parameters indicating the stage type. The driver or the stage monitor may also activate one of the frame interpreters. The two expert systems included in METHODMAN I also play a very important role: the *methodology expert system* contains a set of rules that relate to the structure of the methodology phases, the library topics associated with each phase and the student actions (phase selections or test answers) that the system regards as "correct", as far as the methodology is concerned. The *pedagogical expert system* creates for every student a *student environment* composed of a set of files that contain information on his progress in the course and his performance so far, using the outcome of the firing of the methodology expert system rules and the history of learner system interaction. The structure of the expert module of METHODMAN I follows a cognitive modelling approach, where knowledge is decomposed into meaningful, integrated components, and thus it may be easily understood and applied by humans.

Although METHODMAN I incorporates an expert module and a student environment, its interface is kept as simple as possible, without advanced communication capabilities (like direct manipulation, multimedia presentation or multimodal communication). In addition, its teaching module follows a script where the flow of execution is predefined and cannot change. The task of the expert systems is to guide the learner into an effective sequence of methodology topics access, and to determine whether the learner has met the pedagogical objectives of the course at the end of the session. However, the open architecture of the system permits the integration of different support programs, and in such a way, different METHODMAN-like applications can be produced (using a set of independent editors to produce the content files) that will match the continuously evolving training requirements.

3.3 Ease of use

METHODMAN I offers a simple yet functional User Interface, which only uses some function keys (F1 - F5) to provide access to its utilities (glossary, library, help etc), the space bar and the Return key to continue or acknowledge and the numeric keypad, the T key or the F key for answering the tests. The user can scroll within the menus or navigate through the embedded menus of the glossary with the arrow keys (or the PgUp and PgDn keys) [METHODMAN, 1991].

In addition, METHODMAN I offers five significant utilities (available with a single keypress) that support the user while taking the course:

1. The capability to exit any time the user wants and to restart from this point the next time
2. A Library containing numerous topics on software project management and on MEDOC
3. A Glossary of management and informatics-related terms using embedded menus and windows to move around related terms
4. Up-to-date progress or evaluation test score (depending on the pedagogical context of user actions)
5. Online help on the system functions or a list of suggested topics for the trainee to read (again, depending on the pedagogical context of user actions)

As we have already mentioned, METHODMAN I is a very-easy-to use tool. Therefore, there is no need for the user to be trained to use this training tool; its simple interface together with the on-line help make it easy-to-use even for the non computer expert.

We can say that this is one of the strongest features of METHODMAN I: the user very quickly gets the feeling he is in control of the process with no additional effort. While he is running through the course he always feels "at home" with it, and he can concentrate his efforts in absorbing the knowledge that is presented before his eyes. Let us say once more that the course runs in the user's own pace; in addition, the user is allowed to interrupt the session whenever he feels tired, and restart from that point the next time.

3.4 METHODMAN I usage modes

METHODMAN I meets most of the requirements that a user may have from a computer based training program with intelligence. It is autonomous, complete with respect to the taught methodology, portable, user controlled, and easy-to-use. More specifically, METHODMAN I can be used in four distinct modes:

1. in **self-discipline**, where a user runs the course alone to improve his/her knowledge in project management
2. as **help to instructors** before or during a training session in the use of project management methodology
3. as an **assistant to project leaders**, who may capitalize upon the free consultation topics in order to establish the habit of quality and methodical work

4. as an **assistant to the methodology executive**, who can use the free consultation sheets and the multi-method glossary to improve the Quality Plan of the company

4 GEPRIAM

The project GESEM, being currently carried out in the context of COMETT II program, aims at improving and extending METHODMAN I by delivering a package of advanced training tools [COMETT, 1991], in order to introduce the project culture in the European industrial and academic communities involved with innovative activities (those aiming at developing and / or intergrating new technologies). Directions of research carried out by the GESEM team include those proposed in [Clancey, 1990] with the incorporation of a more powerful pedagogic expert system and the adaptation of MEDOC methodology to different domains.

Currently, the emphasis is placed on the design and implementation of an Authoring Environment called GEPRIAM, which will enable the authors adapt MEDOC (or any well-structured methodology) to various domains, reducing the effort needed to create specialized educational packages [Whiting, 1991].

4.1 Teaching strategies

An application constructed with GEPRIAM is equivalent to the sequential execution of pedagogically autonomous objects we call *learning units*. Each learning unit corresponds to an integral block of knowledge that must be presented to the learner and has an internal structure (simple or complex). Its execution is pre-emptive (in the sense that it cannot be interrupted by the execution of another learning unit) and has clearly defined pedagogical objectives and prerequisites (the execution of a learning unit cannot commence or terminate unless these objectives are met).

These objectives may correspond to the goals being sought by a learner, as these are defined in [Yolles, 1991]. When goal related objectives are not clear, the learning process can be erratic and inefficient. Learning can also be restricted by other factors regarding the mental model of the learner. That is why different learners may require to navigate through an individual sequence of learning units in order to achieve a particular learning goal, since learning strategies may differ from learner to learner. To support different learning trajectories, GEPRIAM offers a variety of teaching strategies, as will be described in the next subsection.

There exist two types of learning units:

- elementary units, such as text or picture frames, whose internal structure is almost non-exixtent (usually they are referred to as *frames*), and
- complex units called *stages*, which encapsulate a teaching method and consequently have an internal structure that reflects the teaching method principles (such as learning by discovery, by tutoring, by examples etc).

In GEPRIAM, as in METHODMAN I, an effort has been made to relieve the author from the need to construct and specify a pedagogic strategy (our experience with METHODMAN I showed that the authoring process is speeded up by a factor of 20 in such a case). Stages form a set of predefined pedagogical strategies; the author, who need not be a pedagog, may choose one or more that satisfy his needs, and execute them in some order. If the author wants to explicitly construct a strategy of his own, the system supports completely this phase. It has been argued, however, that to achieve *effective learning*, a minimization of learning constraints must be adopted [Laurillard, 1987]. That is why semi-structured approaches to learning can be more satisfactory than highly structured approaches. In GEPRIAM stages that support this kind of teaching strategies are provided to the author.

GEPRIAM supports three kinds of teaching strategies structuring:

- *sequential execution of learning units*: here the teaching strategy is encoded in the stages used by the author
- *non sequential execution of learning units*: here we have two levels of structuring: the first is within the stages used and the second is in the script file. The learner chooses (or is forced to follow) a path from a set of allowable paths specified by the author
- *execution of the learning units as suggested by the pedagogical expert system*: here the author defines the set of learning units and the pedagogical prerequisites and objectives associated with each. Then the pedagogical expert system manages the presentation of the learning units and the learner interaction

4.2 Architecture

GEPRIAM is composed of two major subsystems: the *authoring subsystem* and the *user execution subsystem* [COMETT, 1992]. The former is used for application construction, while the latter supports application execution. In this way, a prototyping facility is provided to the author, while the integration and packaging of the application is facilitated.

The authoring subsystem is composed of a number of modules that enable the author specify the contents of the application. Although GEPRIAM is not yet a full multimedia environment, it contains a text and a picture editor (inclusion of a sound editor is under consideration). A module that supports the construction of hypertext glossaries is also included. Finally, it contains modules that support the specification of pedagogical strategies and of the methodology to be taught. The output of the authoring subsystem is a number of files that are used by the programs of the user execution subystem.

The teaching strategy, that is, the learning units contained in the application and all the allowable execution paths, is contained in the *script file* of the application. The execution of an application is commanded by the *application monitor*; this program appropriately calls all the other programs of the user execution subsystem. These are mainly *learning unit interpreters*, that is, programs that display the different types of learning units and manage learner system interaction, *student environment programs*, which monitor the progress and performance of the learner within the application, and some *utility programs*, which perform supportive functions, like score calculation, application exit and restoration of a previous position etc.

GEPRIAM also includes two expert systems:

- *a methodology expert system*, which is used during the authoring process by the author for the structuring of the methodology to be taught. During application execution, this expert system is called by certain stage types to evaluate learner perfomance and guide him through the correct answer path
- *a pedagogical expert system*, which is currently used only to evaluate the results of learner perfomance using the data collected by the programs of the student environment. When completed, it will completely support learner-system interaction, and thus facilitate the author in the specification of the teaching strategy

Another feature of METHODMAN I that has been carried over to GEPRIAM is the open design and the ability to replace any runtime program without affecting the system performance (for example the text interpreter may be replaced with a new advanced version, and a sound interpreter can be included as well). Compatibility between applications created with different versions of GEPRIAM can be maintained by maintaining an extended set of runtime support programs; the application will automatically detect and use the appropriate ones.

4.3 Ease of use

From the user perspective, GEPRIAM has been designed to meet several requirements, the most important of which being to impose the less possible cognitive load on the author. To this end, an advanced user interface has been designed, which tried to make an efficient use of screen space, so as to achieve maximum communication bandwidth between system and user [Thimbleby, 1990]. The same interaction metaphor has been used in all the modules of the authoring subsystem, with the left part of the screen used for information exchange and current state representation, while the right part of the system contains a set of "controls" enabling the author to carry on the authoring process (these two parts may also be interchanged to suit the needs of left-handed users). In addition, windows are used to separate different modes of operation, and menus and buttons to present the author with the available actions.

Two more features that lead in a more efficient system-user interaction are the incorporation of a tightly structured model of interaction and the separation of the content entry phase from the teaching strategy specification phase.

The authoring process is regarded as the satisfaction of a series of *subgoals* which amount to the *overall goal* of application construction. A pre-emptive window corresponds to each subgoal. Within each window, specific areas are used for smaller subgoals. In this way, the user knows all goals he has to achieve in order to construct an application. Goals are achieved using *actions*; the *context* of each action is automatically defined by the subgoal it is associated with. In this way, the system tacitly guides the author through the authoring process, and it is also flexible enough to let him control the process, while it prevents him from pitfalls. This model also supports the creation of learning unit libraries, which will enable the easy adaptation of MEDOC to various domains.

One limitation inherited from METHODMAN I is that the author cannot yet specify the user interface of the application; he can only use the one supported by GEPRIAM.

5 Conclusions

In this paper, we have presented two CAI tools for computerized methodology teaching and a suitable methodology. This is MEDOC, a general methodology for project management with a structure that permits it to be easily coded in a computer program. Such a program is METHODMAN I, the first tool we presented, which teaches the adaptation of MEDOC in software project management. The architecture, teaching strategy and user interface of METHODMAN I were presented, and its weaknesses discussed

As part of the product validation and quality assurance plan, some demonstrations were performed by SYSECA S.A., followed by evaluation surveys [SYSECA, 1989] in a population of 70 users (60 of whom were not familiar with the spirit of enterprise). The outcome of these surveys showed that:

- 82 % were generally satisfied with the program, while only 5 % were disappointed
- 55 % felt that their knowledge of methodology improved a little after a session with METHODMAN I, while 45 % said that their knowledge improved a lot
- 81 % would recommend METHODMAN I as a training discipline to a colleague asking for advice, while 11 % would recommend a traditional training practice
- The principal quality of METHODMAN I is *usefulness*, followed closely by user-friendliness

Though METHODMAN I is, as users have suggested, a well-designed tool that performs satisfactorily [Kameas, 1992], we believe that it could be improved in three directions, in order to adapt to the new perspectives and techniques that are shaping the field of computerized education today [Pea, 1987]:

- towards AI by evolving into a full Intelligent Tutoring System
- towards multi-domain adaptation, by providing an easy way for the domain expert to codify his knowledge in METHODMAN-like courses
- towards multimedia presentations

To this end, GEPRIAM, an Authoring Environment supporting the construction of methodology teaching applications was shortly presented. GEPRIAM offers many supporting functions and an advanced user interface to support the authoring process. More specifically, the author is guided through the phases of the authoring process using a model based on pedagogical objectives and learner characteristics to specify the order of execution of the course learning units. This model regards the authoring process as the achievement of a number of subgoals that lead to the course construction.

Although a prototype of GEPRIAM is functioning (as part of system validation, METHODMAN I was constructed again using GEPRIAM), the system is not yet complete. It lacks true multimedia capabilities, and as a consequence, it cannot produce multimedia applications. In effect, the author cannot even specify the user interface of the application. In addition, a large part of the pedagogical expert system has not yet been implemented, and learning unit libraries are not fully supported. Finally the student environment is essentially the same as in METHODMAN I and needs a great improvement.

In the next year, we plan to use GEPRIAM to create several applications that would teach MEDOC and other methodologies applied in various domains. By evaluating these applications, we will set the goals that the next version of GEPRIAM will have to meet. Our principal aim will be the construction of the pedagogical expert system, and its integration with the system. Luckilly, the object–oriented design we have used will greatly facilitate the process.

We envisage GEPRIAM as evolving into an Intelligent Tutoring System for the development of intelligent methodology-teaching applications. Our effort, however, is concentrated in providing as many facilities as possible to support the author who is not a computer expert. We believe that this is the only way that will enable the efficient coding of expert knowledge into any computerized teaching tool.

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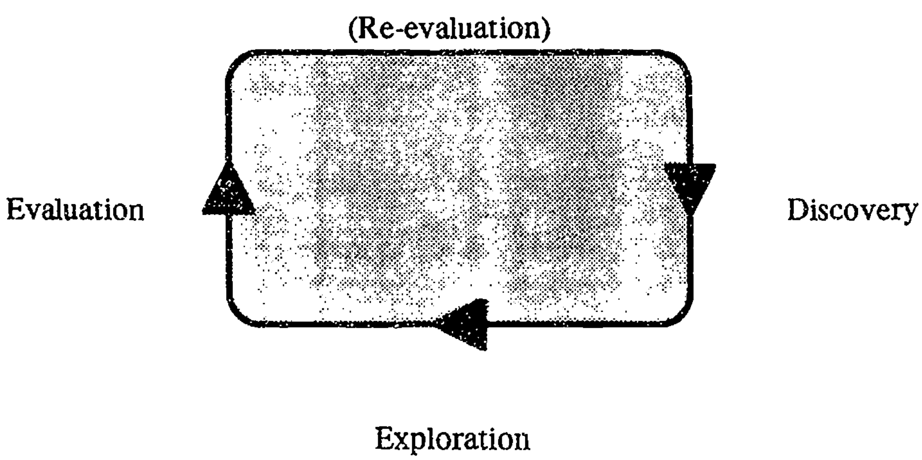

Figure 1: The Crampes' Learning Style (for complex learning Domains)

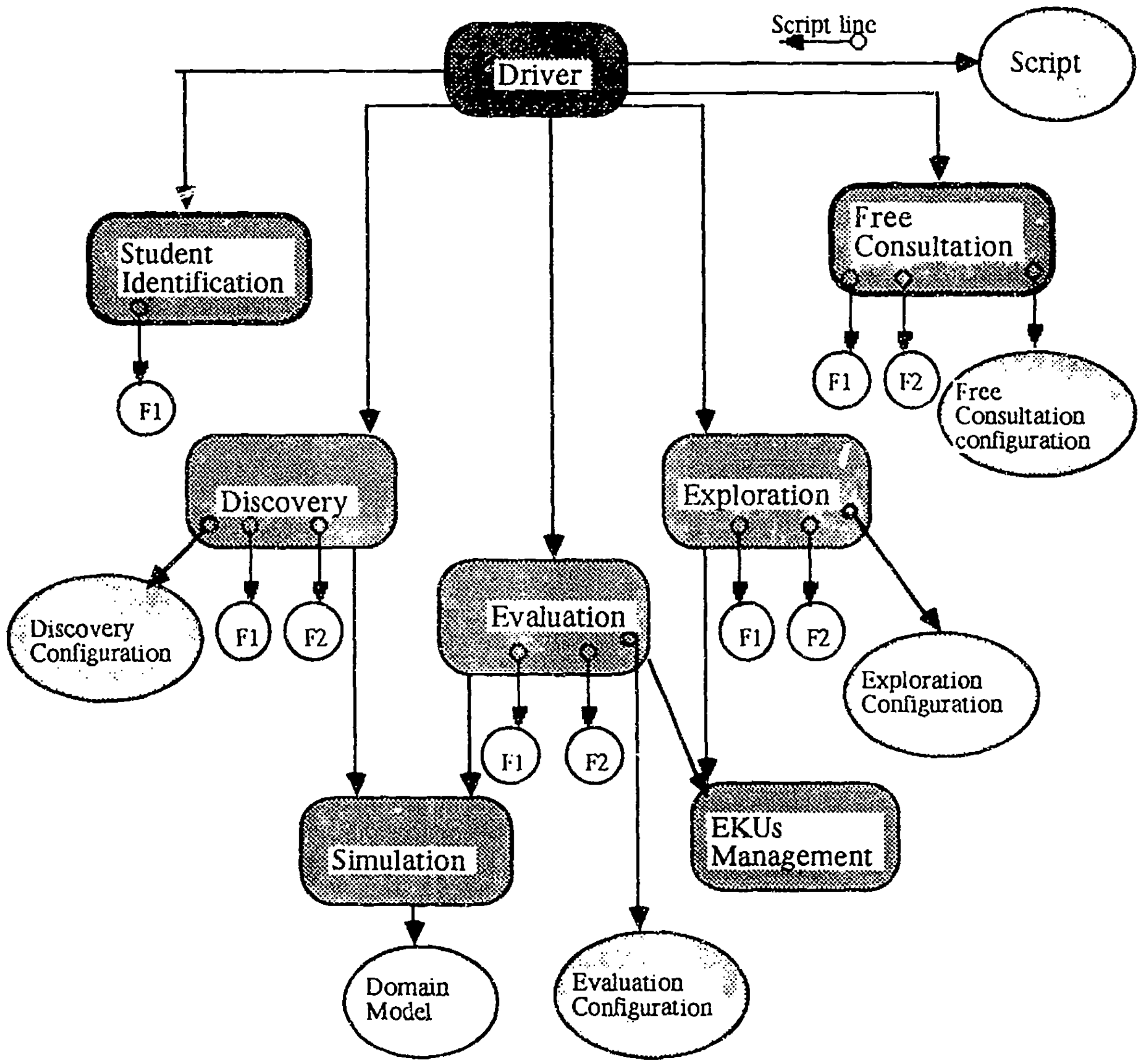

Figure 2: Functional Architecture of Methodman I

Legend:
F1: Pedagogical Expert System (Manages the Student Environment)
F2: Methodology Expert System (Manages the Structure of the Methodology Presentation)

In Search of New Ideas, Research Findings, and Emerging Technologies? Here's Where to Find Them

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(Paper presented at the 34th ADCIS International Conference, Norfolk, VA, USA, November 8-11, 1992)

Abstract

There are many avenues available to CAI practitioners and developers in search of access to new ideas, research findings and emerging technologies -- that will assist them in their work (developing CAI). Seven such avenues are discussed in detail. These seven avenues are as follows:

- *Graduate Students (Interns)*
- *Industry Publications & Trade Journals*
- *Industry/Trade Conferences*
- *Direct University Education (Graduate Level Courses)*
- *Hiring Professional Consultants*
- *Research*
- *Establishing Affiliations with Universities*

Paper

It is not unusual as a developer of computer assisted instruction (CAI) to get extremely bogged down with work assignments, projects, meetings and the like. I have spent many hours fully concentrated on something as minute as a subroutine that just won't work right...and before I knew it, not only had lunch come and gone, so had the entire day! I've also found myself thinking about how to get a particular piece of code to work...*on my time off* (good grief)! Anyone who has had a tough time seeing past "this project" has consequently felt a little "out of touch" with what's going on in our field as a whole. This article will furnish some solutions to our problem.

The purpose of this article is to provide and discuss seven avenues through which CAI developers can gain access to new ideas, research findings and emerging technologies. These proposed solutions will assist developers in their work performance (developing computer-based interactive instructional products). These seven avenues are as follows:

- Graduate Students (Interns)
- Industry Publications & Trade Journals
- Industry/Trade Conferences
- Direct University Education (Graduate Level Courses)
- Hiring Professional Consultants
- Research
- Establishing Affiliations with Universities

1. Graduate Students (Interns)

Graduate students (interns) can bring unique insights to corporate organizations. They are usually bright, hard working, and willing to learn. Additionally, graduate student's minds are richly soaked with theory and research that CAI developers in the field may be missing, as the developers may have been out of school for many years.

Acquiring interns can be either a formal or informal process. Some organizations, like Arthur Andersen & Co., have internship programs that are very formal and structured, and hire many interns (12-16) three or four times a year. Creating such an arrangement in an organization requires strong "buy-in" and support from both upper-management and human resources, since doing so is a significant undertaking which takes much commitment and effort to initiate.

Additionally, a constant line item budget allocation for the intern's salaries[1] will be required. Full-blown internship programs take time to get established, and while they can greatly provide long term organizational benefits, it is a major undertaking if a developer's primary concerns are his or her personal needs.

With some other organizations, the process for hiring interns is not as structured, as they are used more sporadically. In such places, hiring an intern is more "personal" or one-on-one in nature. For instance, graduate students seeking an internship may approach professional CAI developers or managers in the field personally (e.g., they send a letter of interest), requiring the developer or manager to provide justification for hiring the intern. Or, if a need has already been established, the CAI professional could approach an Instructional Technology department at a local university (such as the University of Georgia) to inform the chairperson that they are looking for an intern. Since only one or two interns are being dealt with, all that is needed is the approval of a few managers, and the approval to hire a "temp" for a few months. This "personal" approach is a quick way to get in touch with what's going on in the field of technology-based instruction, and only requires the developer's own commitment and some extra money.

For more on internships, see the following references:

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2. **Industry Publications & Trade Journals**

Industry publications and trade journals (e.g., Journal of Computer-Based Instruction) provide numerous research findings and reports on emerging technologies. Taking the time to read but a few articles, reports, and studies on a

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[1] Note: Not all internships are paid, but most graduate students will expect to be compensated. The salaries for interns are not as high as for full time staff (about 1/2 to 2/3), which again is what most graduate students are accustomed to.

regular basis can provide many new ideas. Even though it can take up to year from the date an article was written and submitted, to the date it appears in print, its well worth the time to read the journals and newsletters.

3. **Industry/Trade Conferences**

Industry/trade conferences (e.g., ADCIS, AECT, SALT) provide a plethora of resources from which to get new ideas, research findings, etc.. Beyond attending the concurrent sessions (which is paramount), a conference is a place to establish dialogs with peers, scholars, and other professionals in the field of CAI. By attending sessions and networking, one can get a good grasp on what's going on *now*. It cannot be stressed enough how rewarding it is to attend at least one conference a year. There is much to be learned at conferences, both formally (sessions) and informally (socializing). And not only can you learn from others, they can learn from you too!

4. **Direct University Education (Graduate Level Courses)**

Direct university education (graduate level courses) via a local university will without a doubt get one back into the research. Courses that may be relevant to CAI professionals include: computer-based training, computer uses in education, artificial intelligence, video production, computer graphics and animation, instructional design, human factors, adult education, cognitive psychology, and programming. This avenue allows developers to broaden their knowledge of the field, and make them more valuable to their employer to boot. Attending school part time allows one to work during the day while taking classes at night. Also, it is not necessary to be seeking a degree (e.g., M.A. or Ph.D.) in order to take a few courses. Another option is to take a leave of absence and return to school full time. Those who are lucky work for companies with a tuition reimbursement policy. If not, and cost is an issue, consider taking one or two classes at a time; or, if quitting work is a prerequisite to attending school (full-time), look into applying for a graduate assistantship that offers a tuition waiver and stipend.

5. **Hiring Professional Consultants**

Professional consultants also can be a rich source of new ideas, new ways of doing things, and emerging technologies. Since consultants move around from organization to organization, they tend to have a broad perspective on specific CAI techniques (such as GUI's), and on methods and technologies that other professionals and organizations are using. Consultants often tend to know first hand what works, and what does not; thereby giving the hirer the edge of avoiding the mistakes of others. Again, as with the interns, hiring a consultant requires "sign-off" from manager(s). Consultants can be costly (much more costly than interns) and are generally desired for specific needs (e.g., a project with big demands). Unless a project requires specific skills that can not be found internally, it will be hard pressed to provide justification for hiring a consultant.

6. **Research**

Research, that is actively going into the library stacks (as opposed to passively subscribing to publications), is a sure fire way to get to what's going on in the field. Doing research is not an arduous task, especially if 'on-line' or CD-ROM platform databases like ERIC are utilized. Research is most fruitful when there is a specific topic information is needed on -- like instructional models, writing objectives, or developing interactive instruction for inner-city youths.

7. **Establishing Affiliations with Universities**

Establishing affiliations with universities requires the most amount of work. Such links require initiative and commitment from "up top." These "high-tech connections" between industrial firms and academic institutions require a substantial amount of cooperative effort. The nature of the affiliation can vary; such as inviting college professors to sit on an academic review board, or providing funding to an Instructional Technology (or similar) department/institute in exchange for theories, models, design documents, instructional techniques and actual development work. Affiliations are usually long term, and go beyond simply "farming out" some development work to some graduate students. For more information on academic/industrial relationships, see the following references:

Johnson, L. (1984). The High-Technology Connection: Academic/Industrial Cooperation for Economic Growth. ASHE-ERIC Higher Education Research Report No. 6.

Milligan, F. (1988). The vital role of faculty in developing successful relationships with business and industry. (ERIC Document Reproductive Service No. 293 608).

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As can be seen, there are many options available to CAI practitioners in search of avenues through which they can gain access to new ideas, research findings and emerging technologies, that will assist them in their work. While some suggestions require more effort than others, one can not go wrong with any of them; diligence will be rewarded. Both you, and your organization, will be much the better off -- so go for it!

Interactive Multimedia Courseware:
A Perspective on Competency-Based Training for the Hospitality Industry[1]

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Abstract

This paper describes an Australian project which has developed a set of interactive, multimedia competency-based courseware modules for the hospitality industry. The establishment and focus of the project depended on three critical factors: receiving funding, adopting alternative design strategies, creating truly interactive courseware modules and integrating testing components to assess competencies attained. The discussion considers initial multimedia impressions, coping with demands on storage and assisting clients new to interactive technology. Within this context, the acquisition of appropriate development tools and hardware, recording, sequencing and co-ordinating audio as well as linking multimedia events with authoring systems became significant considerations. Other areas of significance included project management and evaluating learning outcomes. Experiences gained from this project were invaluable and many insights into acceptable courseware were obtained.

Introduction

The project was initially conceived to develop a computer-based training system for the Hospitality Industry. However, based on the rapid development of award-restructuring and the demand for multi-skilling, the project was expanded to include a prototype management system to support the introduction of competency-based standards. Funding was applied for and granted by the Education and Training Foundation (ETF) of NSW in July of 1991, and the specific objectives were to produce a range of interactive multi-media courseware modules for the Hospitality Industry as well as a Competency management system. To comply with ETF funding requirements, a number of organisations were required to be involved with the project. These included the project management, design, development and marketing groups, associate organisations such as Tourism Training Australia and the NSW Tourism Industry Training Committee and supporting hotels and clubs which undertook to provide trial sites and pilot study subjects.

The Hospitality Courseware

The courseware modules were developed using current trends in the design of interactive materials (Allen, 1992), with emphasis on successive approximations and prototypes rather than traditional and linear analysis-design-development methodologies. However, considerable effort was placed on delivery

[1] An earlier version of this paper was presented at the ITTE Conference, Brisbane Australia, September 1992.

strategy and interactive sequences. The courseware modules selected were based on accredited courses supplied by Tourism Training Australia, and designed to provide the foundation for the common *Introductory* and *Basic Food and Beverage* modules. Meetings with subject matter experts and industry representatives ensured that the specific content requirements of the Hospitality industry were met. To evaluate the project, selected trial sites were established in which the courseware modules were installed to assess effectiveness and ease of use.

A major consideration was the delivery platform and associated development tools to be used. After considerable research, it was decided to use the MS-DOS environment running Windows 3.x, as most hospitality organisations had, or would have, similar operating platforms. To integrate multi-media components within the courseware, the decision on development tools was based on experience within the development team. The initial decision to select Authorware Professional for Windows was based on its heritage (a descendant of PLATO) as well as its productivity and flexibility for prototypes and creating complex interactive applications. While a high level of productivity took some time to realise and the MS-DOS/Windows multi-media environment was, and remains, somewhat restrictive, the choice has been justified through the product developed

Courseware Strategies

The major strategy used for the courseware modules was based on *learner-integration*, proposed by Sims (1991, 1992), which suggests the presentation of interactive events in which the student is integrated into a typical work-environment. By providing a suitable and relevant context for presenting content material, learning outcomes will be more effective than those presentations which use the screen as a surrogate page. The observable aspects of learner-integrated courseware are a series of displays which provide an opportunity for students to interact with, and possibly suffer the consequences of, manipulating objects within their work environment. The learner-integrated approach is an enhancement of many simulation strategies, such as those detailed by Alessi & Trollip (1991), and represents a step towards the use of "virtual" environments in interactive training.

One of the major requirements for implementing this approach is a clear definition of the sequence of events which is to take place, and the environment for their action, and a sample of the descriptions used for one of the Occupational Health and Safety modules is shown in the Appendix. As an example, Figure 1 illustrates a display from a kitchen, in which the trainee has caused an accident through a lack of awareness of occupational hazards. This particular strategy is a significant departure from traditional courseware applications in that the student was given minimal information as to the existence of hazards and it was their responsibility to identify them or suffer the consequences - **just as it happens in the real world!** Initial feedback from the trial sites suggests that this strategy has been successful.

Similarly, Figure 2 provides an example of one of a series of actions which the student has to identify before proceeding. Again, the use of sequencing based on hypothetical real-life events provides a significant departure from the traditional technique of presenting individual units of content and illustrates that there are alternative ways in which the technology can be used, especially with the advent of high-resolution graphics and sophisticated development tools. This use of alternative presentation techniques has resulted not only from the frequent criticism of linear courseware but also from the relative newness of the technology itself - we are only now learning about its most effective application.

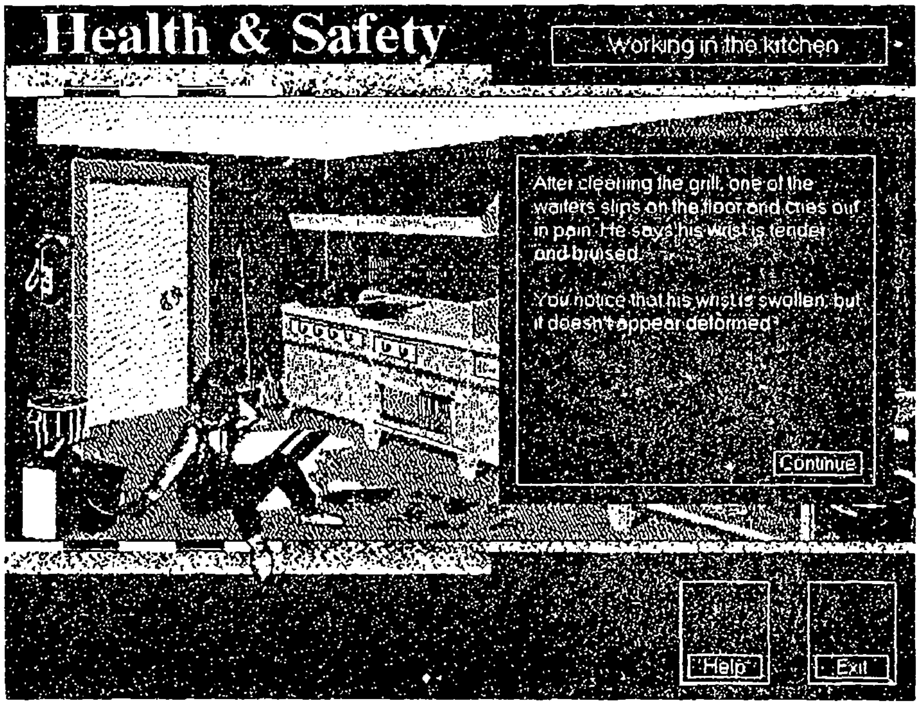

Figure 1: Learner-Integrated Display

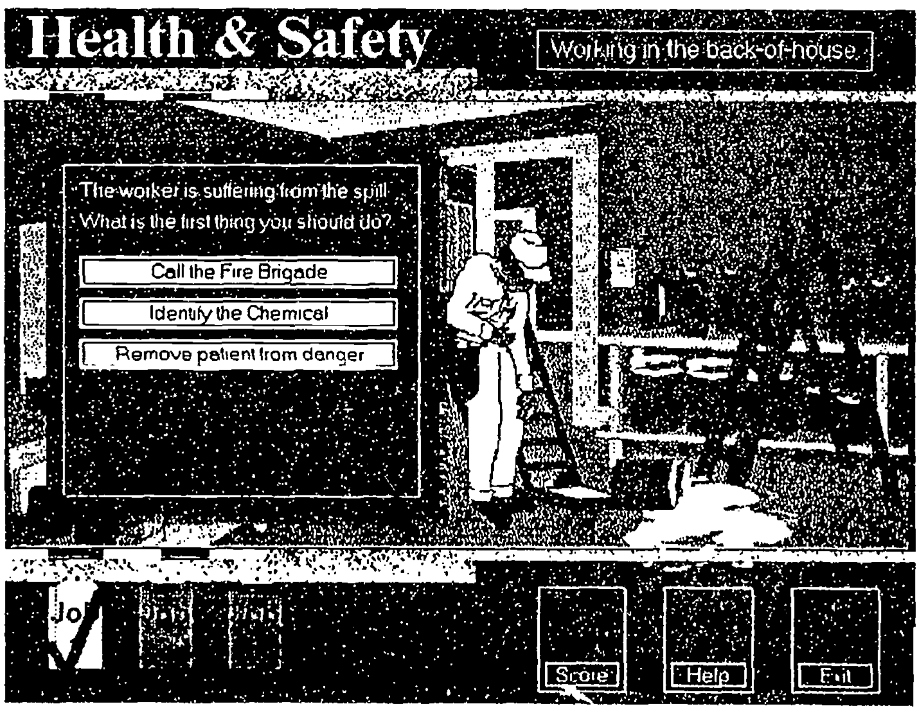

Figure 2: Integrated Event Sequence

Learner-Computer Interface

Recently, significant changes in courseware applications have been seen in design, interface and control options. The traditional format, based on hierarchical menu systems, demanded the availability of extensive controls to enable the student to move "up" and "down" the hierarchy. However, this approach made it very easy to get lost in the menu maze. It would also seem that this structure has resulted, in part, from the application and interpretation of Instructional Design Methodologies which result in the content hierarchy being used as the basis for lesson design. As this format can almost eliminate the capabilities of current technology, new approaches to the structure and design of courseware were required. The following discussion examines some of the factors which have contributed to this change and the outcomes seen in courseware itself.

Traditional courseware has used a philosophy based on the trainee being at one "frame", with two general options: to "go forward" or to "go back". However, it is contended that there is a fundamental flaw in this approach, based on both human-computer interface and life/work patterns. When we, as humans, attend training or perform our work duties (or do anything), we go from one activity to another and, because time travel is (so far as we know) impossible, we are not able to return to our earlier experiences. However, we are able to bring with us into the present objects which we acquired in the past. In stark contrast to the general way we operate, courseware development projects have built complex branches and paths which demand trainees to manipulate through a complex hierarchy in order to return in "time" to a previous frame.

To eliminate this problem, a new environment is required in which the trainee never needs to return to a previous screen, but operates in a way in which any required "objects" are transported through the lesson, and the lesson context remains as a real environment. Instead of returning to "Frame X", the trainee can return to a building, room, desk or cabinet and retrieve whatever objects are desired. Based on this argument, it is suggested that courseware should mimic our real-life patterns and behaviours rather than maintain a non-contextual framework with unrealistic expectations on the user to travel backwards and forwards in time. This concept is largely based on the model provided by the graphical adventure games, in which players may return to a scene, but always one which has been affected by time - or previous visits. From another perspective, it appears that players of such games have little difficulty learning the sequence of events to achieve the goals - is it not possible that this same strategy could be used for learning?

The courseware illustrated in Figures 1 and 2 provides examples of this concept, and additional illustration is manifested in the concept of a single-screen delivery environment, with all controls always available to the trainee (Figure 3), providing maximum control over the material being presented. In many ways, it is analogous to a TV and the ability of the viewer to select channels as and when required. This concept also places the student in complete control of the lesson sequence, although there is always the option for hidden restrictions to be built-in by the developers.

Assessment

A significant component of the courseware development was the provision of assessment modules to cover the objectives for the content, as specified by the certifying body. For the modules in the

Designer; additional graphics were created through Corel Draw and Windows Paintbrush. The final items were all converted to either .PCX or .BMP format for importing into Authorware. The graphics were constrained to 16 colours, as it was anticipated that the installed equipment base would be operating with 16-colour VGA monitors. Given the current installations, this was a correct choice and the quality of the courseware has not been reduced by these colour restrictions.

The basic outcome from the project is that developers of multi-media courseware will need considerable expertise in creative drawing and sketching as well as competence in the complexities of the various graphics and painting applications available. However, it must be emphasised that creative graphics are only one component of the courseware product. The overall quality of the courseware will depend on the instructional strategies, contextual structures and learner-computer interface concepts implemented, and which are represented by and through the graphics.

Creating Audio

The audio components for the courseware had to be configured to the Authorware Professional requirements. To achieve as professional quality as possible, a sound engineer and sophisticated recording equipment (an 8-track TASCAM 388 Studio 8) were used. Using both live (Foley) and CD sound effects, the audio segments were mastered to a single track and then imported using the VEDIT2 utility provided with the Sound Blaster Pro audio card. The audio was recorded to memory at 22MHz using the Lo filter and saved as a .VOC file and then converted to .WAV format using the VOC2WAV.EXE utility.

One of the most interesting aspects of the use of audio is the increase in file-size resulting from the use of sound in the Authorware lessons. The graph in Figure 4 illustrates the increase after the sound files were included. For users with storage capacities of 80-100MB, this can begin to cause problems as disk space is continually have to be found to store the applications. As a guide, it is suggested that new systems have a 200MB hard disk.

Evaluation

The courseware covering The Hospitality Sector has so far been installed at two trial sites and evaluation data has been collected. Overall, the feedback has been very pleasing, with almost all respondents indicating a positive response to the courseware, as indicated in Figure 5. While this positive response may in part be due to the novelty of the material, it was evident that the provision of self-paced materials, available 24-hours a day, was invaluable for organisations whose operations and working environment is such that staff often have limited opportunities to undertake training during their shifts.

A more important aspect of the evaluation is the acceptance of multi-media delivery, which is reported as providing extremely effective learning environments (Larsen, 1992). While the data from the trial sites has provided no anti-media evidence, there was little reference to the audio which was used to support user understanding of the material. While TV and radio broadcasters can easily specify audio requirements, courseware developers are still in the learning mode.

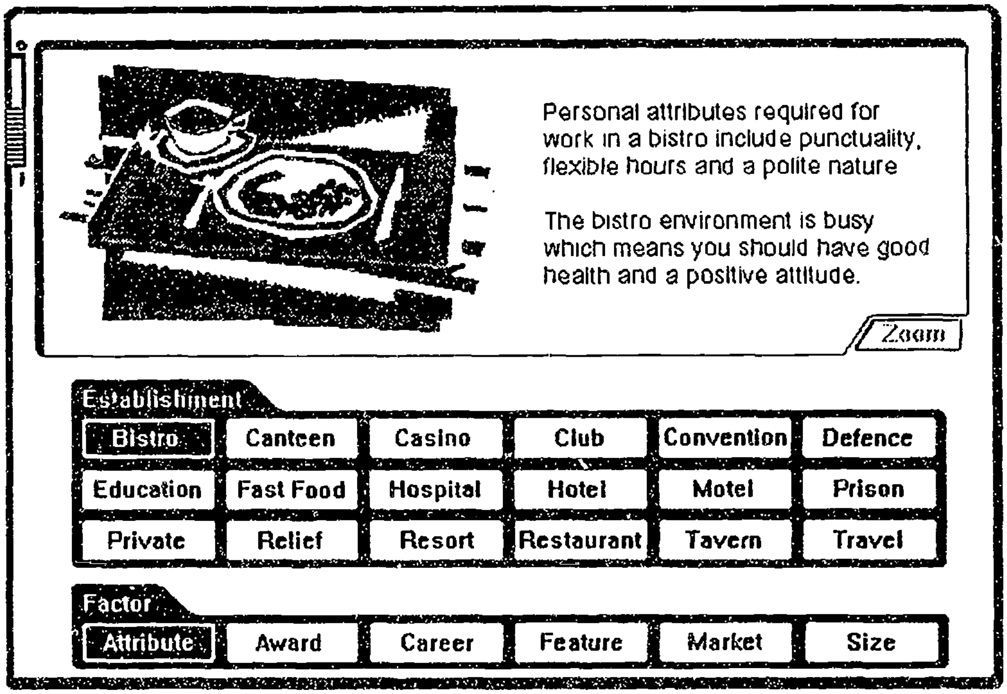

Figure 3: Maximising Learner Control

Hospitality Industry, the assessment questions were linked specifically to the units and elements of the competency so that the results could be directly accessed by a management system. A different approach was taken with the second module, where the assessment was based on students being able to correctly work through the Health and Safety situations without prompts. However, the challenge was to provide assessment items based solely on performance criteria (i.e. competencies) rather than knowledge.

However, the assessment of competencies through interactive media is a complex process, especially when the courseware is focused on performance factors rather than content structures. In terms of data collection, this has been one of the most complicated factors and integration with the management system has been difficult, although once implemented, management systems provide a very useful set of performance data. It is anticipated that the courseware and assessment modules will be accredited and employees who gain achievement status in selected competencies will be deemed to have those competencies.

Creating Graphics

Graphics have become a major consideration for courseware developers, who not only require access to sophisticated graphical software but also the services of competent graphics artists. Based on the experiences from the courseware project, graphics were defined then created using a number of tools and devices. First, sketches were hand-drawn and scanned to create .PCX and .BMP images; these were then manipulated using Animator Pro, Windows Paintbrush, Windows Paintshop and Micrographx

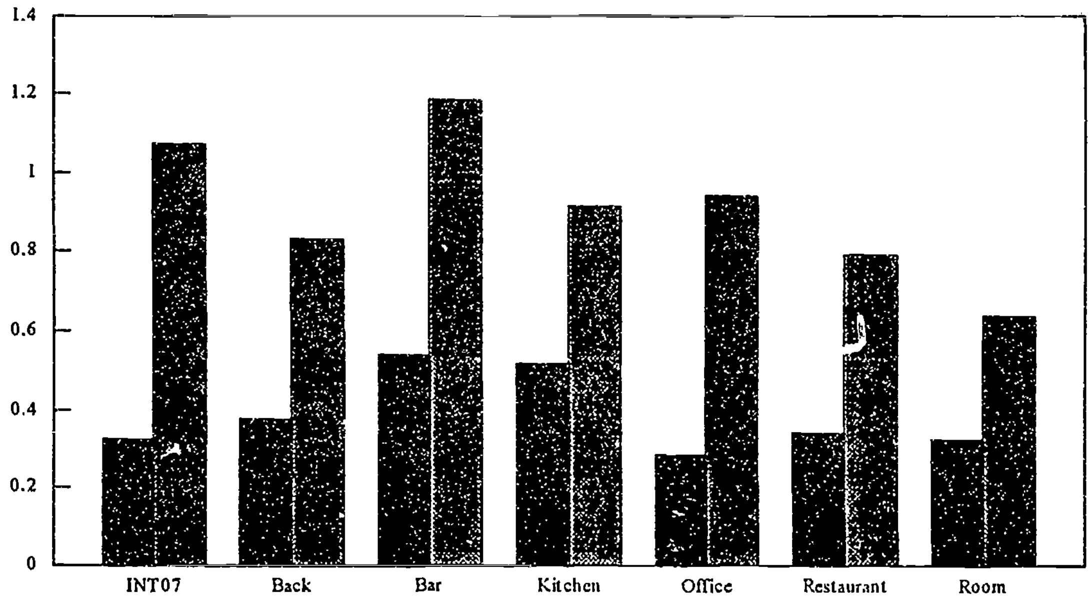

Figure 4: Effects of Audio on Courseware Size

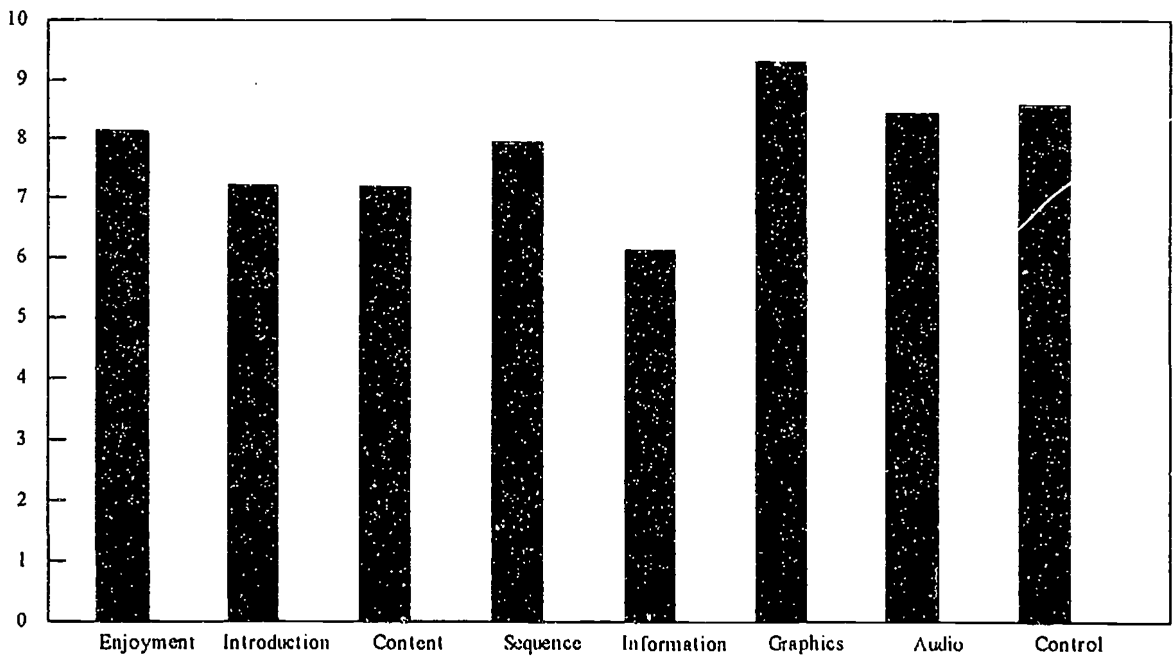

Figure 5: Initial Evaluation Results

Conclusions

The provision of interactive training facilities for the introduction of competencies into the Hospitality industry has proved a valuable learning experience in terms of the development of multi-media courseware and the integration of assessment data with a computer-based management system. There are many skills which developers of traditional courseware will have to learn if they are to create effective interactive environments.

Based on the experiences from this project, it would seem that multi-media has not only provided a new set of tools for delivery of interactive training, but also the opportunity to advance the effectiveness of courseware through the introduction of alternative strategies. These strategies make better use of the medium and focus on the environments and performance skills with which trainees are familiar.

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Appendix: Course Documentation

Overview

This Appendix provides extracts from the original documentation used to describe the concept and logic for the second Ho.-Train interactive module on Occupational Health and Safety. The specifications were designed as a storyboard for both the graphics artist and author to implement with Authorware® Professional™ for Windows. It should be noted that as the product was developed, a number of changes were made to ensure the continuity and structure of the interface were maintained.

Concept

The concept of this lesson is based on a "virtual reality" instructional game. The aim of the game is to successfully maintain a safe environment for employees and apply first aid techniques where necessary. The trainee will play the role of a new Occupational Health and Safety Officer in a Hotel. The conditions of the game are such that the trainee must visit each of the available scenarios; until they have completed their "jobs", they will not be given the opportunity to review. However, they will always have the option to exit; on returning to the lesson, their data should be maintained and the lesson set to resume at the point of exit.

In this role, the trainee will be asked to resolve certain Occupational Health and Safety (OH&S) issues while visiting or working in each of the scenarios. For each scenario, a major Accident or Event will occur; in addition, the trainee will be required to identify approximately three potentially dangerous and/or potentially safe working conditions in each scenario. If these conditions are identified, the trainee will be rewarded (Merit Certificate) and any unsafe conditions corrected. If the conditions are not identified, the trainee will be shown the results of not correcting an unsafe environment. For example, if the handles of pots are left sticking out from the stove, the trainee will burn themselves and incur a 5-day "sick" penalty.

When a major accident occurs, the trainee will have to choose the correct sequence of actions, including the most appropriate time to assist injured persons, remove dangerous conditions or call for assistance.

Scenario Structure

For each scenario selected, the trainee will be assigned a number of typical hotel jobs to complete. They will have the choice of one or more of (a) completing the task, (b) identifying dangerous conditions or (c) identifying safe conditions.

If (a), the trainee will receive a call in between tasks to attend another incident. If (b), the trainee will be asked to follow the DR ABC procedure as required as well as contacting the appropriate medical or managerial staff. The selection of the correct procedure will be via multiple choice icon-buttons (e.g. raise arm, bandage wound); each button should be logically valid. At the end of each major accident, the DR ABC procedure will be reviewed. If necessary, the trainee can ask for assistance from a supervisor; if this occurs, points will be deducted.

The trainee will be awarded points for each scenario, depending on the successful identification of good/bad conditions and the application of first-aid support to injured persons. This will be kept as a running total on the "drop-down" menu bar. Trainees will be introduced to the option to "click" on potentially dangerous situations without being prompted - at start of scenario tasks, trainee can select a new task or click to correct. Graphically, the "problems" should be relatively obvious.

Overview of Kitchen Scenario

In the kitchen, the trainee will have to address the following situations: (a) Chef cut by slicer OR Attendant cut by broken glass, (b) Kitchen Hand burnt by boiling oil OR Frying pan on fire, (c) Knives not put away, (d) Badly stored items and (e) Wet floors.

Kitchen Objects
Pans with handles sticking out; Pans knocked over; Pans with handles in; Knives lying around; Poorly stacked plates; Pools of water on ground; Mop in corner; Glasses around sink; Electric Slicer; Deep Fryer; Broken plates on floor; Towels and cloths

Kitchen People
Chef; Kitchen Hand; Maintenance Man on ladder; Chef with sliced hand; Kitchen Hand with arm badly cut by glass; Kitchen Hand with oil burn; Close-up of 1st/2nd/3rd degree burns; Maintenance Man slipped off ladder; Kitchen Hand slipped on floor

Kitchen Tasks
Washing dishes; Washing pots; Lifting vegetables; Cleaning grill; Stacking Plates and Glasses

Scenario Logic
One point scored for each item selected; on selection, the problem is rectified and the danger visibly removed; items not selected are not to be explained but recorded for later use. T then selects task. If (a), T reminded that they should always check for any potentially dangerous situations.

Washing Dishes
T shown at sink. If 1(b)(iii) recognised then message to indicate they have done well and possibly avoided an accident. If 1(b)(iii) not recognised, then T has hand cut by broken glass, not badly but needs attention (this results in a loss of 2 work-days). T asked to apply First Aid and Safety procedures: (a) remove any danger (broken glass), (b) don't remove embedded objects, (c) stop bleeding by applying pressure (use towels) and elevating limb and (d) contact supervisor, first aid officer or ambulance, depending on severity.
Use a place-in-correct-order sequence by point and click.

Washing Pots
T shown at sink when Chef cuts hand severely with slicer. T must follow the necessary steps to provide aid: (a) Assess scene (stop slicer), (b) Summon supervisor/first aider/ambulance, (c) Stop bleeding (pressure with towels; elevate limb), (d) Sit or lay patient down, (e) Talk and reassure patient and (f) Monitor consciousness - if drowsy, lay on side.

Lifting Vegetables
Before commence task, frying pan catches on fire. T must select correct fire extinguisher. Kitchen Hand has burnt arm. Actions required: (a) Remove patient from danger, (b) Summon supervisor/ambulance, (c) Cool burn with cold water, (d) Reassure patient.
If no assistance requested for lifting (5 days incapacitated), damaged back.

Cleaning Grill
OK if pan handles turned, otherwise T burnt. While cleaning grill maintenance man carrying ladder slips and falls. T notices wrist swelling. Follow with procedure: (a) Summon assistance, (b) Rest patient, (c) Apply ice compress, (d) Support bandage, (e) Elevate and (f) Consider any other injuries.

Stacking Plates and Glasses
OK if water removed from floor, otherwise slip and fall.

Summary
Show point score for each of the tasks and hazard identification.

AN INTELLIGENT FRAMEWORK FOR THE CREATION OF EFFECTIVE COMPUTER-BASED INSTRUCTION

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The Advanced Instructional Design Advisor (AIDA) is an exploratory research and development project at the Armstrong Laboratory which provides on-line instructional design expertise to developers of computer-based training (CBT) materials (Spector, 1990). The theoretical framework for AIDA consists of second generation instructional design theory (Merrill, Li, & Jones, 1990), the nine events of instruction (Gagné, 1985), and enterprise theory (Gagné & Merrill, 1990). The basic idea behind AIDA is to provide subject matter experts with an intelligent framework for instructional design and a powerful set of development tools. This paper provides an analysis of two different kinds of instructional design expertise which have been prototyped for AIDA. One type is rule-based and the other is case-based. Our findings indicate that the case-based methodology shows more immediate promise, which supports the conclusion that instructional design is more art than science.

Several researchers have attempted to develop automated instructional design systems which guide subject matter experts through the lengthy and complex courseware authoring process (Duchastel, 1990). Enabling subject matter experts to perform most of the authoring activities associated with courseware development has two distinct advantages: (1) development costs are held to a minimum, and (2) instructors are empowered to make optimal use of new technologies. The primary challenge is capturing and making available (on-line) meaningful and adaptive instructional design expertise.

The Armstrong Laboratory's Technical Training Research Division has an exploratory research and development project called the Advanced Instructional Design Advisor (AIDA) which provides subject matter experts with an intelligent framework and a powerful set of object-oriented development tools (Spector, 1990). The theoretical framework consists primarily of second generation instructional design theory (Merrill, Li, & Jones, 1990), the nine events of instruction (Gagné, 1985), and enterprise theory (Gagné & Merrill, 1990). Enterprise theory stresses the importance of an integrated, purposeful human activity as the focus of instruction -- particularly important in the task analysis phase of instructional planning. The nine events of instruction provide an easily accessible, high-level framework for providing instructional design guidance. Second generation instructional design theory provides the concept of a transaction shell or intelligent framework for lesson development.

The objective-level instructional design expertise has been prototyped in the Experimental Advanced Instructional Design Advisor (XAIDA). XAIDA makes use of object-oriented transaction shells (Merrill et al., 1990), which are adaptable and intelligent lesson development templates. The larger perspective (lesson, module, or course) instructional design expertise has been prototyped in the Guided Approach to Instructional Design Advising (GAIDA), which is an instantiation of the nine events of instruction with four completely work case examples. Each approach (XAIDA and GAIDA) captures a different kind of instructional design expertise.

Field tests indicate that both kinds of expertise are required in order to design effective CBT (Canfield & Spector, 1991; Gagné, 1992; Spector, 1990). Moreover, there is growing evidence that a great deal of instructional design expertise is not easily captured in the form of procedures, rules, or algorithms (Perez & Neiderman, in press; Rowland, 1992; Tessmer, 1992). One implication of this finding is that more reliance should be placed on a case-based approach to instructional advising when attempting to provided automated instructional design expertise.

Intelligent Design Frameworks

Thinking About Design Guidance

In order to provide a context for offering instructional design expertise to novice developers of CBT, let's first consider an analogous situation with regard to architects. It is a well-known but undocumented fact that all architects and most experienced home builders are fond of gold nibblets. Suppose that gold nibblets have been discovered in Nebraska. This announcement has caused a great many architects and builders to move to Nebraska thereby creating a sudden shortage of architectural and home construction expertise in many other parts of the country. A forward thinking firm in Dime Box, Texas, has decided to respond to this crisis by building an architectural advising program. This program will be made available to recent graduates of a nearby university who are being hired by local home builders. These graduates are all rednecks by birth and have an innate understanding of hammers, nails, and floor joists. However, these novice builders/architects obviously lack the kind of expertise in design and construction that comes from years of experience.

In the design phase of this effort, this firm has hired an artificial intelligence expert and an experienced architect. They have provided the following advice regarding the home design advisor program:

1. There are four kinds of advice or assistance that can be provided in an automated home design advisor:

a. High level reminders. These are things that should have been learned in school. An example might be this: If the house is to be located near the base of a hill, then an underground French ditch should be constructed to divert run-off. It will be important to make this kind of advice easily accessible and context-sensitive so as to avoid information overload. On-line help systems provide a reasonable model in this regard.

b. Example plans. These should be based on previous cases that are known to provide attractive (both aesthetically and economically) solutions. This case-based advice should also be context-sensitive and easily accessible. In addition, these examples should be modularized so that portions could be extracted and inserted into a current plan under development.

c. Configurable shells. These provide a ready-made framework for the kind of home design being developed. These shells would come complete with default settings which would determine such things as the placement of doors, windows, and electrical outlets. Of course, the defaults would automatically satisfy existing building codes since they would be generated by a rule-base. These shells would provide the designer with a rapid prototyping capability so that clients could be shown the consequences of early design choices such as one-story vs. two-story, adobe vs. wood frame, etc.

d. Consistency checks. Since the shells can be altered by the novice designers, there would need to be some consistency checking of proposed designs to insure that building codes had not been violated, that original design constraints (e.g., cost, square footage, etc.) had been satisfied, and that basic design principles had been followed.

2. In order to provide this kind of advice and assistance, the program would require the following:

a. A set of rules representing existing building codes.

b. A set of rules representing basic design principles.

c. A set of examples representing a variety of building designs.

d. A representational scheme which allows the previous three items to be related.

e. A mechanism which could interpret a given design goal, select an appropriate shell, and allow changes that did not violate any rules.

3. It would be desirable to embed this design advice in a program which automates the more tedious aspects of design (e.g., a computer-aided design (CAD) program).

4. Providing this type of design advice is possible, but it is also complex and requires a significant initial investment. The minimum that should be attempted is a set of worked examples along with the high level reminders. The configurable shells can be developed one at a time starting with the most frequently used shell (e.g., one-story, single-family, three bedroom, two bath, brick, etc.).

As with most fantasies, this one has a happy ending. This firm has gone on to great success. They sold their home design advisor program to Homes 'R Us and purchased the entire town of Dime Box with the proceeds. (P.S. Dime Box has since incorporated and been renamed Golden Nibblet.)

Instructional Design Guidance

The previous scenario was introduced because home designs result in familiar physical structures, which makes it easier to imagine what design expertise is essential and how it might be represented and made available to novices. Instructional designs result in plans of instruction which are used to create or modify mental structures and associated behaviors in learners. Mental structures are not so readily accessible for evaluation, which makes assessment of instructional designs more difficult. Nevertheless, we argue that the situation is similar to the home design situation sketched above and that it is useful to think of automated instructional design advice in an analogous fashion.

We shall assume that our novice instructional designer either has subject matter expertise or has access to a subject matter expert (SME). Furthermore, we shall assume that our novice designer has had at least a short course (perhaps the equivalent of one college semester's work) in instructional design. We are now positioned to consider whether and what instructional design expertise can be automated and offered to such users.

It is certainly possible to offer high level reminders. In the case of instructional design, these amount to something like Gagné's nine events of instruction (1985). These events can be provided in a context sensitive manner. If the user is involved in a particular event (e.g., gain attention -- event #1) and asks the system for help, then the system would provide elaboration of techniques for gaining attention. If the user has just completed an event and is wondering what to do next, then the system could provide an overview of the next event. If some scheme other than Gagné's nine events of instruction were used as an organizing schema for the instructional design advisor, then that scheme would have useful high level reminders which could be elaborated at the user's request.

To illustrate these high level reminders, it is desirable to have fairly complete examples in a variety of domains so that an example sufficiently close to the case at hand can be offered to the user. These examples or cases can be cross-indexed by instructional objective, instructional event, and subject domain. In short, context-sensitive example plans can also be incorporated in-+to an instructional design advisor. In fact, GAIDA is an existence proof of the possibility of accomplishing these first two kinds of intelligent instructional design advice.

It would certainly be useful to provide novice designers with the equivalent of configurable shells -- intelligent design frameworks for lesson development. Merrill et al. are attempting to do just this with the notion of a transaction shell in their second generation instructional design theory (1991). An evaluation of an early prototype of an instructional development shell for teaching nomenclature (name, location, and function of parts of a device) clearly indicates that in some cases it is possible to provide meaningful shells (Spector & Muraida, 1991).

The difficulty or challenge with regard to configurable shells is in generating sufficient rules and details to support a much wider variety of learning objectives and subject matter. This is the challenge addressed by XAIDA. It is still too early to say to what extent we will achieve success in this area, but four shells designed by Merrill and colleagues at Utah State University and engineered by Mei Technology, Inc., are currently being field tested. These shells are: Identify, Classify, Interpret, and Decide. The first two concern mainly declarative knowledge involving objects or entities; the second two involve processes and procedures. The subject domain chosen for experimental purposes is electronics maintenance.

The analog of a consistency checker is conceivable for an instructional design advisor (Duchastel, 1990). Such a system would act as a critic and inform the novice designer when a basic rule or principle had been violated.

Conclusions

In general it appears that some instructional design expertise can be captured in automated systems. In addition, both case-based and rule-based systems have a role to play in this enterprise. In short, the techniques of artificial intelligence do have a legitimate application in the domain of instructional systems design and development.

Both GAIDA and XAIDA provide the potential to conduct a great deal of empirical research in the area of instructional design. GAIDA can be used as a mechanism for decompiling instructional design expertise. XAIDA can be used to systematically alter specific instructional parameters in a shell (e.g., sequencing of events, placement of objects on the screen, time allotted for learning activities, etc.) in order to determine optimal default settings for a range of instructional situations (different learning objectives, learner profiles, delivery media, etc.).

Finally, these and other automated instructional design systems and tools will provide the means for determining whether and to what extent instructional design is a science or art. Our belief is that there are scientific aspects of instructional design (e.g., designing materials so as to minimize the load on working memory appears to be empirically well-established), but there are also artistic aspects of instructional design (e.g., designing a specific event that is relevant to the instructional task at hand which gains and is likely to maintain attention appears to be a task for a creative artisan.

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CBT the soft way.

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Abstract.
This paper examines the state of the art of computer-based training (CBT) design and reviews some of the common practises currently advocated by various CBT designers. Currently there is no standard methodology available for CBT design. This situation is akin to the software crisis problems facing computer developers a decade ago. Software engineering encompasses a set of three key elements - methods, tools and procedures that enable the developers to control the process of software development, and provides the practitioner with a foundation for building high quality software in a productive manner. The software engineering paradigms, the classic software development cycle, prototyping, and fourth generation techniques are briefly reviewed. The software development life-cycle with its different phases is compared with courseware development from the analysis phase to design. Several available software methodologies and tools are examined and examples show how Jackson Structured Development and Object-oriented design can be used in the development of courseware. The paper concludes with a plea from the author for further research in this area.

Courseware Instruction Methodologies.
Currently there are no standard courseware development techniques or methodologies for CAL development. Various techniques and methods are advocated by various CAL designers. Despite the lack of a standard methodology for courseware development, most proponents of CAL adopt a form of systematic approach to its design, based on the notion of instructional design. Although the techniques and methodologies used vary, the basic concepts are similar. An overview of some of the well known CAL design methodologies is given below.

The Three Phase plan.
A plan is central to the production of a CAL lesson, according to this methodology [Steinberg 84]. The three phases of the plan are (1) Initial planning, (2) the ripple plan, and (3) completing the lesson. The first and third phases relate to the lesson as a whole, the middle phase to individual units of instruction. The three phases can be thought of as planning, producing, and putting it together.

The Three Phase Plan for generating CAL instruction lessons.
I. Initial planning: Lesson level.
Characterise the target population;
Formulate overall goals;

Analyze the task;
Designate the pre-requisite skills.

II. Ripple plan: Unit level.
Generate the presentation: Program and evaluate;
Expand response judging and feedback: Program and evaluate;
Make human factor and management decisions: Program and evaluate.

III. Completing the lesson: Lesson level.
Complete human factor and management decisions;
Generate introductory displays;
Generate concluding displays;
Complete initial set of evaluation measures;
Evaluate and revise;
Document;
Plan maintenance.

A design model for courseware.
Keller [Keller A. 87] proposes the design process for CAL to consist of the following eight steps:

[1] See the problem in system terms.
[2] Specify a solution.
[3] Code and make preliminary tests.
[4] Fine-tune for easier use.
[5] Do a formative evaluation.
[6] Revise as needed.
[7] Implementation.
[8] Perform a summative evaluation.

An eight-step model for developing computer-based instruction.
The eight step model developed by Alessi and Trollip [Alessi & Trollip 85] is oriented directly toward computer delivery of instruction. The model includes not only designing a lesson on paper, but getting it into a computer and evaluating it. An important feature of the model, claimed by its proponents, is that it contains steps specially intended to foster creativity and to increase the likelihood that the developer will produce lessons that use the computer in new and more innovative ways.

Many of the procedures of the model are quite similar to some components of the ISD approach. The intention is to take those parts of the ISD approach that are specifically related to individual lesson design, simplify them for the beginning instructional developer, add to them those procedures necessary for delivery by computer, and incorporate into them procedures that will enhance the creative use of the computer.

The model begins with the design of the lesson, starting with rough ideas, engaging next in the creative generation of ideas, followed by organising and analyzing ideas. It then deals with the production of the lesson, starting with text, graphics, and other presentation on paper, and then progressing to the computer component, the detailed design, production, and evaluation of the computer program.

The following are the eight steps:

1. Define your purpose;
2. Collect resource materials;
3. Generate ideas for the lesson;
4. Organise your ideas for the lesson;
5. Produce lesson displays on paper;
6. Flowchart the lesson;
7. Program the lesson;
8. Evaluate the quality and effectiveness of the lesson.

The Roblyer and Hall method.
The method combines the Alessi and Trollip method with the Gagne design model. It has three phases, with a number of steps in each phase and several activities to accomplish at each step [Roblyer 88]. The proponent of the method stresses the importance of team work for effective design. An optimally effective courseware design team consists of at least one person of each of the following types: Instructional design expert, knowledgeable in courseware design and learning theory; content expert who has taught in the area, and a programmer experienced in CAL development. The documentation produced at each of the steps in the first two phases is an important part of quality assurance during design and development. This written information is the blueprint for the product, and allows everyone on the design team to have a clear idea of what is being planned before it is coded.

<u>Phase I: Design</u>.
- Step 1. State instructional goal.
- Step 2. Perform instructional analysis.
- Step 3. Develop performance objectives.
- Step 4. Develop testing strategies.
- Step 5. Design instructional strategies.

<u>Phase II: Program development</u>.
- Step 1. Develop flowchart and storyboards.
- Step 2. Develop support materials.
- Step 3. Review and revision before programming.

<u>Phase III: Program development and evaluation</u>.
- Step 1. Program first draft materials.
- Step 2. Perform formative evaluation.

The system approach to training (SAT). [R.A.F.]
The system approach to training (SAT), sometimes called the

systematic approach to training, is a methodical approach to the design and development of training courses used by the Royal Air Force in the late 1960's - early '70's. [RAF] It developed from the programmed techniques of the mid-1960's. SAT is usually considered to consist of seven parts:

[1] Job or task analysis;
[2] Statement of training problem;
[3] Definition of objectives;
[4] Design of tests;
[5] Developments of strategies and methods;
[6] Internal validation;
[7] External validation.

The preceding sections outline some of the state-of-the-art methodologies currently used by CAL designers in their development of courseware. This is by no means a exhaustive list. There seem to be many different methods used, depending on the experience and background of the CAL designers.

Despite the different methodologies advocated by the different designers, all of the methodologies mentioned share many commonalities. The courseware engineering cycle can be basically grouped into the following phases:

[1] Requirement analysis;
[2] Courseware specification;
[3] Design;
[4] Implementation;
[5] Evaluation and revision.

Courseware materials for CAL are designed to facilitate learning. However, much of the courseware currently available is of poor quality and fails to meet standard requirements. Despite there being many authoring tools which proponents claim would reduce development costs and time, little impact is being made. The tools which are available are merely tools for the implementation phase of the cycle, and they lack guidance for designers during the critical phases of analysis and design. The situation is akin to the software crisis many years ago. Since then a new discipline known as Software Engineering has emerged which appears to have resolved some of the problems facing software developers. The author of this paper believes that software engineering methodologies currently available can be used to resolve some of the problems associated with courseware production. Before outlining how this may be so, a brief review of software engineering is given.

What is Software Engineering?
According to Fritz Bauer [Bauer 69], software engineering is, "the establishment and use of sound engineering principles in order to obtain economically software that is reliable and works efficiently

on real machines".

Software engineering encompasses a set of three key elements - methods, tools, and procedures - that enable the manager to control the process of software development and provide the practitioner with a foundation for building high-quality software in a productive manner.

Software engineering is composed of steps that encompass the methods, tools, and procedures. These steps are often referred to as software engineering paradigms. A paradigm for software engineering is chosen based on the nature of the project and application, the methods and tools to be used, and the controls and deliverables that are required. The three paradigms are:

[1] **The classic software development cycle;**
[2] **Prototyping;**
[3] **Fourth generation techniques.**

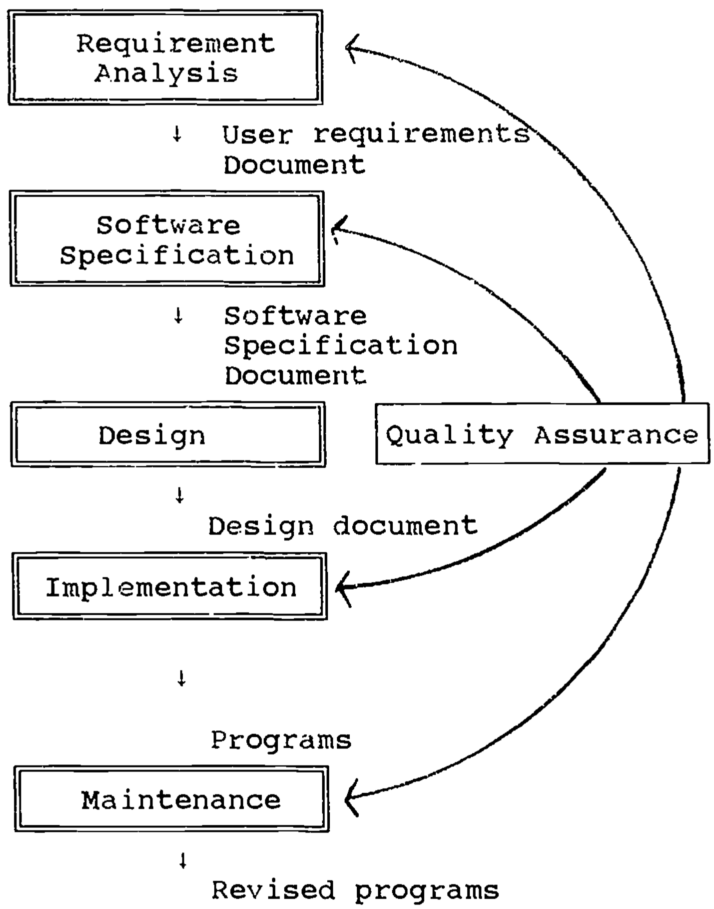
[1] The classic software development cycle.
The figure overleaf shows the software development cycle, often referred to as the "waterfall model". (see Fig. 1.)

(i) Requirement analysis. This stage is concerned with extracting from a customer the exact requirements that are needed for a piece of software.
(ii) Software specification is concerned with dealing with the function (purpose) of the software.
(iii) Design is concerned with creating descriptions of a software system in terms of how it is to carry out the functions.
(iv) Implementation is the process of writing the programs that form the software system.
(v) Testing and Maintenance. Testing focuses on the logical internals of the software, assuring that all statements have been tested. Maintenance is probably the most important stage of the lifecycle. This occurs after a piece of software has been released and become operational. It consists of modifying the software system in response to error reports, or changes in requirements or specifications.

Quality Assurance, shown to the right of the diagram, affects all stages of the lifecycle. It is the process whereby each step in the development process is checked, and has the aim of ensuring that the delivered product satisfies the requirements identified at the start of the project, and that the output of each stage meets the specification of input to the next stage.

The importance of the software development life-cycle.
The concept of software development life-cycle is important for two reasons. First it recognises and partitions the act of developing software into different phases, each phase having distinct and

unique activities associated with it. Second, a model of the software life-cycle enables a software developer to carry out planning activities more easily. A closer look at the software lifecycle reveals that it bears a close resemblance to the courseware cycle. This should not be seen as surprising, for the process of courseware production is, after all, the development of computer programs for teaching. In subsequent sections of this paper, an attempt will be made to examine how some of the techniques, methodologies and tools currently available for software engineering could be used in the analysis and design phases of courseware.



Quality Assurance is a feature of every phase of the life-cycle.

Maintenance can affect every phase of the life-cycle, and may result in changes to some or all of the documents.

Fig 1. The Classic Software Development Lifecycle.

The classic lifecycle is the oldest, and most widely used paradigm for software engineering, however, over the last few years, criticisms of the paradigm have caused even active supporters to question its applicability in all situations. Often a customer will define a set of general objectives for software, but will not identify detailed input, processing, or output requirements. In other cases the developer may be unsure of the efficiency of an algorithm, the adaptability of an operating system, or the form that human-machine interaction should take. In these, and many other situations, a prototyping approach to software engineering may be best.

[2] Prototyping.

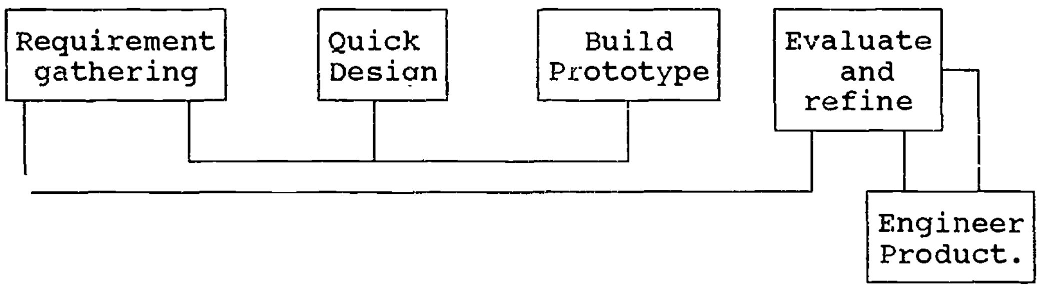


Figure [2]. Prototyping.

This is a process that enables the developer to create a model of the software to be built. the model can take one of three forms: a paper prototype that depicts human-computer interaction in a form that enables the user to understand how such interaction will occur, a working prototype that implements some subset of the functions required of the desired software, or an existing program which performs part or all of the function desired, but has other features to be improved upon in the new development effort. The sequence of events for the prototyping paradigm is illustrated in figure [2] below.

[3] Fourth generation techniques.

The term encompasses a broad array of software tools that enable software developers to specify some characteristics of software at a higher level. The tool then automatically generates source code based on the developer's specification. Currently, a software development environment supporting the 4GT paradigm includes some or all of the following tools:

- non-procedural languages for database query, report generation, data manipulation, screen interaction and definition, and code generation;
- high level graphics capability; and
- spreadsheet capability.

The 4GT paradigm for software engineering is depicted in Fig [3] overleaf.

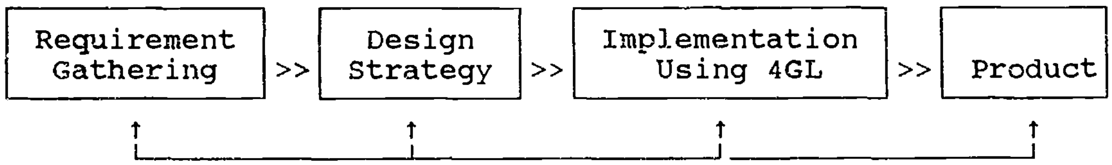


Fig [3]. Fourth generation technique.

Implications of Software Engineering on CAL.
The courseware engineering process, like software engineering, is iterative. There is a great amount of feedback from each phase to the previous one.

Engineering techniques for producing computer software have been gaining widespread acceptance recently. This section examines the first three phases of the software cycle in greater detail, and notes how the techniques, methodologies, and tools used in the three phases can also be utilised for developing courseware.

[1] Requirement Analysis.
The starting point of any software project is a document prepared by the customer for a system, known as the statement of requirements. In it, the author sets out in detail what a proposed software system is required to do, and specifies constraints upon the system and constraints upon the development process. Given a statement of requirements, the developer has to carry out the process of requirement analysis. Requirement analysis consists of analyzing the statement of requirements and extracting and clarifying the important parts; i.e. the functions and the constraints. The purpose is to produce a document called a system specification or software specification.

Courseware Requirement Analysis.
Courseware development originates with a customer training request. From this customer training request the designer performs the following activities:

- identifies the training goals of the courseware and the target population;
- defines how the training goals are to be met;
- plans the activities needed to develop the course.

The aims of analysis are:

- to establish the nature and content of the work for which the training is intended;
- to determine what skills, knowledge and attitudes are required to perform the job;
- to determine what skills, knowledge and attitudes the student

already possesses;
- to document the training needs of the work for which the training is intended.

As systems analysis is an activity which encompasses most of the tasks in producing the user requirements document. Similar activity known as instructional analysis is involved in identifying the appropriate skills and knowledge that should be involved in instructional materials to achieve their goal. It involves several steps, such as:
- learning task analysis.
- information processing task analysis.
- task classification

Learning Task Analysis, or Hierarchical Task Analysis.
Learning task analysis has been used for some time for designing instructional models. this approach helps in breaking down complex skills into more elementary skills obtaining a hierarchy of the learners skills and/or behaviours. It is possible to obtain a hierarchical tree which describes the subdivision of skills and the terminal level corresponds to the entry level skills of the learner.

An Information-processing Task Analysis.
This approach includes the following steps: [Merrill '87]
[1] Identify the operation and decision steps of the procedure.
[2] Sequence the steps in the order in which they would be performed.
[3] Prepare a flowchart representation of the sequenced steps.
[4] Validate the flowchart using different initial inputs.

Unfortunately, information processing using a flowchart to depict the sequence of operations and decision steps is fraught with inherent weakness. Recent research and evaluation of computer programs [Yourdon & Constantine 79] has shown that complex programs using this methodology suffer significant deficiencies. These deficiencies manifest themselves in (a) programs that will not work properly, (b) difficulty in finding and correcting errors in programs, (c) difficulty in modifying or expanding programs, and (d) difficult in reading or understanding programs.

Computer scientists have proposed and validated some new approaches to the analysis and design of computer programs in recent years. By using one new approach called Jackson Structured methodology, each of the problems listed above can be significantly reduced, and such an approach will be presented later.

Task Classification.
Another step involved in instructional analysis is to classify the goal statement according to the kind of learning that will occur.

(Known as domains of learning) A number of ways of classifying the capabilities involved in human tasks have been proposed. Among them are the categories described by Bloom and his co-workers [Bloom 65] comprising, Cognitive, Effective, and Psychomotor; the Component Display Theory of Merrill [Merrill 83]; and the learning categories of Gagne [Gagne 88].

The system of task classification proposed by Gagne comprises the five categories of verbal information, intellectual skills, cognitive strategy, attitude, and motor skills. In this system, the cognitive domain consists of the three major categories of verbal information (declarative knowledge), intellectual knowledge (procedural knowledge), and cognitive strategy. The basic postulate of this system is that the mental processing required for learning and retention of verbal information is demonstrably different from the mental processing required for the learning and retention of intellectual skills, and that comparable differences exist among the five categories of learned capabilities. There are several crucial reasons for classifying these capabilities. The three reasons given by Gagne [Gagne 72] are:

(1) They can be used to provide information about instructional treatments. Research studies have indicated that different instructional treatments are effective in promoting different types of learning.

(2) To identify the parts of various subject areas that are subject to the same instructional treatments.

(3) Each category requires different techniques for assessment. Requirement analysis is the most important stage of the system cycle for both software and courseware development. The role of requirement analysis is to assist the designer in deriving "a precise and independent description of the software elements of a computer-based system."

[2] Software Specification.
The development of the software requirements phase focuses on the outcomes of the requirement specification carried out in phase 1 of the software cycle. It is concerned with the nature and style of the software to be developed, the data and the information that will be required and the associated structural framework, the required functionality, performance, and various interfaces. Requirements for both the system and the software are reviewed for consistency and then reviewed by the user to be certain that the software requirements faithfully interpret and produce the system requirements. A systems requirements document is produced in this phase, which becomes the technology and management guideline which is used throughout all subsequent development phases, including validation and testing.

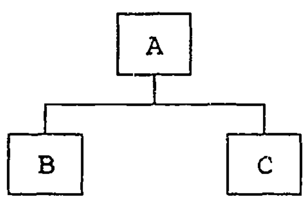
Over the past decade, a number of software analysis methods and techniques have been developed to assist designers in analyzing software requirements specification. The methods and tools can be divided into four broad categories:

- data flow-oriented analysis
- data structured-oriented analysis
- object-oriented analysis
- language based formal specification.

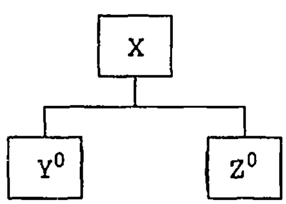
The following is a list of the most common requirements-analysis methods and tools.

- Data structured system development - manual and automated.
- Information engineering workbench - automated.
- Jackson System Development - manual and automated.
- Software requirement engineering methodology (SREM) - Formal specification language and automated.
- Structured analysis and design technique - manual and automated.

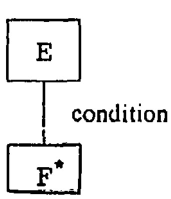
One of the methodologies, Jackson Structured Development [Jackson 83], can be used to address the shortcomings of using flowcharts in task analysis mention earlier. When used in the context of JSD, the structure of an entity describes the entity's history by considering the impact of actions over time. Jackson introduced a diagrammatic notation known as Jackson Structured Diagram to illustrate actions applied to an entity as a sequence, as part of an 'either/or' selection, or repetitively (an iteration).



(1) Sequence.
Component A is a sequence of two components, B followed by C.



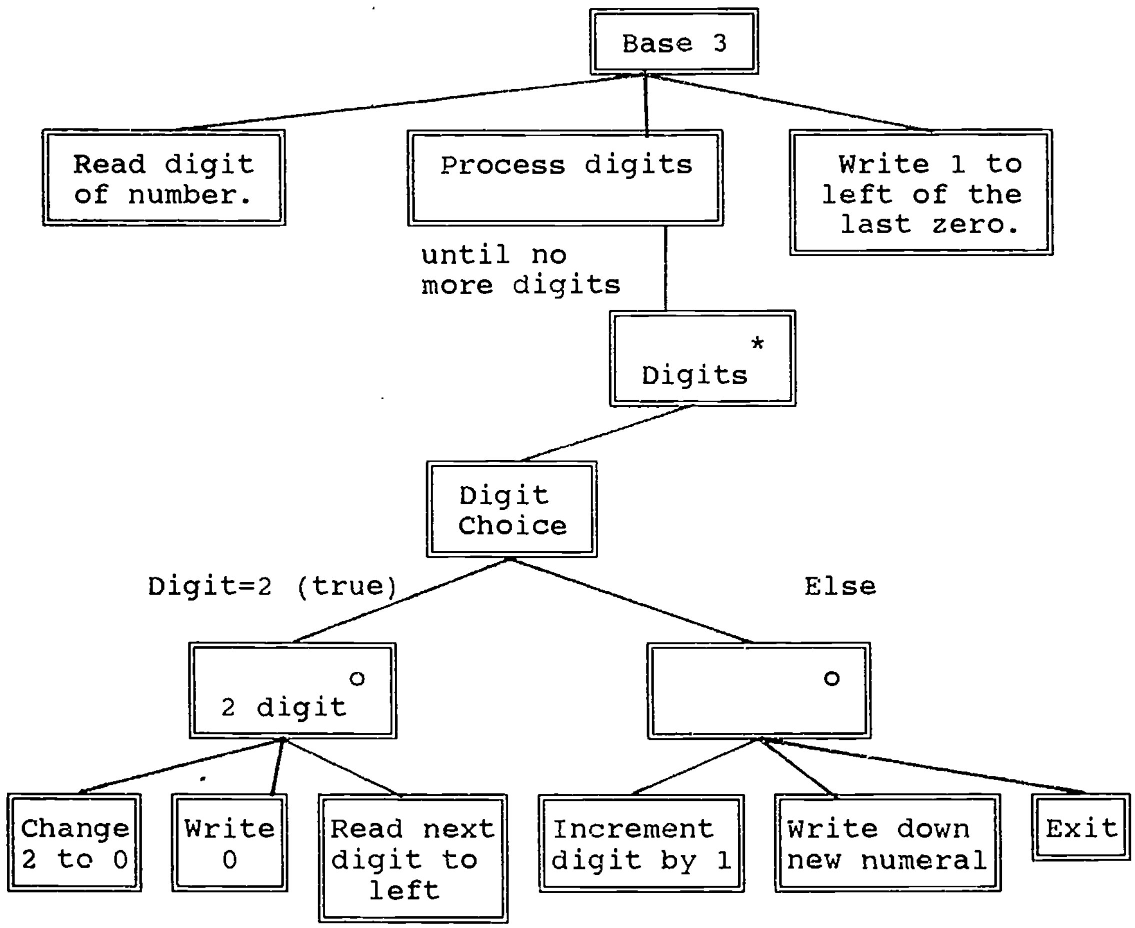
(2) Selection.
Box X is a selection or choice of Y or Z



(3) Iteration.

Box E is an iteration of a number (possibly zero) of F's. The number of F's id controlled by a specified condition.

As mentioned previously, using flowcharts to represent information processing is fraught with inherent weakness. The J.S.D. methodology can be used to overcome these limitations. Figure [4] below is an information processing task analysis using J.S.D to represent the procedure for generating the next number in Base 3.



<u>Automated Tools for Requirement Analysis</u>.
The analysis methods and tools were originally developed to be applied manually. Today each of these methods, along with a class of techniques specifically designed for automated processing, are available in a "computer-aided" format. Some of the important automated tools for requirement analysis are:
(1) SADT - a structured analysis and design technique that has been widely used as a tool for system definition, software requirement analysis, and system/software design [Ross 85].
(2) SREM (Software Requirements Engineering Methodology) [Alfred 85] is an automated requirement analysis tool that makes use of

requirements statement language (RSL) to describe elements, attributes, relationships, and structures.

(3) PSL/PSA (Problem statement language/problem statement analysis) was developed by the ISDOS project [Thichoew 77] at the University of Michigan. PSA provides an analyst with capabilities that include:

(i) description of information system regardless of application area;

(ii) creation of database containing descriptors for information system:

(iii) addition, deletion, and modification of descriptors;

(iv) production of formatted documentation and a variety of reports on the specification.

<u>Software Requirement Specification</u>.

The software requirement specification is produced at the culmination of the analysis task. The function and performance allocated to software as part of system engineering are refined by establishing a complete information description, a detailed functional description, an indication of performance requirements and design constraints, appropriate validation criteria, and other data pertinent to requirements.

<u>Courseware Specification</u>.

Having completed the task analysis and subsequently identified the requirement specification, the CAL designer would be in a position to design the objectives and criteria-test statements describing intended instructional outcomes, which are called <u>objectives</u> because their accomplishment can be measured. Course objectives are derived from the analysis requirement specification prepared earlier. Mager [Mager 90] identified three components of a well written objective.

- the behaviour to be exhibited
- the condition under which it is to be exhibited
- the criteria by which acceptable performance will be judged.

Following the requirement analysis performed earlier, the <u>courseware specification</u> now contains the following:

- an analysis of the target population and environment;
- topics and their relevance (according to defined classification);
- the interconnection between the different components of the courseware;
- needed prerequisites to enter each part of the courseware;
- the planning of activities, the employed resources and time schedule;
- courseware test plan which describes the testing methodology;
- maps of required skills.

[3] Design.

Software design is a process through which requirements are translated into a representation of software. System design consists of taking a functional specification of a software system and expressing that system as a series of procedures. A set of fundamental design concepts has evolved over the past three decades. Each provides the software designer with a foundation from which more sophisticated design methodologies can be applied.

The development phase must be instituted regardless of the software engineering paradigm applied. Using one of a number of design methodologies, data design, architectural design, and procedural design are conducted. Data design focuses on the <u>definition</u> of data structures. Architectural design defines the <u>relationship</u> among major structural elements of the program. Procedural design <u>transforms</u> structural elements into a procedural description of the software.

There are a number of design methodologies such as Data-flow Oriented design, Data Structure Oriented design, and Object-oriented design. Each software design method introduces unique heuristics and notation as well as a somewhat parochial view of what characterises a design quality. They all share a number of common characteristics:

(i) A mechanism for translation of information domain representation into design representation;
(ii) A notation for representing functional components and their interfaces;
(iii) Heuristics for refinement and partitioning;
(iv) Guidelines for quality assessment.

There are a number of notations available to describe the internal logic of a procedure. One such notation is known as Design Structure Diagram (DSD) [BSI 87] and shows the flow of control within a module. In Figure [5], the DSD describes a module accumulates the temperature readings from a thermocouple taken every second over a minute of time. It also checks that each reading is valid that is, the reading lies between the limits 0-200° C. It also counts (in a variable name total) the number of valid readings.

<u>Program Design Language</u>.

Program design language (PDL) called structured English, or pseudocode is another notation in detailed design. The illustration below shows the program design language equivalent of the design structure diagram.

```
MODULE    reading
     Set total and count to zero
  REPEAT
       Input a reading
       Increment count
       IF reading is within 0-200°C
       THEN
```

```
            increment total
            add reading to store
         ENDIF
    UNTIL count is 60
  END_MODULE
```

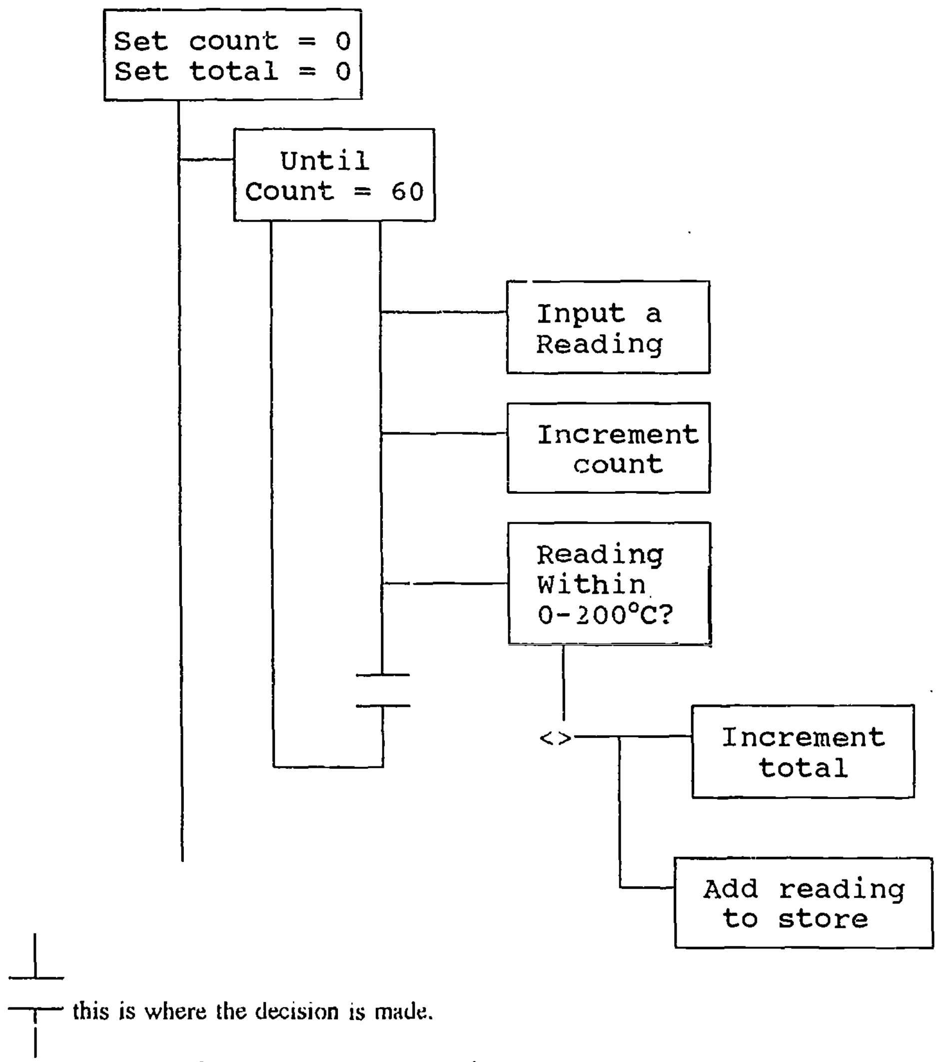


Fig.[5] A Design Structure Diagram (DSD).

<u>Courseware</u> <u>Design.</u>
The aim of the design phase is to provide design specification based on the requirements set in the analysis sub-phase. The following steps are involved:

■ Definition of course modules as components of the overall courseware architecture.

- Definition of the overall architecture.
- Educational objectives definition.
- Contents domain representation.
- Instructional strategies definition.
- Definition of assessment methods.
- Development of Standard definition.
- The script and storyboarding.

The design of courseware follows the same procedure as software design by generating a series of modules or procedures for each of the tasks analyzed. From the learning-task analysis, a preliminary description of the sequence of the lesson is obtained. Having decided on the mode of instruction to be implemented, lesson design may now commence. The design of an individual lesson is very much the same as writing a program or procedure in the software environment. Many of the design techniques and methodologies used in software engineering could be applied here.
Software engineering deals with problems similar to those involved in courseware production. CASE tools used in software engineering can be considered to transfer their methods and techniques to courseware design. A possible tool could be an intelligent adviser/guide for:

- the formal description of the objectives in non ambiguous way.
- the identification on the basis of the fundamental characteristics of each module (objectives, content, topics, prerequisites).

The use of flowcharts is strongly to be avoided because of their unstructured nature. Better methodologies such as Jackson Structured Programming (JSP), Program design language (PDL), and the use of design structure diagrams are strongly recommended. All of the above methodologies may be used in conducting task analysis. The design phase completes with the production of the courseware design specification document.

<u>Object</u> <u>Oriented</u> <u>Design</u>.
One of the methodologies, known as Object-Oriented Design, offers great potential for courseware design. There are various object-oriented analysis and design methodologies available. The advantages of object orientation over traditional functional decomposition are as follows:

- integration of abstractions viewpoints is possible;
- higher productivity through reuse of software components;
- more extensible architectures through the behavioural partitioning provided by inheritance;
- easier maintenance and system evaluation because of strong partitioning resulting from encapsulation and uniform object interfaces.

Object-oriented techniques can be used for the analysis and design of a software system. Object-oriented design is a method of design encompassing the process of object oriented decomposition and a notation for depicting both the logical and the physical as well as the static and dynamic models of the system under design.

Object-oriented design decomposes a system into objects, the basic components of the design. The object-oriented approach attempts to manage the complexity it inherits in the real world by abstracting knowledge and encapsulating it in objects. Finding or creating these objects is a problem of structuring knowledge and activities. The knowledge captured within an object can be partly hidden from the external view. This is known as information hiding. The mechanism for invoking the use of an object is done by passing messages between the objects, which invokes one of its operations. This operation is called a method. A particular object is an instance of a class. All objects of one kind belong to a class. A benefit results from the fact that a class normally serves as a template to construct an instance, so achieving a sort of reusable design.

In order to build even higher levels of abstraction, the object-oriented approach introduces a concept called inheritance, which allows us to derive more concrete objects from more abstract ones. For example; if we wish to express the fact that tigers and lions are specialisations of cat, we would first build a class 'cat' which describes the general properties of cats, then create subclasses of 'cat' for tigers and lions which inherit the general properties and can then be extended by their special properties.

The benefit from this sort of abstraction is that objects (classes) can be reused and the amount of object descriptions significantly reduced.

A method known as CRC-Method introduced by Kent Beck and Ward Cunningham would be used here. This method separates an object into its name (class), its behaviour (responsibilities), and the objects it has relations to (collaboration). Index cards are used to document an object. The CRC cards an be used for collaborative design decisions by a group of people.

The CRC Method.

Course Describe what to teach and how to teach	Goal Instruction.

The top of the card contains classname, the right part is a list of collaborations, and the lower left part contains a description of responsibilities.

The following section shows how the object-oriented technique can be used in courseware development. Based on the CRC method, some of the objects which are needed are presented.

<u>Instructional Design Objects</u> are those which deal with the instructional design aspects of course planning and development.

<u>Partial Class Hierarchy of Instructional Design Classes</u>.

Problem Statement
Instructional goal
- objective

Instructional analysis
Instructional class entry
- Theory
- Concept
- Fact
- Procedure/process
- Task

Link
- Instructional analysis link
  - Subordinate
    - part-of-taxonomy
    - kind-of-taxonomy
    - prerequisite
    - reference
  - Sequence
    - follow-on-activity

Instructional strategy

:
:

Associated with each class would be methods to carry out the necessary operations for that particular class. Messages are also specified for each class.

Approaching the design using object-oriented method enables the designer to maintain modularity and reliability, thus saving valuable time. Another benefit of using this approach is for rapid prototyping. Object-oriented methodology lends itself to rapid prototyping because it contains a number of facilities - inheritance, polymorphism, abstraction, which enable the character of a system to be changed quickly, and consequently can be used to develop rapidly a prototype which can easily be changed.

Conclusion.

The evolution of applying an engineering approach to the development of software has provided some of the solutions to problems facing software developers, and offered some hope of improved productivity. Today this approach is fast becoming the *de facto* standard for producing software systems. Whereas there are techniques, methodologies and tools available for software developers to use during the development lifecycle, the situation is not so encouraging for courseware production. However, the software engineering discipline does offer tremendous potential for courseware developers to adopt and adapt the various techniques, methodologies, and tools to their own craft. This paper has only managed to scratch the surface of the potential tools available to courseware developers. It is time that courseware producers took up the challenge and began to explore the possibilities. Certainly more research should be undertaken to further the development of intelligent authoring tools.

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Selected Abstracts for the

Special Interest Group for Interactive Video-Audio (SIGIVA)

Development of an Interactive Multimedia System for Use in Public Access Environments

Jeanne Gleason, New Mexico State University

The Natural Resource Extravaganza, an award winning interactive multimedia presentation for use in public delivery settings, was developed in 90 days with extremely limited time, personnel, and equipment. It operates at the nation's fifth largest state fair, and shopping malls and events in the Southwest.

Unlike "training" multimedia systems designed for "captive" learners, multimedia presentation in busy, noisy environments require extra attention to specific design issues. The presenter will share her experience with:

--effective lengths and designs of video clips,
--system feedback to keep users engaged,
--menu designs,
--user options,
--system defaults,
--basic structure of the information to be delivered,
--development of design specification, and
--template designs for economical development.

The presenter created a comprehensive development model, called ADOBE, to organize students, professionals, and artists to economically develop an effective multimedia system within her limited budget. She will share how her design templates can support original but parallel development.

This system was developed for the PC environment, using touch screen input, a laser disc, computer graphics, and the IMSATT programming language. The presenter is currently developing additional systems using Macintosh systems for The Smokey Bear Center, the USDA, and the Navajo Indian Tribe.

A MICAL Project Update

Darleen V. Pigford and Greg Baur, Western Kentucky University

The Multimedia Interactive Computer Aided Learning (MICAL) research project was implemented in the spring of 1991 at Western Kentucky University. Its four phase program was presented and discussed in a paper given at the 1991 ADCIS meeting in St. Louis. The project is now running and is undergoing the usual peaks and valleys.

The purpose of this presentation is to bring attendees up-to-date on the past, present, and future of the project. It will discuss successes, lessons learned and future directions of the project. The presenters will share their experiences and problem solving techniques as the project moves through its intermediate phases.

An Interactive Video Demonstration Tutorial of the *Visual Almanac* that Empowers Preservice and Inservice Teachers

Charlotte Scherer, Bowling Green State University

For many teachers, multimedia, such as an interactive video package, is still an overwhelming set of technological resources that they are unsure they want to deal with. There is also, among both neophyte preservice and inservice teachers, some fear that technology might be used to replace teachers in the classroom, or lead to more impersonalized classrooms. Thus, it becomes difficult to empower teachers with the technology that could be an outstanding resource for enhancing student learning. At Bowling Green State University, we introduce neophytes to a rather complex interactive video disc (IVD) resource, the *Visual Almanac*, created by Apple Computer to demonstrate the potential of this media for K-12 education. We developed an interactive video stack that accesses sample segments of the three areas of the *Visual Almanac* program: Collections, Activities, and Composition Workspace. This stack does not require the use of the CD-ROM player and can be used with a 20 megabyte harddrive, unlike the full package which requires a CD-ROM player or a 40 megabyte harddrive. The *Visual Almanac* demonstration tutorial has been successfully used with small groups of teachers and as an assignment in a secondary education methods course.

Knowledge and Skills of Team Members for the Preproduction Stage of Developing IVD Courseware

Carol Smith, West Virginia Consult

Utilizing the modified Delphi technique, a panel of experts in the IVD development process identified and validated knowledge and skills required by seven specified roles involved in the preproduction stage of developing level III IVD courseware. The panel was segmented according to expertise in roles performed on IVD development teams (role specialist group and non-role group for each role included in study). The panel identified several knowledge and skills as belonging to more than one role. The roles included in the study were: project manager, instructional designer, content expert, computer programmer, video specialist, script writer, and graphic specialist. The panel also identified levels of expertise (basic, intermediate, advanced) for each knowledge and skill factor.

As a result of this study, the panel achieved consensus on 144 factors: 76 knowledge factors and 68 skill factors for the roles included in the study. Differences in perceptions of levels of expertise for each knowledge and skill factor between the role specialist group and the non-role group were determined. One conclusion of the study was that the roles of video specialist and content expert were the least understood roles for the non-role groups.

Empowerment through Museums and Multimedia

Paul Wangemann, Motorola Museum of Electronics

The Motorola Museum of Electronics and local school districts in the Schaumburg, Illinois area have formed a partnership to develop and implement a hands-on, inquiry-based approach to science teaching and learning. Hands-on classroom activities and developed curriculum provide the background and foundation for understanding the technologies that are presented at the Motorola Museum. Problem-solving activities at the museum utilize the science concepts learned in the classroom. In the museum these concepts are demonstrated through real world applications. Group activities in the classroom after an experience at the museum focus on societal applications, explanations, and implications for technological solutions to human problems based on the technology studied at the museum.

The underlying assumption of the educational experiences available in the museum is that the learning process and environment are as important as the subject matter. The museum integrates multimedia interactive video experiences into exhibits and provides extensive learning activities in computer and hands-on laboratories. In order for visitors to learn about the world of electronics they need to experience in a meaningful way. Computers play an important role not only as a tool in the educational process but as a motivating example of how electronics helps to do important things differently than in the past.

Embedding Instructional Delivery Systems for Maximum Effectiveness

Stuart H. Weinstein and William H. Skipper, SWL Inc.

This comprehensive session will examine the instructional effectiveness, time savings, and cost benefits resulting from the use of high technology instructional delivery systems that are coupled with actual equipment in the job setting. The presenters will guide conference participants through the analysis, design, development, and delivery of a performance-based bank teller training program as a means of illustrating the use of training technology (computer-controlled interactive videodisc) with actual bank equipment (teller machines) in the real job setting (a bank branch office).

Based on the bank training demonstration and personal training experiences, conference participants will generate an approach to determine the appropriateness for training with multimedia technology that is coupled with actual equipment. The first goal of this session will be to give the conference participant the ability to identify needs and processes associated with the analysis, design, development and delivery of "on-demand," flexible, and cost-beneficial training. Through a participatory exercise the participants will then determine opportunities, benefits, methods, and applications for the use of actual equipment in the design and development of training for business, industry, education, military, and government clients.

Selected Formal Papers from the

Special Interest Group for Interactive Video-Audio (SIGIVA)

ADAPTIVE INSTRUCTIONAL USE OF INTERACTIVE VIDEODISC PATIENT SIMULATIONS

Paunpimon Amornkul,
Lowell A. Schoer, &
Michael W. Finkelstein
University of Iowa

Abstract

This study compared the effectiveness and efficiency of adaptive instruction with that of non-adaptive instruction with an interactive videodisc patient simulations. Interactive videodisc patient simulations are used to teach clinical problem-solving in the health sciences. Sixty-two sophomore dental students at the University of Iowa College of Dentistry were subjects. An Analysis of Covariance (ANCOVA) using a two by two factorial design was utilized to compute the obtained data. A pre-test was set as a covariate variable. Two instructional strategies (adaptive and non-adaptive) and two levels of pre-instructional GPA (high and average identified by above versus below 3.29 median) were independent variables.

The results indicated that both instructional strategies were equally effective in teaching problem-solving, as measured by student achievement and student retention. However, adaptive instruction was significantly more efficient than non-adaptive instruction in terms of student study time. There was no interaction between instructional strategies and pre-instructional GPA.

Introduction

Problem-solving in Dental Education

A dental curriculum integrates basic science and clinical dental sciences using a variety of teaching methods including lectures, seminars, laboratory practice, clinic practice, and simulated clinic practice. Even though dental students have equal opportunities to acquire knowledge of the basic sciences and technical skills, differences in clinical problem-solving skills exist.

The term "problem-solving" used in this study is modified from McGuire's (1985) medical education term. It encompasses all cognitive skills implied in patient evaluation and management. These include patient information-gathering, diagnostic reasoning, medical decision-making, and patient treatment.

In a clinic, students diagnose and manage patients' diseases with the help of competent and experienced faculty. However, the cases which are presented in the clinic may lack sufficient variety to thoroughly develop students' problem-solving skills. In addition, limited time may restrict students' experiences. Students may, therefore, lack experience in developing a systematic approach to gathering information and solving diagnostic and management problems across the full range of situations they are likely to encounter in regular practice.

Simulations in Dental Education

Simulations give practice in dealing with some aspect of the environment by imitating or replicating it (Alessi & Trollip, 1985). It is an aid that brings a close approximation of reality to students. In the traditional curriculum, students usually deal with physical simulations of dental practice in a clinic setting. Simulations have not been widely used to teach problem-solving strategies.

The University of Iowa College of Dentistry has developed a series of interactive videodisc simulations, called the *Dental Diagnosis and*

Treatment (DDx&Tx) System. The purpose is to teach problem-solving skills by using an interactive videodisc system to deliver a variety of dental cases to students.

The *DDx&Tx System* uses a laser-reflective videodisc controlled by a microcomputer. The student views two television screens and communicates via the microcomputer keyboard. One screen displays videodisc images while the other displays text. The system allows the student to gather visual and textual information on the patient's disease, offer a clinical diagnosis, and propose treatment (Finkelstein, Johnson, & Lilly, 1988).

The advantages of *DDx&Tx System* are the following. First, it teaches students how to think and make decisions in a logical, organized manner. Second, it delivers active, individualized patient simulations. Students are actively involved in the learning process and are required to make decisions. Third, it presents a greater number and variety of cases than students could see in the clinic. Fourth, it can be used as review for examinations. Finally, it can be used in continuing education courses.

Context of Problem

DDx&Tx System seems to be a useful instructional tool. However, further research is needed to establish its effectiveness and efficiency. The amount and complexity of the system should not only maximize students' achievement but also minimize the amount of time involved. An adaptive instructional strategy was implemented in this study to achieve these goals.

Adaptive Instruction. The term "adaptive instruction" is used in this study as defined by Tennyson and Rothen (1977; 1979), i.e., strategies which prescribe the optimal amount of instruction necessary to achieve a desired objective. Adaptive instruction involves highly developed monitoring systems which individually assess and instruct students (Breuer & Hajovy, 1987). It is directly tied to student achievement. During the learning process, instruction is adjusted to match the level of student achievement. Low achievers who respond poorly will receive more instruction or less complex instruction. High achievers receive less and/or more complex instruction.

The rationale for adapting instruction is that students should be confronted with instruction that is neither too much above or below their current levels of knowledge (Tennyson, 1988). Low achievers become frustrated and confused with highly complicated instruction, while high achievers become quickly bored with less complex instruction.

Purpose of Study

The purpose of this study was to examine the effectiveness and efficiency of adaptive and non-adaptive instruction using the *DDx&Tx System* as an instructional material.

This study was carried out to answer three research questions.

1. Is adaptive or non-adaptive instruction more effective?
2. Is adaptive or non-adaptive instruction more efficient?
3. Do adaptive and non-adaptive instruction interact with student pre-instructional GPA as related to both effectiveness and efficiency?

Procedures

Subjects

Sixty-two sophomore dental students from the College of Dentistry at the University of Iowa participated in the study. They were enrolled in a required, introductory course in oral pathology. Subjects were separated into two groups based on their GPA. The GPAs were ranked and classified as high or average depending upon above or below the median (50th percentile = 3.29). Within each group, students were randomly assigned to either Group 1, instruction with adaptive strategy; or Group 2, instruction with a fixed number of simulations (Table 1).

Table 1

Basic Research Design and Sample Size

Pre-Instructional GPA	Instructional Strategies			
	Adaptive		Non-Adaptive	
	Immediate Post-test	Delayed Post-test	Immediate Post-test	Delayed Post-test
High	16	14	15	15
Average	15	14	16	15
Total	31	28*	31	30*

* Four students failed to attend the delayed post-test at the pre-scheduled period.

Research Design

There were two treatment groups. Group 1 used adaptive instruction (varying number and complexity of simulations depending on performance). Group 2 used non-adaptive instruction (a fixed number of simulations presented regardless of performance) (Figure 1).

For Group 1, the maximum number of simulations (ten) presented in each difficulty level was three, four, and three simulations in the low, medium, and high levels, respectively. To identify the difficulty level, cases identical to the simulations were presented to a group of junior students during their clerkship exam. The index of case difficulty was pre-defined as a percentage of this group who identified the case correctly. The larger the value of the index, the easier the case.

The criterion to pass each difficulty level was the students completing a simulation with no less than 80 percent correct of the total possible lesion(s) and with no more than one "reevaluate" message appearing during the diagnosis section. The "reevaluate" function is a knowledge of result (KOR) that informs a student of his/her incorrect response while tracing the diagnosis decision tree (Figure 2). It is designed to guide students to the correct decision by eliminating incorrect options.

All students began with two simulations at the medium difficulty level. If students passed the medium level, they advanced to the high level. If they failed the medium level, they worked on simulations in the low level. If students passed this low level, they advanced to the medium level, and then the high level.

Students' use of *DDx&Tx System* was terminated when they either passed the high difficulty level or completed ten simulations. The minimum number of simulations that a student in Group 1 could study was three. If students passed the second simulation of medium difficulty level and one high level simulation, the lesson was terminated. The maximum number, in contrast, was ten: two medium-level simulations, three low-level simulations, two more medium-level simulations, and three high-level simulations.

For Group 2, the simulations were randomly selected from each difficulty-level pool. They were sequentially presented to the students in levels of increasing difficulty. Each started with three low-level simulations, then proceeded to four medium-level simulations, and then to three high-level simulations.

The possible maximum number of simulations presented to students in Group 1 was equal to the total number of simulations presented to students in Group 2 (ten simulations). However, the Group 1 students could receive a smaller number of simulations depending on their performance.

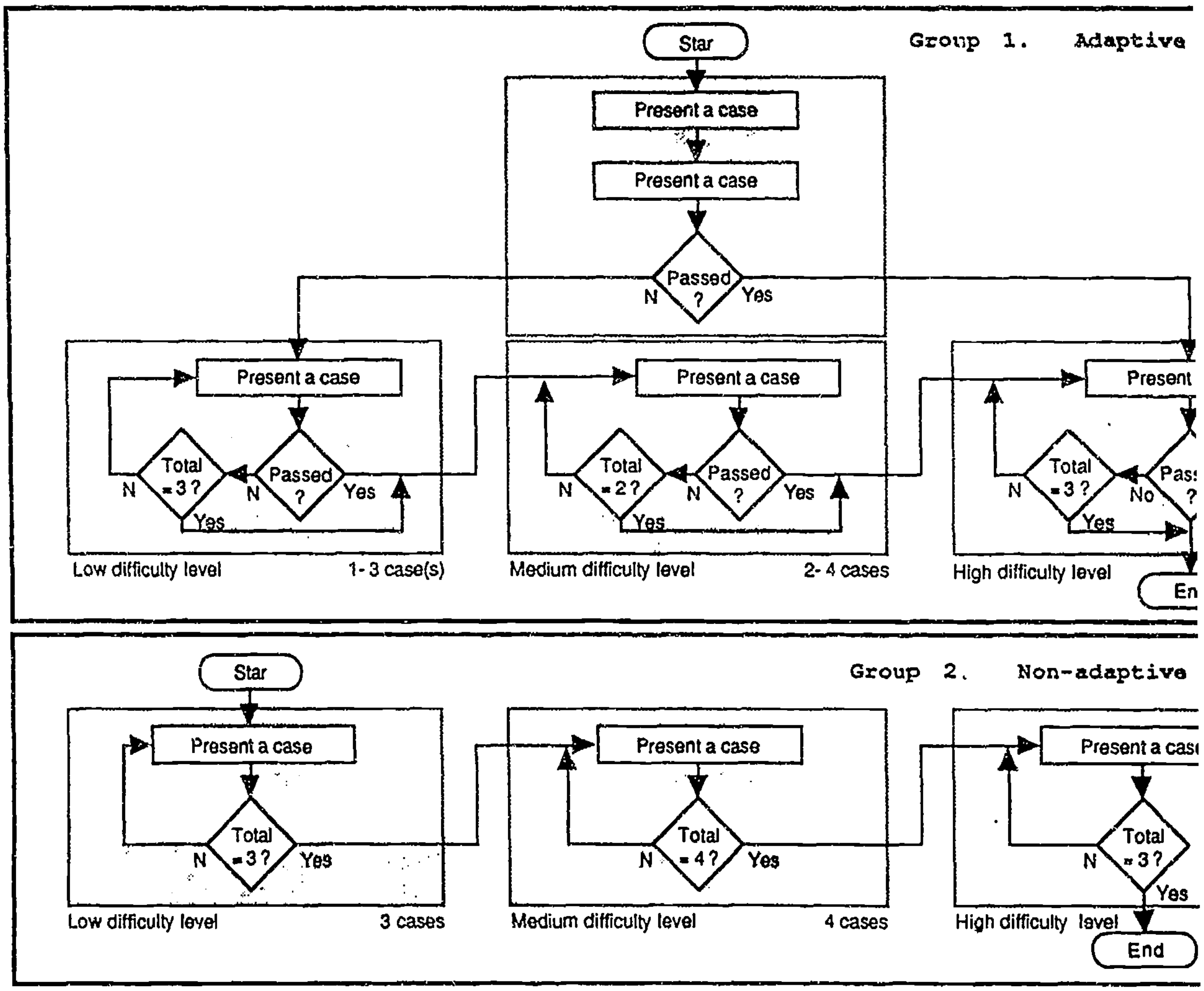

Figure 1. Adaptive and non-adaptive Instructional Strategies

DIAGNOSIS

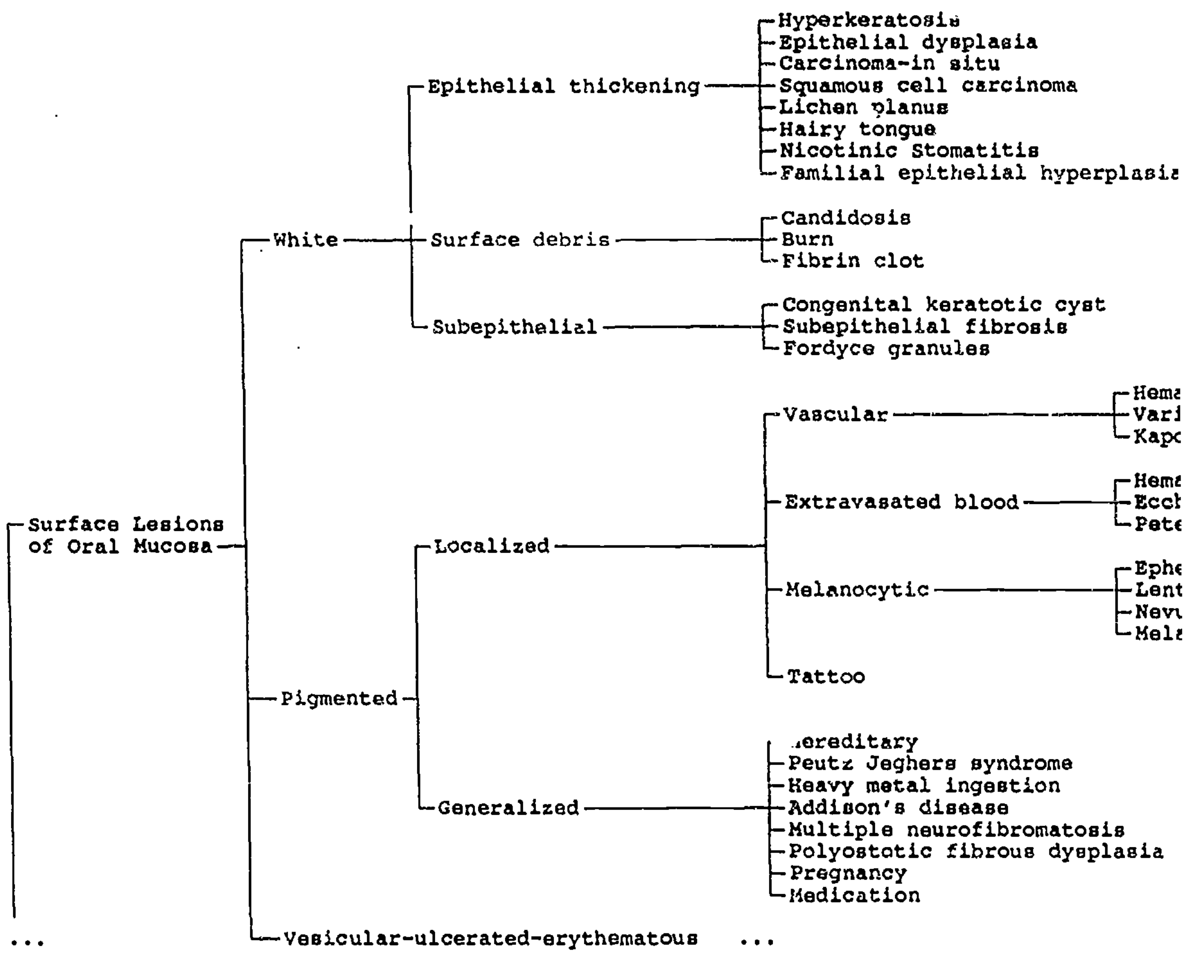

Figure 2. A Section of the Diagnosis Decision Tree

Instruments

Pre-test and Post-tests. Parallel forms of a test were written by the director of the oral pathology course. Both instruments were proven to be very reliable (.80 and .82). The first form was used throughout the data collection period as pre-test and immediate post-test. The other parallel form of the test was used as a one-week delayed post-test.

Each form of the test had two sections: content and case analysis. The content section consisted of ten multiple true-false questions. Each question had nine choices. Students identified the correctness (true or false) of each choice. Each correct choice was counted as one point. The potential score of this test section was 90 points.

The case analysis section was constructed to examine problem-solving skills. This test paralleled the *DDx&Tx System*. It contained five cases presented as slides and descriptive paragraphs. Students studied each case by reading paragraphs describing patient demographic information and patient problems and by viewing related visuals. Students then named the correct lesion(s). The tree diagram of diagnosis, which is a hierarchical organization of lesions, was provided during the test. The total number of correct lesions in these five cases was eighteen.

Student Study Time. The computer tracked the time each student took to complete all simulations. The time started immediately after the student finished typing his/her ID number. It ended when students completed ten simulations or passed the highest difficulty level.

Patient diagnosis is time-consuming and requires the use of complicated problem-solving skills. Presenting the maximum of ten simulations at one time could cause fatigue. In this study, students were, therefore, allowed to stop and return during their three scheduled periods to complete the simulations. The entire experiment lasted twelve weeks.

Data Collection

During the first period, students took the pre-test immediately before beginning the simulations. In Group 1, the computer selected a number of simulations based on students' performance during the lesson. A maximum of four simulations was presented to students. In Group 2, the students studied four simulations. The maximum of four simulations was defined for this period because students needed time to become acquainted with the system and the simulations. The students studied at their own pace on their own time in both groups.

During the second period the students completed the simulations. In Group 1, the computer selected the difficulty level of the simulations based on students' first-session performance. A maximum of six additional simulations was presented. In Group 2, all students studied three medium-level and three high-level simulations. Immediately after completing the simulations, both groups of subjects took the post-test.

A week later, students took a delayed post-test. A potential of 20 extra points (based on their performance) on delayed post-test scores was given to all students.

Results

Since the content scores and case analysis scores have different scales of measurement, these scores had to be transformed into a common scale. To do this, each of 62 raw scores of content and of case analysis was converted to a standard score (z-score). The z-scores of content and case analysis were combined and transformed into T-scores.

Effectiveness

The effectiveness of the interactive videodisc simulation lessons was measured by students' post-test scores (immediate and delayed post-test). The immediate post-test measured student achievement; the delayed post-test measured student retention. These tests were evaluated by an analysis of covariance (ANCOVA) in order to examine the main effect and interaction between instructional strategies and pre-instructional GPA.

The immediate post-test scores were not significant for the main effects of either instructional strategy or pre-instructional GPA ($p > .05$). The interaction effect between strategies and GPA was also not significant ($p > .05$) in any of the analyses (Table 2).

The only significant effect found on the delayed post-test was for GPA groups. High achievers performed significantly better than average achievers (Table 2).

Table 2

Analysis of Covariance on Immediate Post-test and on One-week Delayed Post-test

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F	p
IMMEDIATE POST-TEST					
Pre-test	1889.434	1	1889.434	71.849	0.000
Strategy	0.534	1	0.534	0.020	0.887
GPA Groups	31.019	1	31.019	1.180	0.282
Interaction	0.011	1	0.011	0.000	0.983
Error	1498.936	57	26.297		
ONE-WEEK DELAYED POST-TEST					
Pre-test	939.650	1	939.650	22.037	0.000
Strategy	26.285	1	26.285	0.616	0.436
GPA Groups	265.223	1	265.223	6.220	0.016*
Interaction	2.925	1	2.925	0.069	0.794
Error	2259.871	53	42.639		

* $p < .05$

Efficiency

The time to complete the simulations in the four groups is shown in Table 3. Efficiency was defined as the ratio of study time to performance on the dependent measures. In every case, the adaptive conditions is significantly higher than non-adaptive conditions (Table 4). However, the ANCOVA produced no significant differences for either instructional strategies or interaction.

Table 3

Time (in Minutes) to Complete Simulations

Pre-Instructional GPA	Instructional Strategies: Adaptive	Instructional Strategies: Non-Adaptive	Total
High	HA	HNA	
RM	96	133	115
SD	36.66	9.81	43.23
R	159-40	218-61	188-50
N	16	15	31
Average	AA	ANA	
RM	102	125	113
SD	42.79	43.92	43.35
R	220-51	189-62	204-56
N	15	16	31
Total			
RM	99	129	114
SD	39.72	46.86	43.29
R	189-45	203-61	196-53
N	31	31	62

HA - High achievers in Adaptive instruction
AA - Average achievers in Adaptive instruction
HNA - High achievers in Non-Adaptive instruction
ANA - Average achievers in Non-Adaptive instruction
RM - Raw Mean
SD - Standard Deviation
R - Range (highest score - lowest score)
N - Number of subjects

Discussion

Effectiveness

The ANCOVA produced non-significant differences for instructional strategies, pre-instructional GPA, and their interaction ($p > .05$) on the immediate post-test.

Table 4

Analysis of Covariance on Ratio of Immediate Post-test scores to Study Time and on Ratio of One-week Delayed Post-test Scores to Study Time

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F	p
IMMEDIATE POST-TEST/STUDY TIME					
Pre-test	1.146	1	1.146	25.873	0.000
Strategy	0.463	1	0.463	10.448	0.002*
GPA Groups	0.029	1	0.029	0.644	0.426
Interaction	0.019	1	0.019	0.419	0.520
Error	2.525	57	0.044		
ONE-WEEK DELAYED POST-TEST/STUDY TIME					
Pre-test	1.024	1	1.024	24.563	0.000
Strategy	0.545	1	0.545	13.066	0.001*
GPA Groups	0.011	1	0.011	0.257	0.614
Interaction	0.000	1	0.000	0.004	0.950
Error	2.210	53	0.042		

* $p < .05$

The ANCOVA results of the two post-test scores were used to answer the research questions: "Is adaptive or non-adaptive instruction more effective?" and "Do adaptive and non-adaptive instructions interact with student's pre-instructional GPA related to effectiveness?" The answer to both questions is "No", at least within the limit of the present study.

The students used in this study seemed to learn as much from non-adaptive as from adaptive instruction and this effect did not interact with GPA. Although GPA did have a significant effect on delayed post-test performance, the effect was not significantly different for the two strategies used in this study.

Efficiency

The efficiency of adaptive instruction and non-adaptive instruction was a major concern of this study. The ANCOVA produced significant differences for instructional strategies on both student achievement and student retention.

These data provide the answer to the research question, "Is adaptive or non-adaptive instruction more efficient?". The results of this study suggest that adaptive instruction is more efficient than non-adaptive instruction.

Students in the adaptive group, on average, received fewer simulations than students in the non-adaptive group. This smaller number of simulations they received reduced the amount of time they spent. Interestingly, less time spent on instruction did not create any disadvantage in the learning or retention.

Limitations of the Study

Two major limitations in this study are the content used. More content areas in dental education could have been used, but resource limitations would permit only one.

Another limitation was that students had different levels of computer proficiency. Prior to this study most of the students had little or no direct experience in operating computers. To reduce this effect, orientation sessions were provided to introduce students to the interactive videodisc system and to demonstrate how to operate the patient simulations. Students who had the least computer experience were encouraged to operate the machine during the orientation. However, orientation was only an introduction to the system. Some students needed more advice and practice to operate the system than others. During the actual simulations, time spent on advice and practice was counted as part of the student study time.

Implications for Practice

Adaptive simulations proved to be effective and to decrease student study time. It also saves faculty time in judging and prescribing the appropriate amount and difficulty levels of practice each student needs in order to diagnose patients effectively and efficiently. Further, it can help advise or answer individual student questions by inserting results, discussion, and treatment plans related to specific questions into the simulations.

Most computerized instruction is individualized instruction. The main purpose of developing this instruction is to allow students to study a predefined lesson at their own pace. Advanced lessons may be provided after they have finished some specific lessons. That was the situation in this study. This instruction not only provided a self-paced strategy, but also provided each student distinctive and effective instruction. In this study, students received different numbers of simulations at different levels of difficulty based on their performance.

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Interactive Audio: Research and Practice

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ABSTRACT

Interactive audio is an increasingly important component of multimedia instruction. Instructional designers and developers are faced with many alternatives in hardware, software, implementation techniques, and design strategies. This paper focuses on appropriate applications for incorporating audio into interactive lessons and the advantages and disadvantages of using digital audio.

INTRODUCTION

Interactive courseware has been a largely text-based medium for many years. When audio was first introduced into CBT, it was utilized primarily as feedback for inappropriate input by students. As software and hardware improved, audio in the form of music was added for reinforcement of correct answers and for transitions between lesson segments.

With the advancement of interactive videodisc technology in the 1970s, audio became a viable option. In this format, audio was used to provide spoken instructions, include sound effects, create scenarios, explain concepts, and prescribe remediation (Pratt & Trainor, 1990).

The introduction of digital audio in 1982 created circumstances necessary for effective integration of synchronized, random audio into CBT. Modem digital audio computer cards enable CBT developers to record, store, edit, and play back segments of audio. Control of these segments through computer software programs is precise and reliable.

An abundance of digital audio cards and peripherals is now appearing on the market. The chart in Figure 1 represents common digital audio boards utilized in computer-based training.

AUDIO CARD	COMPANY	PRICE	KHz
DigiSpeech	DigiSpeech Inc.	$198.00	1,3,4,8
DSA-620	Online Computer Systems	$1441.00	4,6,8,12,16,18,37.8
M-Audio Capture & Playback	IBM	$370.00	8,11,22,44
MicroKey Audio Card	Video Associates	$495.00 $295.00	8,16,32
ProAudio Spectrum	Media Vision	$398.95	6,8,11,22,32,44
SoundBlaster Pro	Creative Labs	$299.95	4-44
SoundMaster II	Covox	$236.95	4.6-25.4
VP625	Antex	$450.00	8,12,16

Figure 1. Digital Audio Boards

Many companies are also distributing external digital audio peripherals. For example, the AudioPort by Antex can record and play audio files at various sampling rates. Digital audio cards and peripherals, combined with an increase in computer storage space, have resulted in a dramatic increase in the use of audio in multimedia instruction.

THE RESEARCH BASE FOR INCORPORATING AUDIO

There are many appropriate applications for audio in interactive courseware. Young learners and non-readers are natural targets for instruction in reading(Reitsma, 1988; Wise, 1990). Researchers have demonstrated success with audio-based interactive courseware for mildly handicapped learners (Wiener, 1991). Audio-based instruction is also appropriate for training that involves recognition of specific sound cues, such as sonar operations in the U.S. Navy (Barron & Varnadoe, 1992).

An underlying a. umption, when adding an additional channel of media to transmit a message, has often been that utiliz: on of additional channels will effectively increase the amount of communication and the amount of learning. Reviews of research in this area, however, indicated that studies in multichannel communication resulted in "mixed and contradictory findings" (Severin, 1967a, p. 233). Reasons cited for the controversy included poor sampling techniques, weak designs, lack of randomization, poor controls, lack of probability statements, and test channel bias.

A study was conducted at the University of Central Florida to analyze the achievement differential between various combinations of audio and text in a CBT tutorial. The treatments consisted of the delivery of an identical CBT tutorial through one of three modes: (1) text-only, (2) partial text and full-audio, and (3) full-text and full audio. Results of this study indicated that the various CBT delivery modes did not have a significant effect on overall comprehension of the tutorial content (Barron, 1991).

Although this study concluded that the addition of audio did not increase learning, it also indicated that learning did not decrease when a substantial amount of the textual information was deleted from the computer screen and replaced with audio. This finding can counter concerns that some adults require the visual input to succeed. Lessons with complex screens may be able to provide instruction through the audio channel without adversely impacting the lesson effectiveness.

ADVANTAGES OF DIGITAL AUDIO

In the past, when the decision was made to include audio in interactive lessons, the primary medium was videodisc. Audio on a CAV videodisc is usually analog and is limited to 60 minutes per side, if both tracks are fully utilized. There are several advantages to digitizing audio and storing it on a computer drive instead of mastering it onto a videodisc:

- *Ease of recording and editing*. Most of the audio boards and peripherals have accompanying software for recording and editing sound files. To record audio, a sampling rate is selected in the software and the "record" option is chosen. In many cases, the software also includes a sound editor. This feature allows developers to view the sound waves and "cut and paste" the audio.

- *Random access*. When audio is stored in digital files, it can be accessed at random by filename. If an authoring system, such as TenCORE, is used for development, it can play a recorded file with a DOS call.

- *Flexibility for revisions*. Digital audio is stored by filename. If revisions are required, developers can merely record the file again and replace the previous recording by using the same filename. With this method, changes to the authoring code will not be required to revise the audio.

• *Not tied to video.* Audio on a videodisc in generally stored in analog form and is tied to the video content. When audio is stored in digital files, it can be played independent of the video on a videodisc. In other words, the audio is no longer tied to the video component. This feature makes it possible to include audio in conjunction with still frames and various speeds of video.

• *Capacity limited only by storage.* Audio on a videodisc is limited to 60 minutes per videodisc side, if both audio tracks are fully utilized. When audio is stored in digital form, the capacity is limited only by the available storage. In many cases, digital audio is stored on removable hard drives of over 300 megabytes. Digital audio can also be stored and played from a compact disc.

• *In-house recording of classified information.* If classified material is stored on a videodisc, special precautions must be taken at the recording studio. The mastering costs of classified videodiscs are often twice as much as unclassified videodiscs. To record classified digital audio, the same precautions must be taken; however, many CBT development companies have classified in-house audio studios.

DISADVANTAGES OF DIGITAL AUDIO

Digitizing audio has several distinct limitations. The decision to invest in this technology must be carefully analyzed. Following are some of the disadvantages of using digital audio in courseware:

• *Lack of standardized hardware.* Most of the audio boards in Figure 1 are incompatible with each other. In other words, if you have an Antex card in the development station, the files will not play in a delivery station that has a SoundBlaster Pro. Two trends may help to alleviate some of the incompatibility problems in the future. First, the multimedia extensions of Microsoft Windows are simplifying the process of loading drivers for various sound boards. Secondly, audio peripherals, such as the AudioPort, make it easier to connect and transport sound digitizing hardware.

• *Requires large amount of RAM.* Some of the audio digitizing techniques require a large amount of RAM because the files must be loaded into RAM before they are played. In addition, the drivers for the audio device must be resident in RAM. When purchasing an audio card, check to determine whether it records to RAM, to disk, or provides both options.

• *Requires large amount of disk storage space.* Audio files are extremely memory intensive. Figure 2 shows the requirements for storing audio at various sampling rates. Compression techniques are being perfected that may help to constrain the amount of disk space required for audio files in the future.

SAMPLING RATE	STORAGE FOR 1 SECOND OF SOUND	SECONDS OF SOUND PER 1 MEGABYTE
22 KHz	22 Kbytes	45 seconds
11 KHz	11 Kbytes	90 seconds
7 KHz	7 Kbytes	135 seconds
5 KHz	5 Kbytes	180 seconds

Figure 2. Sampling Rates and Storage

• *Quality is limited by storage requirements.* Because the file sizes are large, developers are forced to accept smaller sampling rates and, therefore, less audio quality on playback. In a recent survey, the most prevalent sampling rates for industrial training were found to be between 8 and 12 KHz (Barron, 1991).

• *Difficult to synchronize.* Because the audio is not "tied" to the video of a videodisc, there is no inherent synchronization. In addition, if the audio files are loaded into RAM before playing, the access time will vary based on the file size, making synchronization difficult.

CONCLUSION

Digital audio is now a viable option for interactive courseware. Appropriate applications for audio instruction include reading education, recognition of specific sound cues, and replacement for text on complex screen displays. If audio is chosen as a delivery medium, digital audio is advantageous if the design requires flexibility, revisions, random access, and large quantities of audio. Disadvantages of using digital audio include the lack of standardized hardware, large RAM and storage requirements, and reduced quality based on storage capacity.

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DIGITAL AUDIO CARDS

DigiSpeech
DigiSpeech, Inc.
1043 N. Shoreline Blvd.
Mountain View CA 94043
(415) 494-8086

DSA-620
Online Computer Systems
20251 Century Blvd.
Germantown MD 20874
(800) 922-9204

M-Audio Capture and Playback
IBM United States
Department 7EY
4111 Northside Parkway
H04L1
Atlanta GA 30327
(800) 772-2227

Microkey Audio Card
Video Associates Labs
4926 Spicewood Springs Road
Austin TX 78759
(512) 346-5781

Pro Audio Spectrum
Media Vision
47221 Fremont Blvd.
Fremont CA 94538

SoundBlaster Pro
Creative Labs, Inc.
2050 Duane Ave.
Santa Clara CA 95054
(408) 986-1461

SoundMaster II
COVOX, Inc.
675 Conger St.
Eugene OR 97402
(503) 342-1271

VP625
Antex
16100 South Figueroa St.
Gardena CA 90248
(213) 352-3092

Partners in Interactive Video: Designing for Research and Implementation

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Abstract

The PETAI Training Tutorial and Database of Pedagogical Knowledge in Physical Education (PETAI-IV) is a multifaceted computer-assisted interactive video program designed and developed as a collaborative effort between the School of Kinesiology & Physical Education and the Department of Educational Technology at the University of Northern Colorado. In light of the unique aspects of this collaboration, an analysis of the design, development, formative evaluation, research findings, and implementation of this CAIV program provides an important source of information for interactive project design teams.

Introduction

Interactive videodisc instruction, since its introduction in 1977, has had relatively limited but enthusiastic application in education (Chen, 1990). Physical educators in various arenas have recently begun to probe the use of interactive videodisc environments. Accordingly, interactive videodisc (IV) instruction is now being tested, applied, and researched in the physical education setting as suggested by Gusthart and Sprigings (1989). IV use in physical education includes the instruction in skill analysis, performance skills, self-analysis, officiating skills, and teaching skills (Mathias & Smith, 1991). In fact, several researchers have investigated IV applications in physical education related areas (Horton, 1992; Lyness, 1985; Mathias, 1990; O'Sullivan, Stroot, Tannehill, & Chou, 1989; Walkley & Kelly, 1989).

Owing to the two primary benefits of computer-assisted interactive video--access to a broader base of materials and the opportunity for individualized instruction (Pavlonnis, 1988; Schwier, 1987; Seal-Wanner, 1988), interactive video-based instruction may become one of the most revolutionary developments in the history of education and training (Gindele and Gindele, 1984). Brody (1984) recommended a systematic analysis of interactive video focusing on research with IV and research about IV. Gindele and Gindele (1984) emphasized that educators should make every effort to understand and to utilize these technologies in order to better manage the tremendous amount of new information that is constantly evolving. A depiction of what has been ascertained about the design and development of a physical education video instructional program, in terms of research and implementation, will hopefully stimulate future developments of this new educational medium.

Overview

Over the last three years, the physical education and educational technology programs at the University of Northern Colorado have developed a close collaboration with the goal of substantially changing and improving the process of training physical education teachers. This collaboration has developed to meet several needs in both programs.

School of Kinesiology & Physical Educatio~

The issues for physical education center on increased course demands and lack of student time to complete the courses. Because of the K-12 scope of physical educator training, students must show competency in a wide range of skills and teaching strategies. The physical education preservice teacher must show competency in analysis of 16 basic motor skills, provide appropriate feedback, and prescribe interventions appropriate to overcome a deficiency. Another critical area is teaching physical educators to be critics of their own teaching. The physical education program uses a computerized version of the Physical Education Teaching Assessment Instrument (Phillips, Carlisle, Steffen, & Stroot, 1986) to observe preteachers, analyze the amount of time spent on various teaching and management tasks, and provide feedback on their performance. In both cases, basic skills analysis and teaching performance analysis, the faculty find that there is not sufficient time in the students course of study to master these important but diverse skill domains.

Department of Educational Technology
Interactive technologies is one of three areas of specialization within the newly formed Ph.D. program offered by the Department of Educational Technology. An important part of the training for doctoral students in this area of specialization is participation in the design and development of "real world" applications of computer-based instruction; including: computer-assisted interactive video, multimedia, hypermedia and learning environments. Additionally, these types of projects provide tools for ongoing research about effective instructional design. As the Ph.D. program continues to expand, the department needs content areas to supply design and development projects as a basis for doctoral student training and ongoing research.

Collaboration
The solution for each program is to collaborate on the design, development, evaluation and implementation of interactive multimedia technology which provides introduction and practice on the more basic concepts and skills of analysis, freeing classroom time for more advanced instruction. This partnership began with Mathias' (1990) doctoral dissertation which examined interactive videodisc applied to swimming stroke analysis. This interest led to the development of the Swimming Stroke Analysis videodisc program (Mathias and Smith, 1990). Two projects followed shortly after, Tennis Skill Analysis (Chung, Munson, Smith, & Phillips, 1992) and the PETAI Training Tutorial and Database of Pedagogical Knowledge in Physical Education (Horton, Gregg, Phillips, & Smith, 1992). In light of the unique aspects of this collaboration, this paper will describe the design, development, evaluation and implementation of the PETAI-IV as a model of interactive multimedia program production.

The Physical Education Teacher Assessment Program (PETAI)
The PETAI was designed to measure alterable teacher and student behaviors exhibited in the physical education classroom (Phillips & Carlisle, 1983). The model from which the PETAI was developed consisted of three teacher and three student behavior categories and their corresponding subparts. The scores for two teacher and two student behavior categories are obtained by recording continuous time intervals for each behavior change. This is accomplished by coding a videotape of the class session using the computerized version of the PETAI (Phillips, Carlisle, Steffen, & Stroot, 1986). As an educational tool for physical educator training at the University of Northern Colorado, the PETAI is initially introduced to physical education majors who enroll in a required junior level 10-credit-hour Methods of Teaching and Evaluation Block. The students ultimately use the PETAI to measure their own teaching progress during their field experiences. In-service physical educators have also gained exposure to the PETAI through workshops, conferences, satellite colleges and physical education pedagogy graduate courses offered at the University of Northern Colorado.

Following from the successful use of the previous IV programs in the physical education program and based upon the need for more efficient means of delivering instruction, professors in each of the collaborating programs initiated a plan to design and develop an interactive video training tutorial for using the PETAI.

Design Parameters for the PETAI-IV
Given the broad range of potential users of the PETAI-IV a two phase program of design and

development was formulated. In Phase 1, as part of a doctoral dissertation study, the PETAI-IV would be field tested in an undergraduate physical education methods course. Based on the results of this field test, Phase 2 would expand the PETAI-IV into a more robust learning instrument that could be used in the classroom or as a reference resource. The initial instructional goal, for Phase 1, was to train the student to use the computerized PETAI for identification and coding of teacher and student behavior variables as defined by the Physical Education Teacher Assessment Instrument (Phillips & Carlisle, 1983). However, since the evaluation of Phase 1 was conducted as part of a doctoral dissertation, in order to satisfy the requirements of the dissertation research, two additional goals were added; understanding PETAI content knowledge and understanding pedagogical knowledge in physical education.

Chen (1990) listed three obstacles that discourage the implementation and use of IV in education: 1) limited amount and lack of quality of IV programming, 2) prohibitively high price of IV systems and interactive program production, and 3) teacher and staff resistance to implementation and integration of IV instruction into the curriculum. To make every conceivable effort necessary to increase the likelihood of the successful development and implementation of the PETAI-IV, a design team was selected, each with particular skills that addressed each of these three obstacles.

The PETAI-IV team was composed of a content expert, authoring languages/computer expert, video technician, and a facilitator. The content expert and the facilitator were from the School of Kinesiology & Physical Education and the computer and video experts were housed in the Educational Technology department. Each team member contributed to the instructional design, although primary duties were shared by the content and video experts. The team members from the Physical Education department had no formal training in instructional systems design (ISD) but were experts in the area of pedagogical knowledge in Physical Education, whereas the team members from the Educational Technology department were experts in instructional design.

Smith, in his 1987 review of the use and implementation of interactive video, stated that there had been little discussion of interactive video design models in the literature perhaps due to the implicit assumption that "any good instructional design model can be adapted to the medium" (p. 7). Furthermore, he indicated that in the absence of a specific design model IV designers rely on experience in media production, CBI, and instructional design. Tripp and Bichelmeyer (1990) proposed an approach to instructional design for computer-based software using the principles of rapid prototyping. They listed several situations for which rapid prototyping might be appropriate including design problems for which conventional methods have proven unsatisfactory and new design situations in which an abundance of experience is lacking.

The first design and development phase of the PETAI-IV was initiated using traditional instructional design methodology. Several videodisc design and project management models were used as the basis for design, development and project management decisions (Hooper & Hannafin, 1988; Kelly, Walkley, & Tarrant, 1988; Tarrant, Kelly, & Walkley, 1988; Strohmer, 1988). Growing pressure due to the constraints of time and budget led the design team to shift to a more pragmatic and efficient macro-design methodology, employing many of the principles of rapid prototyping. For Phase 2, the design team will use rapid prototyping methodology as a model for design and development instead of more traditional instructional design methods. Hooper and Hannafin's (1988) ROPES model will guide micro-design decisions.

Design assumptions and solutions were based upon current knowledge in pedagogy in physical education and cognitive learning theory. Learning from media, according to Salomon (1983), is a function of the degree of mindful engagement by the learner throughout instruction. Based upon several reviews of IV design (Chen, 1990; Cronin & Cronin, 1992;

Smith, 1987), the PETAI-IV design team made specific design decisions regarding attributes of interactive video thought to promote active involvement and deep processing on the part of the learner, including: 1) degree of interactivity, 2) learner control, and 3) feedback.

Development

Several factors influenced the design and development process:

- time limitations,
- budget constraints,
- restrictions to meet needs of the dissertation research, Phase 1 goals and Phase 2 goals,
- Windows-based platform requirements.

The ultimate goal of the PETAI-IV was to use the characteristics of interactive video to produce a high quality teacher preparation educational tool which could be implemented at various stages in a teacher's career. However, the first step was to design a training tutorial that met the needs of the field test dissertation research. It was determined that a highly flexible authoring environment would be necessary to accomplish both directives. Furthermore, at the outset, given the timeline for development and evaluation and the relative inexperience of the primary development team members, a traditional instructional systems design approach was abandoned as being too time consuming and possibly inefficient. Again, a more flexible approach was adopted using the principles of rapid prototyping.

ToolBook by the Asymmetrix Corporation was chosen as the authoring environment since it met the requirements for plasticity and modularity needed for rapid prototyping (Tripp & Bichelmeyer, 1990) and it was Windows-based software. Software development using an authoring environment such as ToolBook or HyperCard can be time consuming. However, the design team estimated that use of the rapid prototype design model would more than offset the additional software development time. The choice of a flexible authoring environment was validated when a pilot test of the PETAI-IV led to restructuring the sequencing of program modules. Such a last minute revision could not have been accomplished using most types of authoring software.

Hoekema (1983) stated, based upon familiarity with television, viewers expected broadcast quality video production value. This level of video production was not possible for this project. However, an analysis of the decision making process for coding the PETAI revealed that in most cases the salient information that indicates a switch in behaviors was verbally indicated. Thus, even using a video acquisition format of mediocre technical specifications (sVHS), the designers were able to produce a videodisc of acceptable quality by paying particular attention to shot selection and use of color to focus attention within the frame, and by recording broadcast quality audio.

The final form of the PETAI-IV was built around an instructional unit including definition, video examples and related pedagogical knowledge for each of the teacher and student variables as defined by the PETAI. A brief review with practice was placed at the end of each major section of teacher and student variables: teacher instruction time, teacher management time, student participation time, and student management time. Following each of the two major components, teacher behaviors and student behaviors, were a non-assisted coding practice exercise and a guided PETAI coding practice. Each unit allowed for learner control of pace and review. Elaborative feedback was provided to the learner in response to learner input for all practice items within the section review and within the non-assisted coding exercise. The non-assisted coding practice consisted of several examples of teacher or student behavior requiring learner response after each behavior. After incorrect responses the learner had the option to try another input, to repeat the stimulus video, or to review the relevant material. Completion of each coding practice exercise required correct identification of the teacher or student behavior in every video example.

Evaluation

Ongoing formative evaluation is implicit in the rapid prototyping model of design. This type of evaluation was used throughout the development of Phase 1 of the PETAI-IV. As was stated previously, results from such an evaluation led to a major restructuring of the program sequence and indicated the necessity of adding another section of practice coding at the end of the training tutorial.

Horton (1992) has reported very encouraging results using the PETAI-IV in a teacher preparation study. The method of evaluation was a media comparison study, a type of study that has been criticized in the literature (Clark, 1983). Slee (1989) asked "do we really need to compare in order to justify" (p. 3). As part of a formative evaluation, a media comparison field test provides important data for decision-makers considering implemention of a new instructional system within the curriculum.

Students who have used the PETAI-IV have perceived the interactive videodisc instruction as effective and useful. Many students felt that they were more active learners while using the IV system. Furthermore, the students felt the PETAI-IV adequately prepared them to properly identify and code teacher and student behaviors using the PETAI.

Preliminary analysis investigating the use of the PETAI-IV was recently initiated. Results indicated a confirmation of the Horton study using another method of calculating achievement based on a cumulative accuracy score. Using a modification of audit trail recording (Misanchuk & Schwier, 1992), the IV users were categorized by path selection and proportion of errors in practice exercises. People who performed with fewer errors significantly differed from those with high error performance in a number of areas including accuracy and attitude. Analysis is proceeding to determine the reasons for the differential error rate.

Implementation

The evaluation results indicated that the PETAI-IV tutorial was as effective as traditional classroom instruction yet required much less instructional time. Based upon these results, the PETAI-IV program is being integrated into the preservice teacher education curriculum of the School of Kinesiology & Physical Education. Restructuring the curriculum, even at such a small scale, will not be accomplished without difficulty. Technical support, student reaction and cooperation, and faculty support have already become key implementation issues. Even with the highest quality design and development of IV programming, success of this or any instructional interactive video program depends on proper implementation (Russell, Sorge, & Campbell, 1991). As the design of the PETAI-IV moves into Phase 2, the facilitator assumes a critically important role within the design team.

Conclusion

Phase 1 of the development of the PETAI Training Tutorial and Database of Pedagogical Knowledge in Physical Education (PETAI-IV) took only five months to complete with actual cash outlay totalling less than $1,000.00. The development of the PETAI-IV system took a commitment from a team of individuals. Approximately 1,000 man-hours of time was devoted by the team to the development of the PETAI-IV system. The successful collaboration of the design team has created new opportunities for both programs. The physical education program has a validated instructional system that is being integrated into their curriculum. The educational technology program has a continuing source of design and development projects for doctoral student training. Both programs are benefitting from the results of the ongoing research generated by these projects.

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Using a ToolBook® Database Front End to Manage Multimedia Resources

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Abstract
Managing resources for multimedia is becoming a nontrivial task. The presentation describes and demonstrates a database approach for managing multimedia resources using an Asymetrix Multimedia ToolBook® database front end. The resources demonstrated include different content formats such as text, graphics, animation, audio, still images and motion video. Storage media includes optical devices (*e.g.*, CD-ROM, laser videodisc), a PC-VCR, and an audio library. A new term, **resourcebase**, is proposed for multimedia and Microsoft's RIFF format is advocated for file types.

Background

Resources available for multimedia are popping up so fast that managing them is a nontrivial task. Traditionally, such resources were fairly easy to manage. For example, a computer-based video instruction program had one set of resources. The program "owned" that set of resources and the format and access path were a part of the program (see Hassett, Hassett & Unger, 1991). With current multimedia, a given resource may be shared by numerous programs; there is a growing independence of resources and programs. One may wish to use the same audio resource in two different multimedia programs and be unable to locate the original resource. If one has audio libraries, graphics libraries, scanned images, *etc.*, finding a particular resource in real time is often difficult.

The impetus for this paper came in 1991 with the proliferation of multimedia resources, such as those on CD-ROM, and the overwhelming task of keeping track of them. Resources such as bitmap graphics and audio waveforms were created, modified and merged as applications were developed, but without history or documentation. Later, when these resources needed updating or modification, things got sticky. For example, what might start off as a prototype could evolve into a final product. Without a method to link various resources to their origins, or documentation on how the resources were created, issues such as copyright ownership suddenly became important. Also, the sheer <u>number</u> of resources became unmanageable. Miller noticed a difference between end-user functions for a videodisc player *versus* CD-ROM (MIller, 1992). One can easily search videodiscs for chapters or frames. For CD-ROM, however, such end-user functions are not readily available.

The database approach addresses problems with data management. Since a similar phenomenon has taken place with *data* as compared to multimedia resources, a review of the database approach became the starting point.

Database Approach

Databases are integrated collections of automated data files related to one another to support a common purpose (Stevens, 1991). The database approach views data as being shared by a number of applications rather than being exclusively owned by one application. The conceptual (user) view of the data is independent of the method used to physically store the data. The three most popular conceptual models are the relational, hierarchical and network. And more recently object oriented models have been proposed. The relational model is used as a basis for a number of database management systems such as Borland's dBASE IV.

It became evident that the approach needed to managing multimedia resources is very different from the approach used so successfully for managing data. The paper describes a proposed approach for managing multimedia resources that borrows from techniques used in the database approach: resourcebase. The Asymetrix Multimedia ToolBook is a software construction set for building multimedia applications in the Microsoft Windows 3.0 environment (Asymetrix, 1991b). Multimedia ToolBook® was used to build a database front end and rapid prototyping was used to develop the approach (Hassett, 1992). The multimedia resources include different content formats such as text, graphics, animation, audio, still images and motion video. Storage media include CD-ROM graphics, laser disc video and an audio library.

Traditional Databases

Traditional databases are comprised of data represented by numeric, aphhanumeric and symbol (the smallest unit of storage). A traditional database storage hierarchy consists of these elements: **SYMBOL ☞ FIELD ☞ RECORD ☞ FILE ☞ DATABASE** (see Table 1). For example, a fictitious record company, *FASTRAK Records*, may have a database called CD, in which are listed all compact disk titles, type of music (*e.g.*, contemporary, pop, country) the artists, the titles of the recordings ("cuts") on each disk, the recording label (record company name), etc. Each file contains records (rows) and fields (columns). A typical query of the database might be to list all the recordings by a particular artist and the names of the title CDs that carry these recordings. A database front end created in ToolBook would provide *FASTRAK* with friendly end-user functions (Asymetrix, 1991a).

Database Front End

A ToolBook database front end provides instant access to functionality, accessing data with a Dynamic Link Library (DLL) or Dynamic Data Exchange (DDE) (Asymetrix, 1991a). ToolBook ships with a sample database front end that provides access to dBASE or dBASE III files. (One does not need to own dBASE to use the DLL.) The database front end provides the following:

1. maintenance of data in its original form;
2. an easy-to-use functions with the database, including:
   a. ways to view all data
   b. ways to reorganize the data to be viewed

c. ways to add new data or modify existing data; and
3. hiding the complexity of the database manipulation language.

Resourcebase Approach for Multimedia

A new term, **resourcebase**, is proposed as a new approach for multimedia management. Resourcebases are integrated collections of automated directories containing tagged resource files and related to one another to support multimedia (Hassett, C. M., 1992). The smallest unit of storage in a resourcebase, as in a database, is a symbol. Observing multimedia resources, it is proposed that the resourcebase storage hierarchy consists of these elements: **SYMBOL ☞ RIFF CHUNK ☞ FILE ☞ DIRECTORY ☞ RESOURCEBASE** (see Table 1). For example, an author may have a multimedia resource called MM, in which are listed all audio objects (*e.g.*, sound effects, music), graphics objects (*e.g.*, clip art, figures, scanned images), animation (*e.g.*, multimedia movies), commonly used text objects, and video objects (*e.g.*, digitized motion).

Table 1.
Resourcebase vs. Database

Resource-base	Database
•DIRECTORY	•FILE
•FILE	•RECORD
•RIFF CHUNK	•FIELD
•SYMBOL	•SYMBOL

Resourcebase: C. Michael Hassett, 1992

Prototype: Resourcebase

The work station for the prototype consisted of the following: IBM PS/2 Model 95 microcomputer with IBM M-Audio and M-Motion boards, a NEC MultiSync 5FG display, a Pioneer CD-ROM Changer DRM-600, an HP LaserJet IIIsi printer.

Primary

Primary multimedia resources include those that are device dependent and those device independent (Figure 1). Device dependent resources include: CD audio, laser videodisc and audiocassette tapes. The prototype uses all the device dependent and independent resources.

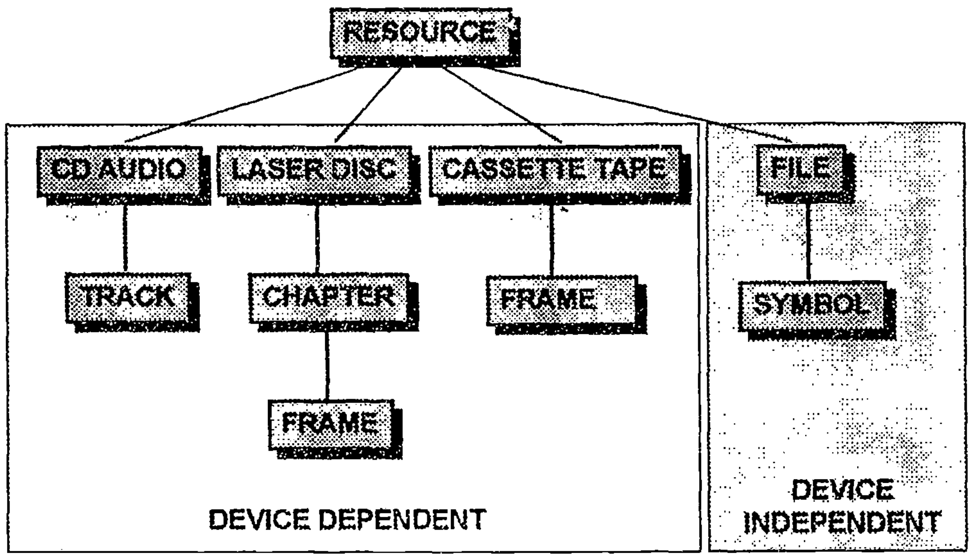

Figure 1. Primary multimedia resources.*

*Developed by C. Michael Hassett, 1992

Secondary

Secondary multimedia resources include: digitized images (*e.g.*, photographs), and digitized audio (*e.g.*, recordings). Secondary resources often require special handling. One excellent advent is the audio library, such as the Prosonus MusicBytes™ (Prosonus, 1991). MusicBytes provides excellent music, sound effects and MIDI resources.

Resource Interchange File Format (RIFF)

In a traditional database, similar data are grouped together as records in one file. Multimedia resources, however, presently require one file per resource. The resource must be referenced using the file name; in the Microsoft DOS/Windows environment, this means eight characters for the name and three characters for the extension. With this limitation, one must be quite creative to properly manage even a small number of resources. What was needed was a way of attaching the reference data to the file. The Microsoft RIFF file format, along with a complete set of I/O (Input/Output) services, provided the solution. Resource Interchange File Format (RIFF) is a platform-independent multimedia specification allowing audio, graphics and other multimedia to be stored in a common format (Miller, Sayers, Reeve & Kasten, 1991). The first attempts to manage resources using file names and indexing was abandoned as soon as RIFF became available (Figures 2 & 3).

The RIFF file format is a tagged file structure that allows chunks of data (called "RIFF" chunks; see Table 2 for sample registered chunk IDs) to be stored with multimedia resource data (sound, graphics, multimedia movies, palettes) in one file. RIFF forms are registered with Microsoft Corporation. A list of sample registered forms is found on Table 3.

RIFF has a counterpart, RIFX that can be used to define RIFF file formats that use the Motorola format rather than the Intel format. Like RIFF the RIFX forms must be registered. The Windows 3.1 Software Development Kit (SDK) provides a number of functions for managing RIFF I/O services. For example the functions **mmioAscend** and **mmioDescend** ascend and descend the chunks of a RIFF tagged file structure.

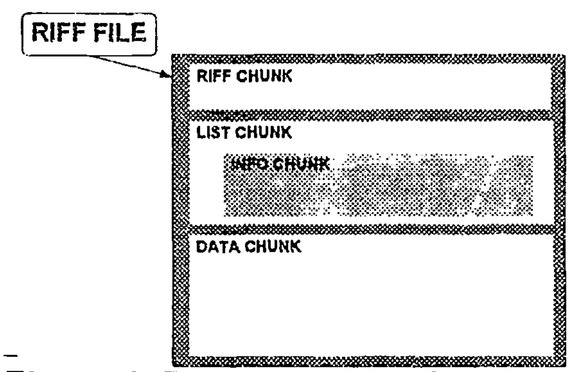

Figure 2. Resource Interchange File Format (RIFF).
Microsoft Corporation. (1992). Multimedia programmer's guide.

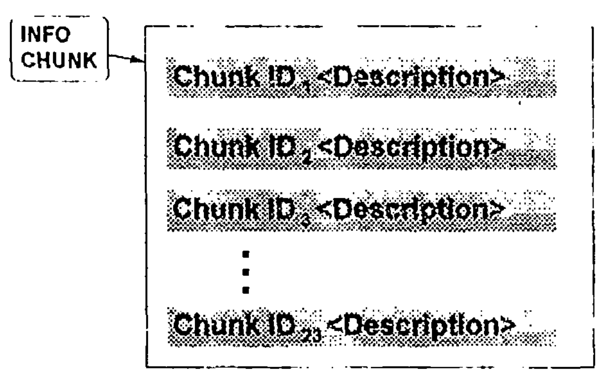

Figure 3. RIFF INFO chunk.
Microsoft Corporation. (1992). Multimedia programmer's guide.

Table 2.
Sample Microsoft Four Character INFO Chunk IDs

Char	INFO Chunk ID
IARL	*Archival Location*
IART	*Artist*
ICMT	*Comments*
ICOP	*Copyright*
ICRD	*Creation Date*

IDs Registered by Microsoft, 1992.

Table 3.
Registered RIFF Forms

Form Type	Description
PAL	Palette File Format
RDIBRIFF	Device Independent Bitmap Format
RMIDRIFF	MIDI Format
RMMP	RIFF Multimedia Movie Format
WAVE	Waveform Audio Format

Registered by Microsoft, 1992.

Convert and FileWalker

The Microsoft Multimedia Development Kit (MDK) provides a set of file editing tools. The Convert and FileWalker tools were used to prepare files for the resourcebase. The Convert tool was used to convert non RIFF files to RIFF format. The FileWalker is an editor that performs the following tasks: (a) view the outline and data structure of a file, (b) create new structures, and (c) edit file data. The FileWalker was used to create the RIFF chunks and input the data that is depicted on Figure 4. Future implementations of the book will incorporate these functions and the FileWalker will not be needed.

Implementation: ToolBook Front End Prototype

Asymetrix Multimedia ToolBook proved to be an excellent tool for developing a resourcebase (multimedia database) front end. The Widgets Book provided the controls for managing most multir iedia resources. When the controls (buttons, fields, *etc.*) were copied to the new book, the scripts were included. Only minor debugging was required to make the controls functional in the new book. A major advantage of ToolBook is that features can be added without making major revisions in existing features. For example, controls for viewing reference information in an audio file such as Author, Copyright, *etc.*, was added to a book page. Later, controls were added to audition the audio. This type of activity was essential for the rapid prototyping development.

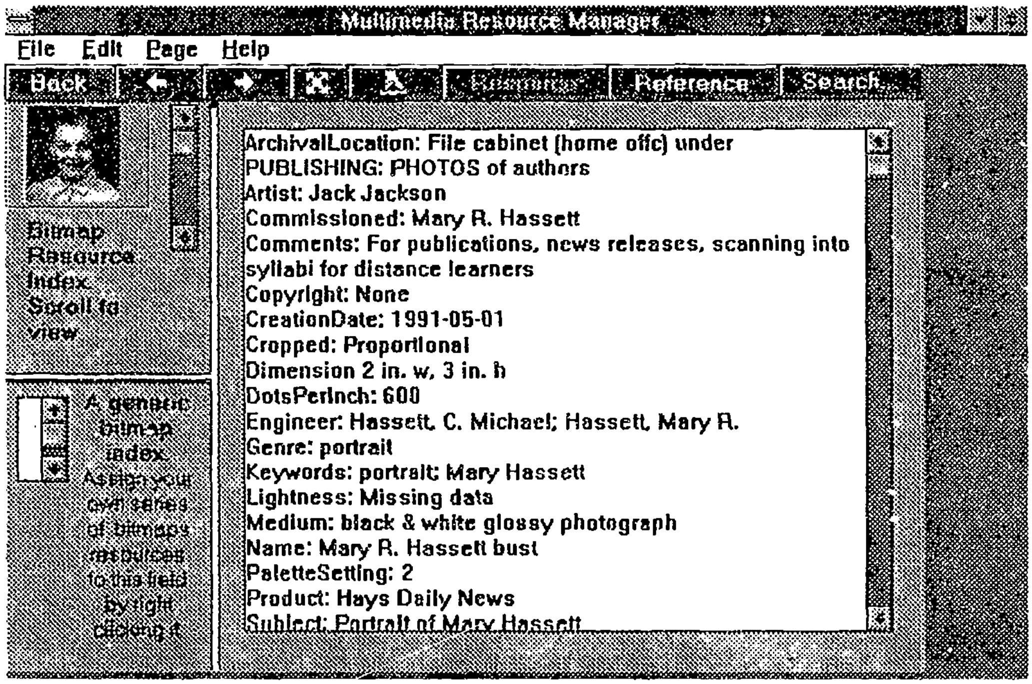

Figure 4. MM Resource Manager page.

Created w/ Asymetrix MM TookBook by C. M. Hassett & M. R. Hassett, 1992.

Dynamic Link Libraries

ToolBook did not provide I/O (Input/Output) services for the Microsoft RIFF file format. It was necessary to write a Dynamic Link Library (DLL) to provide ToolBook access to the RIFF files. Writing the DLL required a Microsoft C compiler and Microsoft Software Development Kit (SDK). The Borland C compiler can also be used to write DLLs. The Microsoft C++ version 7.0 and Microsoft Windows 3.1 were used. SDK was used to write the final DLL. A good starting place when writing DLLs for ToolBook is to download the notes and examples from the Asymetrix Bulletin Board Service. The gnosis.zip example file contained a sample ToolBook book that used a DLL, a compiled version of the DLL and a Microsoft C version 6.0 source code version. Only minor changes were necessary to compile the DLL using the new Microsoft 7.0 C++ compiler.

This source code version of the DLL was used as a "shell" and the required RIFF I/O functions were added to support the resourcebase front end ToolBook. little work, it can be done. the ability to write DLLs greatly extends the opportunities available to a Microsoft Windows user.

Using the ToolBook Front End Prototype

The ToolBook Front End Prototype is organized into ToolBook pages, based on the type of resource and the management function. For example the page in Figure 4 allows the user to select a directory and then view all the bitmap resources in that directory. Additional pages provide resource management for special requirements. For example the resourcebase might contain person photos (bitmap), person recorded names (waveform) and person signed signatures (bitmap). The user can select a person photo directory to view all the photos and related signatures. While a given photo is displayed the recorded name related to that photo and signature can be auditioned. The user can initially select any of the three resources and the ToolBook Prototype will automatically match the other two related resources.

Conclusions

The RIFF file format has provided a partial solution to managing multimedia resources (resourcebases). What is lacking is registered forms for video. It is expected these will be forthcoming when video is commonly digitized (*e.g.*, with Digital Video Interactive, DVI). The authors recommended that the concept of resourcebases for multimedia be tested and evaluated.

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A PRIMER ON DVI: DIGITAL VIDEO INTERACTIVE

Dr. D.V. Pigford
Western Kentucky University

ABSTRACT
This paper on Digital Video Interactive will highlight the basic technical details and applications of this new technology. DVI is a hardware/software platform designed to foster the rapid transmission of digital video/audio on Intel 386 or MacIntosh personal computer networks. Topics covered will include a brief overview, developmental history, hardware basics, software implementations, and project applications.

OVERVIEW OF DVI
Digital Video Interactive or DVI is a technology, not a system. This technology allows for the storage/display of audio and video files for enhancing multimedia platforms. The all digital formats from a DVI system, unlike the interactive videodisks systems, allow for the editing, transforming, and sending of audio/video files across a microcomputer network.

A DVI system consists of four components: a set of custom VLSI chips, audio/video file specifications, formats for a run-time interface, and a set of compression/decompression algorithms. These components are commercially available as Action Media II products from Intel/IBM and the EyeQ board from New Video Corporation for the Macintosh. From a user's perspective, a typical DVI system is comprised of a personal computer or workstation with Intel's Action Media II playback card, system software, and a CD-ROM drive. With the addition of the capture card and peripherals (videotape player, audio cassette player or camera), a user can create multimedia elements (motion video, 3D graphics, and multitrack audio) for display/play.

DVI multimedia products are currently being developed on the following personal computer platforms:

Operating Systems: OS/2, Windows 3.1, DOS
Computer Bus: AT, Micro Channel, NUBus (MacIntosh)
Processor: Intel 386 SX, Intel 386/DX, Intel 486, Motorola 6800
Media Format: CD-ROM, Hard Disk, Network
Graphics: VGA, XGA
Network Support: Token Ring, Ethernet, Fiber Optic

Since these multimedia elements are all in a digital format, they can be stored on any random access storage device and even transmitted across a network. The DVI platform, moreover, allows content to be developed once and employed in several environments.

DEVELOPMENTAL HISTORY OF DVI
Realizing the potential for an all digital multimedia system, the Radio Corporation of America (RCA) began such investigations in 1983 at its central research laboratory, the David Sarnoff Research Center in Princeton, N.J. Even though a team of fifty people headed by Arthur Kaiman worked on the project development, Larry Ryan is usually termed the "Father of DVI". In 1986 RCA sold DVI rights to General Electric. At that time the DVI technology was capable

of playing full motion digital video from a CD-ROM. In March 1987 DVI was shown publicly at the 2nd Microsoft CD-ROM Conference in Seattle, WA.

In November 1990 Intel introduced a set of components (the i750 video processor) which allowed manufacturers to add digital video and audio to personal computers. In October of the next year Intel and IBM introduced powerful cost effective add-in boards (based on an upgraded version of the same video processor) called Action Media II boards to foster multimedia software development across the OS/2 and Windows environments. Currently the ActionMedia II boards cost about $1900 and the MacIntosh DVI boards run about $2500.

HARDWARE BASICS OF DVI

From a hardware perspective, a DVI video system is composed of the following components:

- 82750PB Pixel Processor
- 82750DB Display Processor
- Video RAM
- Host Microprocessor Interface Logic
- VRAM timing generator

A video digitizer and video buffer/mixer are optional components.

The pixel and display processors are based on the i750 chip set. The 82750 RB pixel processor runs its own microcode to perform operations on digital images at 12.5 MIPS (Millions of instructions per second). The processor can compress/decompress image data from memory to generate fast graphics and special effects at a rate of 2.5 million 16 bit pixels per second.

The 82750 DB display processor takes data from a bitmap in VRAM and converts it to a digital output signal which feeds a triple D/A converter to drive a color RGB monitor. The possible outputs are compatible with NTSC or PAL standards. The bpp (bits per pixel) ranges across 8, 16, and 32 with screen resolutions up to 1024 by 512. The video resolution is 256 by 240. The display processor allows the screen resolution, active pixel area, video and synch formats, screen border, interrupt generation, and color map entities to be programmed [Luther89].

The hardware handles both still video images and video sequences (movies). A still image file (512 by 480) ranges from 15-35K in the JPEG standard (Joint Photographic Experts Group). A PIC file format for video images ranges from 80-115K or 150-250K. The PHOTO CD Image format used by Kodak for its PHOTO CD products is also supported. The video sequences are much larger. It takes 18 million bytes of data moved per second to produce 30 frames of video per second. The hardware compresses each frame to 150,000 bytes on CD-ROM.

The algorithms for the compression of video frames throw out the redundant pixel information keeping only new information relevant to the previous frame. The algorithm stores only one out of every few pixels during compression. During decompression, an interpolation scheme is used to recreate the missing pixels. These schemes along with current improvements enable a motion video frame to be compressed to a ratio of 160 to 1. A DVI board is required for playback of any video/audio.

DVI algorithms support two modes of motion video today, RTV and PLV. RTV (Real Time Video) is produced in real time and is near VCR quality. PLV or Production Level Video equals VCR quality but it must be produced offsite by a licensed vendor.

In summary, the DVI hardware supports both still and motion video standards and uses compression/decompression algorithms to effect digital video.

SOFTWARE DEVELOPMENT FOR DVI

In any technology, the development software must work in harmony with the hardware. The DVI development platform consists of a runtime software library, runtime include files, font files, microcode files, driver files, and "authoring tools". The authoring tools are termed the API or video Application Programmer's Interface. These tools consist of high level C function calls to the runtime software along with lower level C language interfaces and a VGRCMOD interpreter. These C function calls control the videodisk functions, synthetic video, video manipulation, and high speed graphics.

The C application code is linked with four system submodules for graphics, audio/video, real time execution, and standard system functions. The GR submodule handles graphics primitives, video manipulation, and image handling. The AVSS A/V unit supports the playback of audio/video files in the AVSS format and the audio/video playback from CD-ROM, hard disk, or RAM. The RTX unit provides for multitasking inside of the FVI application whereas the STD module handles system functions like memory management, input/output, and error handling. When an application is running, the video, audio, VRAM, and CD-ROM drivers are resident in memory along with the Microsoft CD-ROM extensions.

Presently the DVI authoring tools are most useable by trained C programmers; however, authoring systems are evolving on the market today. Authology from Ceit Systems is a DVI application tool for the DOS environment. MediaScript from Network Technologies is a similar DOS multimedia authoring tool. Both companies plan extensions to either the OS/2 and/or Windows platforms. MediaScript utilizes a visual programming interface for high level multimedia applications. In the Summer of 92 IBM announced two video editing packages, LinkWay Live and Audio Visual Connection for the Windows 3.1 environment. The applications interface is now termed the AVK or Audio Video Kernel.

With an all digital format for video and audio, the DVI environment is a natural for utilization in a networked environment. Network support software called Videocomm for Novell Netware, DOS, and Windows platforms is available from the ProtoComm corporation.

As the software tools evolve and improve, the applications development will definitely increase. Project Applications with DVI With the advent of DVI hardware and software development, application development in multimedia will spiral. Applications range from code review training at Carneige-Mellon University to weapons maintenance training at General Electric Advanced Technology Lab. The following chart summarizes some initial DVI development applications in progress [Ripley89].

APPLICATION AREA	BETA SITE
Truck Driver Safety Training	Applied Optical Media
Clothing Store Point of Sale	Auteur, Inc.
Military Intelligence	Betac Corporation
Steel Casting Training	Bethlehem Corp, & Lehigh
Courseware Development Software	CBIS, INC
Process Control Technology	Dow Chemical
Imaging Systems	Eastman Kodak
Submarine Maintenance Training	General Dynamics
Military/Government Applications	General Electric
Image Storage/Analysis	LTS Corporation
Movies of the Future/Workstations	M. I. T.
Travel Agency Information	Comsell
Educational Products/Exhibits	National Geographic
Training and Merchandizing	Spectrum Interactive
Paint and 3-D Animation	Time Arts, Inc.
Entertainment/Training	Video Design Group, INC.
Furniture/Interior Design	Videodisk Publishing, Inc.
Virginia Polytechnic Institute	Authoring, Education

This list of project applications is expanding rapidly as more and more business, training, and educational multimedia applications are developing.

One interesting application in education, codeveloped by the Bank Street College of Education, is entitled Palenque. This interactive multimedia program allows children aged eight to fourteen to explore a multimedia database about the ancient Mayan sites. In this multimedia application, 360 degree panoramic views are accessible under full user control at interesting points throughout the sites.

SUMMARY

Digital Video Interactive or DVI is a technology in its second generation of development. With its combined hardware and software, the DVI environment can handle audio and video in all digital formats. Once in this all digital format, compressed files can reside on a server for playback on a network of personal computers. With the emergence of recent cost effective commercial products, DVI is a viable multimedia authoring and delivery platform for training and educational endeavors.

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Selected Abstracts for the

Special Interest Group for Pilot (SIGPILOT)

The Compatibility Problem in Designing and Developing Educational Software with the New Generation of Smart Tools

Emile Attala and Tommy DeMoville, California Polytechnic State University

To be able to develop educational software in interactive media and related technologies, the designer needs to have authoring systems that can accommodate and be compatible with several standards of digitized graphics files and captured video files. Authoring systems should provide single button database management systems that can maintain, restore, reclaim, and perform archive backup to all these different files.

What developers face today is working with graphics file standards that are anything but standard. Part of the problem comes from the attempts to maintain compatibility with older formats. This would allow, for example, a VGA system to reproduce CGA and EGA images on the screen and allow older software to continue to run. This compromise creates conflicts between the formats of different color palettes that depend upon the resolution in which they were created. A picture done at one resolution with a given color palette may undergo a color rotation when brought into an authoring language that uses a different resolution. Cyan may change to yellow, red to blue, brown to grey and the resulting output to the screen may not be recognizable to the initial designer.

Resolution conflicts may also produce pictures that are stretched or compacted along one axis or another. Just going from an original 640 x 480 resolution picture to a program expecting 640 x 350 input would result in a multi-colored garbage screen.

Two paint programs rarely produce the same graphics file format. A PCX file is not equivalent to a GIF, MAC or TIFF file. There are even differences between PCX file formats from one company to another or even from the same company with a different release date.

Software developers have tried to work around this problem by creating capture programs that can grab a screen and output a file in the format needed for a given authoring system. They still haven't mastered the ambiguity of the various resolutions and color palettes produced by the variety of video formats available now on the market. Fifth generation object-oriented authoring systems need to be designed to eliminate these conflicts.

Selected Abstracts for the

Special Interest Group for Theory and Research (SIGTAR)

The Application of Motivational Principles to Visual Screen Design

Charles F. Belinski and Jimmy Williamson, The University of Georgia

This session will consist of; a brief description of the ARCS model, a description of environmentally-centered motivational theory, a listing of ergonomic considerations, and a brief discussion concerning components of visual design and instructions on integrating these factors when designing visuals. The emphasis will be on designing appealing and effective instructional materials and visuals.

Using the ARCS Model as a starting point, a taxonomy of motivational characteristics will be offered that can be applied to visual design. Keller's Model as well as other motivational theories will be used to derive a tool for applying motivational considerations to visual design. An emphasis will be placed on screen design. However, a number of media, both still and motion, will be addressed.

Basic visual ergonomics will be addressed, particularly as they relate to screen design. Considerations such as eye fatigue and visual clarity will be discussed briefly. The discussion on the components of visual design will briefly define concepts such as shape, color, perspective, and depth.

The bulk of the presentation will consist of examples of visual design and explanations of the motivational factors considered when creating these examples. Demonstrations of the various characteristics will be done in three formats; still visual, motion media visual, and computer screen visual. A special emphasis will be placed on the application of motivational characteristics for designing computer screen visuals and multimedia applications.

Computer Adaptive Testing: Preparation and Analysis of the Item Pool

Randal D. Carlson, The Pennsylvania State University

The purpose of this study is to report on the calibration and analysis of an item pool that is to be used in a larger study of adaptive testing. Over 14,000 freshmen completed a 72 item mathematics placement test at a large eastern university. From these respondents, a random sample of 1000 was drawn from the approximately 2000 respondents that had answered every test item. Using Item Response Theory, 1-, 2-, and 3-parameter logistics models were fit using the PC version of BILOG3. This program uses the marginal maximum likelihood method for item calibration.

A principal axis factor analysis with the screen plot for factor extraction as well as a dimensionality test suggested by Bejar (1980) provided evidence that the 72-item pool met the assumption of unidimensionality. The 3-parameter model computer by BILOG seemed to have the best fit, with only 3 items showing fit statistics with p-values of less than .01.

ANOVA with Tukey *post hoc* comparisons were used to compare the parameters and fits for both data sets. The items selected for inclusion under various selection criteria are contrasted among three parameterization models.

Models for Using Computer Facilitated Communications to Enhance Instructional Interactivity

Norman R. Dodl, D. Michael Moore, and John K. Burton; Virginia Tech

This presentation examines several models of instructional interactivity within a distance education structure. Satellite delivered video and computer facilitated communication provide the primary contexts within which interactivity is discussed. Two Virginia Department of Education programs, the Electronic Classroom and Virginia Pen, provide examples for explaining the models presented.

Instructional interactivity is defined as verbal interaction between a teacher and one or more students. Verbal interaction occurring within conventional classrooms has been exhaustively studied, however, in the distance education context the research is far from exhaustive. Because face-to-face interaction is not generally assumed as a given within distance education, the models presented in this presentation provide useful springboards for much needed instructional research.

Models for interactivity are presented for three instructional stages: 1) predelivery; 2) during delivery; and 3) post delivery. While the models presented include such conventional means as voice and fax transmission, the major focus for this presentation is on computer facilitated communications. Satellite instructional delivery and wide area interconnectivity via computers are becoming relatively common at the higher education level but are expanding rapidly to the K-12 arena. The models for enhancing instructional interactivity by integrating the unique capabilities of these two technologies presented in this presentation are offered in the hopes of generating increased dialogue and research among those interested in enhancing the interactive dimensions of the distance education process.

What is the Place of Theory in Instructional Design and Educational Technology? A Discussion of the Implications for Research and Application

Michael J. Jacobson, The University of Illinois at Urbana-Champaign;
Steven Tripp, University of Kansas;
M. David Merrill, Utah State University;
David Jonassen, University of Colorado at Denver;
Cynthia Leshin, Maricopa Community College;
Barbara Grabowski, The Pennsylvania State University

This panel discussion considers the role of theory in the fields of instructional design and educational technology. This is an important topic given concerns in the literature about general epistemological and philosophical issues, lack of theoretical perspectives in research and practice, and inconsistent and poor quality research. Furthermore, recently there has been a renewed multidisciplinary interest in the psychological and educational foundations of technological learning environments. The potential exists for renewing and extending the intellectual foundations of fields associated with the design and use of instructional technologies based on the juxtaposition of ideas from different disciplinary paradigms and different communities of scholars, researchers, and practitioners.

The panel members will discuss important themes and issues related to the central role of theory in the design, research, and use of instructional systems. The following topics will be discussed: Dr. M. David Merrill, *The Importance of Theory to Instructional Design*; Dr. Steven Tripp, *No Theory of the Design of Complex Instructional Artifacts is Possible*; Dr. Michael J Jacobson, *Confronting a Pluralistic Theoretical Universe: Instructional Design and Recent Cognitive Theories of Learning and Instruction*; Dr. David H. Jonassen, *The Implications of Constructivist Environments for Classroom Implementation and the Evaluation of Learning*; and Dr. Cynthia Leshin, *The Application of Theory and Research to Real World Situations*. Dr. Barbara Grabowski will serve as discussant.

Automating Instructional Design for Teaching Dynamic Processes
Mark K. Jones

Computer-based instruction is attractive for many reasons, but the dollar and time costs of authoring CBI are extremely high. A series of research projects at Utah State University have as their goal the development of methods and tools for automating portions of the instructional design process to reduce those costs. The focus of the research is on three areas: identifying and representing domain-independent categories subject matter, identifying reusable instructional algorithms for these categories, and representing instructional design expertise for customizing the algorithms for specific students, environments, and tasks.

This presentation focuses on a single category of human performance: the operation of devices. Skill in device operation builds primarily upon skills in identifying and locating the parts of the device, comprehending the process which explain the functioning of the device, and knowing the steps of the procedure for operating the device including the conditions under which to perform each step.

Subtopics to be covered include the representation of the subject matter, including device parts, procedure steps, and processes, with a focus on modelling the functioning of the device, and the reusable algorithms for instructing device operation. It is the author's belief that the methods developed for teaching device functioning will apply to other dynamic processes. Examples of the tools being developed will be shown.

Integrated Instruction for Complex Computerized Tools
Joan C. Lee, US Army CERL

Many tutorials have been developed to teach novices to use computerized tools such as word processing and graphics software. After learning with tutorials, users experience little difficulty in using the tools because of previous similar experiences in a non-automated form (i.e. typewriting and hand drawing). However, designing an instructional software for learning a complex computerized tool such as Computer-Aided Design and Drafting (CADD) requires special consideration because many CADD functions have no counterpart in the non-computerized world. Integrated instruction, that which incorporates both domain-specific and experiential CADD knowledge, bridges the gap between the CADD novice and the CADD expert skill levels. The goal of integrating CADD instruction is to provide users with the knowledge and ability to solve real-world problems, whether they be simple or complex, familiar or novel.

We propose an architectural model of integrated CADD instruction where architects learn to respond flexibly to a multitude of design and drafting problems in the CADD environment. The theoretical framework for our model is Rand Spiro;s Cognitive Flexibility Theory, which emphasized situation-dependent knowledge integration rather than the retrieval of general knowledge from an introductory tutorial.

Accounting Instruction through Structural Learning and Elaboration Theories: A Hypertext Comparison

Tom Lightner and Eric Smith, University of Northern Colorado

Two hypertext programs to teach the accounting cycle to undergraduate business majors have been developed with two key proposes: to provide business schools with an innovative way to complement their current instructional methods and to create a vehicle to test two instructional design models.

The programs meet the first goal by using ToolBook's hypertext capabilities to facilitate the linking of related information. The content comprises the basics of the accounting cycle or the breadth of about one third of one semester of college level accounting instruction. The information is presented in small doses with opportunities for practice and immediate feedback. The second goal was met by designing each of the programs with the guidelines of a different instructional theory. One was designed using elaboration theory, while the other followed structural learning theory.

The same development team using the same content and development tools for each theory. The programs were used as adjunct instruction to the instructors' lectures. This paper discusses the research design and results of the pilot study. Results generalize only within this narrow scope, though the authors will speculate on the application of this approach in other contexts.

Can Graphical Browsers Affect a Learner's Structural Knowledge in a Hypertext Environment?

Eileen Schroeder, Penn State University

Traditional linear instruction incorporates an expert's conception of the structure of the knowledge through the organization of the text, text elaboration techniques, or through graphic portrayals of the structure. Learners are thought to assimilate the new information into their own cognitive frameworks, adding to existing structures, modifying them, or creating new structures. Hypertext can allow the designer or user to link information together and create paths through a body of material, offering the learner control over his/her path through the instruction without many of the traditional connective aids.

Building on the theoretical base of information processing and schema theory, this study examines a method for facilitating the acquisition of a lesson's factual and structural knowledge and its integration into the cognitive frameworks of learners with different degrees of prior knowledge. It examines the achievement of students with different degrees of knowledge in the content area using graphical browsers with the links either labeled or unlabeled portraying the structure of the content versus using embedded "hot words" to navigate through the system. Achievement will be measured in terms of the learner's comprehension, factual knowledge, and structural knowledge after using the systems.

The Instructional Media Research Debate: Medium or Message?

Theodore Shlechter, Army Research; J. Dexter Fletcher, Institute for Defense Analysis

A reoccurring debate in the instructional media literature involves determining whether the effects of any instructional medium are due to qualities inherent in the particular medium or to the instructional content, which may be delivered by any media. Clark (1983) has rekindled this debate with regards to computer-based education (CBE) by claiming that the evidence indicated that such instructional media are mere instructional vehicles. And, Dr. Theodore Shlechter (1990) has also argued that conclusive evidence regarding the effectiveness of CBE does not exist. Drs. Dexter Fletcher (1991) and Robert Kozma (1991), however, believe that media effects do exist. Dr. Kozma has argued, for example, that the inherent symbolic system associated with computers makes this technology most appropriate for certain types of educational purposes. Dr. Eva Baker has advocated an alternative position to those previously discussed. She has suggested that any conclusive statements regarding this debate require the development of new evaluation tools which are capable of measuring the complexities of the instructional effects associated with this medium. This panel discussion will thus allow advocates on opposing sides of the instructional media research debate to collaborate in articulating and resolving their differences.

The Application of Cognitive Flexibility and Constructivism Theories to a Hypermedia Course on Thermal Processing

Wendy Snetsinger and Susan Clark, Penn State University

Computer-based instruction delivered in a hypermedia format is an excellent environment to engage learners by providing self-discovery learning opportunities. In essence, this is ideal for applying cognitive flexibility theory and constructivism to hypermedia.

At Penn State University students taking Food Science 430, "Thermal Processing", enter from a wide range of academic disciplines. None have had courses in thermal processing -- which is the theory, mechanics and application of principals used in the preparation of food through canning. This subject involves aspects of at least three disciplines -- chemical engineering, microbiology and nutrition.

One of the objectives of the course is to harmonize the interdisciplinary information in a way that students from diverse perspectives can understand and appreciate the various components. A second objective is for the students to be able to transfer knowledge to new and unique applications.

Through simulations presented in CBI, students are able to see how thermal processing involves the interrelationship of different academic perspectives. Further, the students must make choices as to what variables they wish to analyze and manipulate. They discover immediately through feedback that employs animation, graphics, sound and text, what the consequences are of those choices.

The Effects of Audio Resources on Learning from a Hypertext Bilingual Dictionary

Steven Tripp, University of Kansas

In an extension of research presented in previous years, we looked at the effects of adding phonological information to a hypertext dictionary. As in previous experiments, dependent measures in this experiment are recognition and recall of Japanese vocabulary after learning from a hypertext dictionary. We previously hypothesized that a lack of information about the semantics hyperspace would cause disorientation which would in turn draw upon limited mental resources, reducing learning. We found that disorientation did result in reduced learning, but adding non-congruent orienting devices did not necessarily increase learning. In a follow-up experiment we used congruently metaphorical graphics with an advance organizer. Results supported the hypothesis that congruency enhances retention. With the intention of gaining more information about learning from an elaborated hypertext/hypermedia dictionary, we added pronunciation information to our software. The use of audio resources in computer-based instruction is, to the best of our knowledge, a nearly completely unexplored domain. It is our hypothesis that the encoding of two sources of information (graphemic and phonemic) should allow better retrieval of vocabulary due to the greater number of access routes. In general, the audio channel is an unused and available medium of computer communication and its value should be explored.

The Effects of Graphical Display Characteristics in a Computer-Based Environment

James B. Wells, North Georgia College; Ben H. Layne, Georgia State University

With the increasing sophistication of computational machinery and software packages offering automated visual displays of quantitative information, there has been a recent renaissance of statistical graphics. To meet the challenge of this renaissance, some scholars have emphasized the major need for a thorough review of the entire graphical-statistical methodology and the development of a theory of graphical methods. To illustrate, research with graphical symbols indicates that some of them are not perfectly perceived by the reader and may suffer from biases. With regard to these errors in perception and biases, other problems and questions emerge. For example, should readers be warned about potential graphical biases? Or should the graphical symbols be altered and corrected?

The research question this study will attempt to answer pertains to an investigation of the potential effects of computerized graphical display characteristics on the accuracy and bias of estimates of whisker length of two different types of box-and-whisker plots. Whereas previous research has shown that the regular (unnotched) box-and-whisker plot demonstrated some inaccuracy and bias in its ability to display quantitative information, no research has been performed to demonstrate the effectiveness of the notched box-and-whisker plot.

Computer-Based Research Formats: Utilizing HyperCard to Administer Research Projects and Collect Data

Ronald Zellner, Texas A&M University

This presentation will highlight HyperCard and illustrate how this environment can be utilized to design fully automated, Computer-Administrated Research formats. The design and function of data collection tools to be used by the researcher while observing research activities will also be illustrated. Automated, background data collection which is not part of a specific research procedure will be included. The structure and function of the HyperTalk scripting will be illustrated in relation to text and graphics functions; data collection, storage and display functions will also be covered. The presentation will highlight conceptual and technical information for potential application to a variety of educational research topics. Stacks will be demonstrated to present both the products of the applications (graphics, data collection formats, data sets, etc.) and the underlying procedures (control scripts, files and subroutines).

Techniques for developing research materials will be presented, including graphics scanning, scripting, and importing text and numerical data from utilities such as word processors and spread sheets. Methods of monitoring and recording subject responses in a variety of forms and formats will be illustrated, including response latency timing, text input, multiple choice responses, graphic selection and spatial location. Techniques for data set transfer to mainframe or microcomputer packages (data base, spread sheet, etc.) for analysis will be described.

Selected Formal Papers from the

Special Interest Group for Theory and Research (SIGTAR)

METACOGNITIVE SKILLS IN COMPUTER-ASSISTED INSTRUCTION

Myung-Sun Clinton and James R. Okey, The University of Georgia

Abstract
Computer presentation of hypermedia or hypertext is being implemented in many instructional settings. Because hypertexts are arranged in a node-link fashion which permits learners to explore material in the sequence which makes the most sense to them (based on their existing knowledge base), the importance of metacognitive control of learning is critical. Metacognition refers to an awareness of one's cognitive processes, of what things are to be done, and of how to accomplish them.

Research on self-regulation and monitoring skills of students through the use of metacognitive learning strategies with computer-assisted instruction has had promising results. This paper will review definitions of metacognition and research findings related to metacognitive strategies in CAI. Implications of findings in metacognition for computer-based instructional design and development will be provided.

Introduction

Given the rapidly changing environment of the world, traditional instruction no longer prepares the learner to know their responsibilities. It does not provide a basis for adaptive problem solving which involves careful examination of personal and organizational behavior and the development of workable alternatives (Armstrong, 1989).

What is Metacognition

Metacognition refers to an individual's ability to accurately determine the goal of a given task, apply appropriate strategies to reach the goal, monitor progress toward the goal, and adjust strategies as necessary. Within the last 15 years, metacognition has become one of the major fields of cognitive developmental research.

Flavell (1976) used a description of learning activities to define metacognition:

> " Metacognition refers to one's knowledge concerning one's own cognition processes and products or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition (metamemory, metalearning, metattention, metalanguage, or

> whatever) if I notice that I am having more trouble learning *A* than *B*; if it strikes me that I should double-check *C* before accepting it as a fact; if it occurs to me that I had better scrutinize each and every alternative in any multiple-choice type task situation before deciding which is the best one; if I become aware that I am not sure what the experimenter really wants me to do; if I sense that I had better make a note of *D* because I may forget it .... Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective" (p. 232).

Metacognition comprises two kinds of knowledge. The first kind of knowledge about metacognition is an individual's awareness of his or her own cognitive resources in relation to the task. That is, the learner understand *what* skills, strategies, and resources are needed to accomplish a task. These activities include finding main ideas, paraphrasing information, creating images of verbal information, copying material, taking selective notes, and underlining important parts of an article.

The other kind of knowledge about metacognition refers to the activities used to regulate and control learning. That is, learner knows *how* and *when* to use these skills and strategies to make sure the task is completed successfully. These processes include planning activities (predicting outcomes, scheduling strategies, and various forms of trial and error); monitoring activities (monitoring, testing, revising, and re-scheduling one's strategies for learning); and checking outcomes (evaluating the effectiveness of one's efforts) (Brown, 1987).

Metacognitive Awareness

A learner's metacognitive awareness is influenced by learner, task, and strategy variables. Flavell and Wellman (1977) hypothesized that learners continually gain additional knowledge about how learner, strategy, and task variables affect both the quality and quantity of learning. Learners have the opportunity to learn about themselves with each new academic environment. For example, they learn about their differential effectiveness on tasks (e.g., I am better at arithmetic than at spelling).

Task, strategy, and learner variables interact when learners engage in metacognitive activities. Learners consider the type and length of material to be learned (task), the potential strategies to be used (strategy), and their skill at using the various strategies (learner). For example, learners might believe that they should take notes rather than underline in finding the main ideas of an article.

Metacognitive Experiences

Metacognitive experiences consist of self-regulation and monitoring activities. These activities are observable aspects of metacognition and presuppose the existence of knowledge, because it is assumed that a strategic activity is based on existing knowledge.

Metacognitive experiences also can activate two types of strategies which are cognitive and metacognitive. Forrest-Pressley and Waller (1984) have dintinguished that cognition refers to the actual processes and strategies that are used by the learner and metacognition is a construct that refers, first, to what a person knows about his or her cognitions and second, to the ability to control these cognitions (p. 6). Meichenbaum (1985) also referred to cognition as the use of operations in learning, and described metacognition as the learner's overseeing of these cognitive operations. That is, cognitive strategies are involved in *using* cognitive processes and metacognitive strategies in *choosing* cognitive processes.

Metacognitive learning strategies are not intended to teach learners specific course content. Rather, these are generalizable, transferable cognitive skills designed to help learners control their learning. Higher achievers are efficient learners because they know what they do and do not know, which enables them to fill information gaps when they exist. This monitoring of comprehension is designed to improve self-control and self-regulation of the learning process. Flavell (1981) argues that cognitive monitoring is a necessary step before there can be any integration and transfer of knowledge, and that cognitive monitoring is the key to critical thinking. Zimmerman and Pons (1986) have explored extensively the differences in this self-regulation component of metacognition in high- and low-achieving high school students. Based on structured interviews designed for both academic and social contexts, they concluded that skilled learners used more strategies consistently across contexts than did less skilled learners.

Computer-Assisted Instruction (CAI) and Metacognition: Related Research Findings

The computer has been modeled by many researchers on human cognitive process systems. Hartly (1980) recommends that students try solutions in a computer program format because it requires that the student give a precise statement in a step-by-step solution. Flavell's (1981) model of cognitive monitoring resembles the computer model because it requires describing the problem or issue, estimating the outcome or end product, deciding upon a strategy and implementing it, monitoring the outcome, and evaluating the process.

Pea (1985) has called for more research into the effects of cognitive process systems, i.e., systems that externalize the products of the mind and leave a path showing where one has been in an episode of problem solving. The computer's capacities represent practical means of testing whether cognitive process systems will make developmental contributions to human reasoning.

Clements and Gullo (1984) have studied the effect of a CAI environment on metacognitive skills. They provided 12 weeks of instruction to 18 first-grade children, randomly assigned to either a Logo or a Computer-Assisted Instruction (CAI) group. Posttesting revealed that the Logo programming group significantly outperformed the CAI group on both metacognition tasks. The ability to monitor one's own thinking and to realize when one does not understand may be positively affected by computer programming environments in which problems and solution processes are brought to an explicit level of awareness and in which consequent modification of problem solutions is emphasized. Through consistent feedback in the form of a visual representation of the procedures and sequences of their own thinking processes, children may have learned how to monitor those processes.

In a follow-up study (Clements, 1986), as in the first study (Clements & Gullo, 1984), measures of creativity, classification, seriation, metacognitive abilities, and achievement were used. Seventy-two first- and third-grade children were randomly assigned to one of three conditions: Logo, CAI, and control. After 22 weeks of computer experience, both the first and third graders in the Logo treatment outscored the CAI and control children on measures of operational competence, two of three measures of metacognition skills, and a measure of creativity and on describing directions. No differences were found on measures of reading and mathematics achievement.

For the replication study of Clements (1986) and Markman (1977), Lehrer and Randle (1987) investigated an experimental study of the instructional effectiveness of two types of interactive software environments. Subjects were thirty-nine first-grade children enrolled in a New York City school serving a low SES population. An alternate ranks design was employed to assign subjects to one of three treatment conditions: Control, Logo programming, and Interactive Software. Students in the Logo and Interactive Software groups were instructed for five months, two times per week for approximately twenty to twenty-five minutes each time. Students in the Control group were instructed once each week for forty-five minutes. At the end of instruction, measures of problem solving, metacognition, and composition were administered to all students. The measure of problem representation was identical to that of Clements (1986). The directions and materials of the comprehension monitoring task were identical to those proposed by

Markman (1977). Results showed that Logo and Interactive Software environments enhanced problem solving performance for a novel task, but the Logo environment was most facilitative for "learning to learn." However, both environments appeared to enhance components of metacognition: comprehension monitoring and the ability to monitor and to integrate old and new information.

The development and enhancement of self-regulation via computer has been predicted on the ability to access and engage one's metacognitive skills (Armstrong, 1989). Fifty-two students, 27 boys and 25 girls in grades 3, 5, and 8, participated in a study. It consisted of nine 50-minute sessions over a two-week period, with approximately ten students in each session. In the initial session, the entire group was introduced to ten things a computer can do. In the second through ninth sessions, the students were given a choice of completing specific tasks individually or with partners. The protocol sheets were designed to include the problem-solving steps which are comparable to the metacognitive skills of planning, error monitoring, reality testing, and re-evaluation.

The computer became the receiver of the students' inputs and strategies and served as a model and structure through which to gain access to their own personal problem-solving strategies. Students analyzed, criticized, adapted, and changed those strategies as needed. Nonproductive steps (or error type), tasks attempted, tasks completed, task sequences, and the debugging and monitoring of strategies employed were recorded. These data were analyzed by sex, grade level, and task type. Proficiency was found to have increased and strategies were more easily adopted and adapted to other tasks and problems. Completion of tasks increased significantly and nonproductive steps (errors) and number of trials (redos) decreased. There were no differences by sex except in the types of errors made. Evidence of self-regulation development was also shown in the types of questioning used by students.

Mikulecky, Clark, and Adams (1989) also found that significant differences in examination results supported the hypothesis that "how to" reading strategies could be taught via computer and that college students were then able to transfer the strategies to study new material. Moreover, interview and questionnaire data indicated that students view computer-assisted instruction positively as a way to learn strategies for reading difficult material.

Implications

As shown in the literature review, instruction that provides conditional knowledge (knowing "when" and "why"), self-regulation, and monitoring strategies has several positive effects on the learner's performance in computer-assisted instruction. Schmitt and Newby (1986) advocate that learning conditional knowledge can be incorporated with traditional systematic designs of instruction. Such systematic instructional design would include the following: gaining attention; presenting information of the "what" (declarative knowledge) and/or "how" (procedural knowledge) of the skill to be learned; and enhancing information through practice, feedback, and follow-up activities. Paris and colleagues (1983) suggest that to use a new strategy properly the learner should be informed of the importance of the strategy ("why") during the gaining-attention phase. Baumann and Schmitt (1986) suggest that the learner should also be informed of "when" the task is relevant after the presentation of the "what" and/or "how" of the strategy.

Since many learners do not use effective strategies, strategy instruction seems to be beneficial to learners. The ultimate goal in CAI is to have learners know how to use strategies independently, skillfully, and appropriately. Therefore, metacognitive strategies should be taught to learners directly over an extended period of time as part of the existing CAI. That is, learners should be provided input about when and where to use the strategies they are learning, and they should be shown how their performance improves by using the right strategies.

To summarize, metacognition comprises awareness and experiences of cognitive processes. Instructional design for conditional knowledge ("when" and "why") can be incorporated in traditional instructional design. The first step in teaching a strategy is to describe the strategy to students. This can be accomplished by the teacher modeling actual use of strategy, particularly with "think aloud" techniques about how to execute the procedure. In addition, strategy instruction should be explicit, intensive, and extensive.

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The Instructional Design Taxonomy: Further Refinements for Describing and Measuring the Interactivity of Computer-Based Instruction

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Abstract

This paper describes two components of a taxonomy for describing the dynamic quality of instructional systems independent of media. The first component includes terms for describing the feedback pattern of an instructional system in responding to a student error. The second component is an application of the terms to develop an instructional flowchart that creates a visual picture of the interactive qualities of the system.

Introduction

This paper describes certain aspects of a proposed taxonomy (Hoskisson 1991, 1992a, 1992b) being developed at the Center for Systematic Courseware Integration, Design, and Evaluation (C-SCIDE) that we hope will accomplish two things. The first concerns educational research that compares two types of media or one theory of instruction to another. We have not been successful in showing any significant difference in this endeavor (Heinich, Molenda, & Russell, 1989). One of the reasons is that we are not asking why a particular systems works well or is better than another (Brandt, 1989). I believe that we need a way to describe instruction without reference to media or theory before we can successfully compare instructional systems.

The other concern deals with the power of the computer. One of the important characteristics of the computer is its ability to manipulate information more quickly and efficiently than we humans. It is this manipulative power that makes the computer such a valuable tool in education. This ability makes it possible to truly individualize instruction. To determine the value of a CBT program we need a way to describe the degree to which the program takes advantage of this dynamic power to manipulate information.

An important aspect in determining the dynamic quality of an instructional system is how it responds to incorrect answers from the student. The feedback pattern of any system can be described in simple terms. The following elements of the taxonomy are based on the work of Brandt (1989).

Attempts allowed: This refers to how many times the student is allowed to attempt to answer a question before being moved to the next question.

Correct answer (ca): Does the system provide the correct answer before going to the next question?

Reteach (rt): Does the system reteach the information and if so is it retaught using the same material (rt.s), new or alternate versions of the original material (rt.n), or additional material (rt.a).

Hints or clues (h/c): There are many variations of hints and clues. Mathemagenic aids can be added to the information. The system can point out or ask questions about specific areas to guide the students thinking.

Error specific response (sr): How does the system decide what type of pattern to use? For example, when a student chooses the wrong answer to a multiple choice question, is the system response determined by the specific option the student chose or does it use the same pattern for each choice?

These elements can be combined in an infinite number of patterns. Each pattern can be shown in a flowchart style representation of the instructional activity. A typical pattern is shown in Figure 1. The

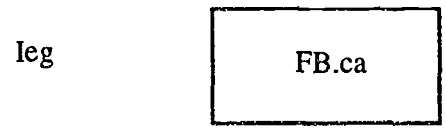


Figure 1. Atypical feedback pattern.

system poses a question and the student responds. If the student is correct the system continues to the next question. If the student is wrong the system indicates the answer is wrong and asks the question again. If the student continues to answer incorrectly the pattern is repeated x number of times until the system gives up and tells the student the correct answer. Figures 2-4 show more possible feedback patterns.

The pattern in Figure 2 shows that a question is presented and the student is informed that he or she has answered incorrectly. The student is ten retaught with a new version of the original material and

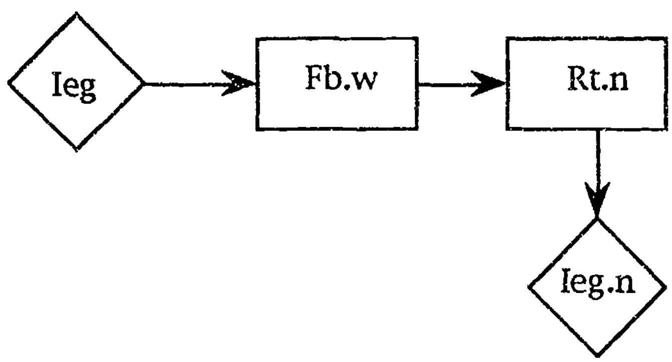
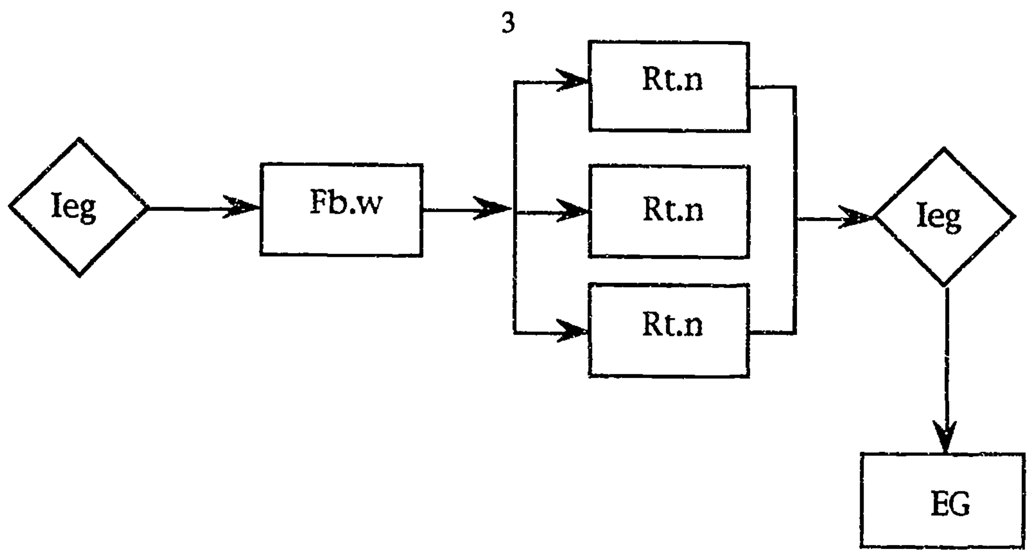


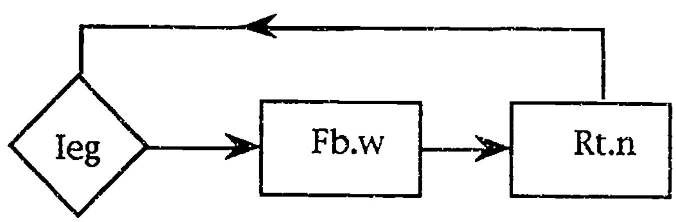
Figure 2. Feedback pattern a

given another question. Figure 3 shows a similar pattern only this time the reteaching is keyed to the specific incorrect response of the student. Again a new question is asked and followed by more information. The pattern in Figure 4 is also similar but returns the student to the original question after reteaching.

This type of instructional flowchart allows us to compare instructional systems without reference to the media involved or to any theory. For example, Figures 5 and 6 show the flowchart for two systems, one is a lesson from a basal reader and the other is a CBT program. It is difficult to decide which is which when all we have to look at is how the teaching is structured devoid of theoretical color and media glitz. We also have a clear picture of how interactive a program is. The basal reader is as interactive as the CBT program. They have the same basic feedback pattern. They pose a question, allow x number of attempts then give the correct answer. in our work at C-SCIDE, we have found this to be a typical feedback pattern for commercial educational materials of all kinds including CBT and interactive videodisc programs.



<u>Figure 3.</u> Feedback pattern b



<u>Figure 4.</u> Feedback pattern c

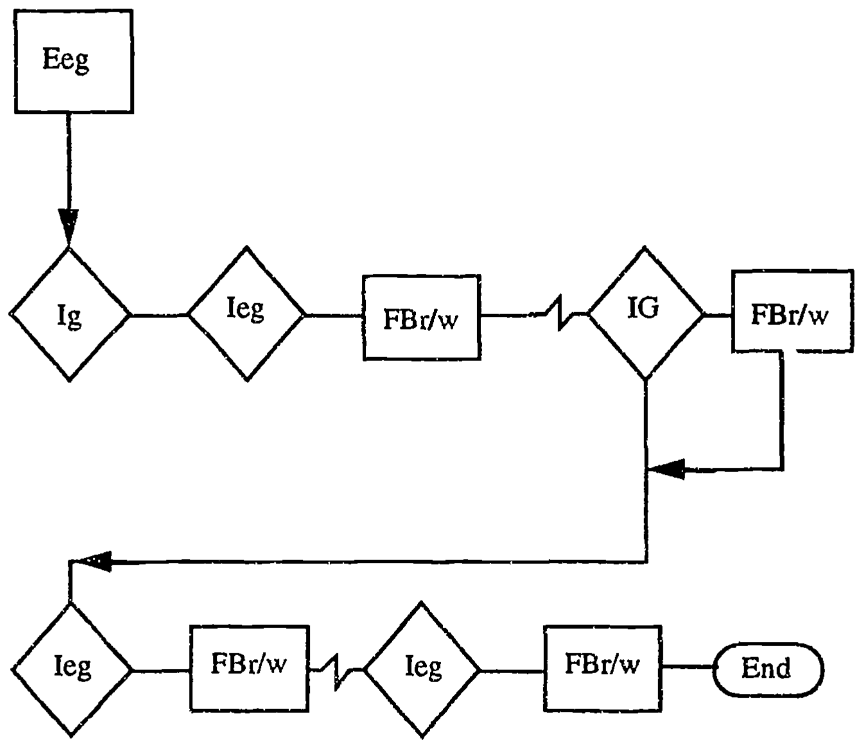


Figure 5. Instructional flowchart for a basal reader

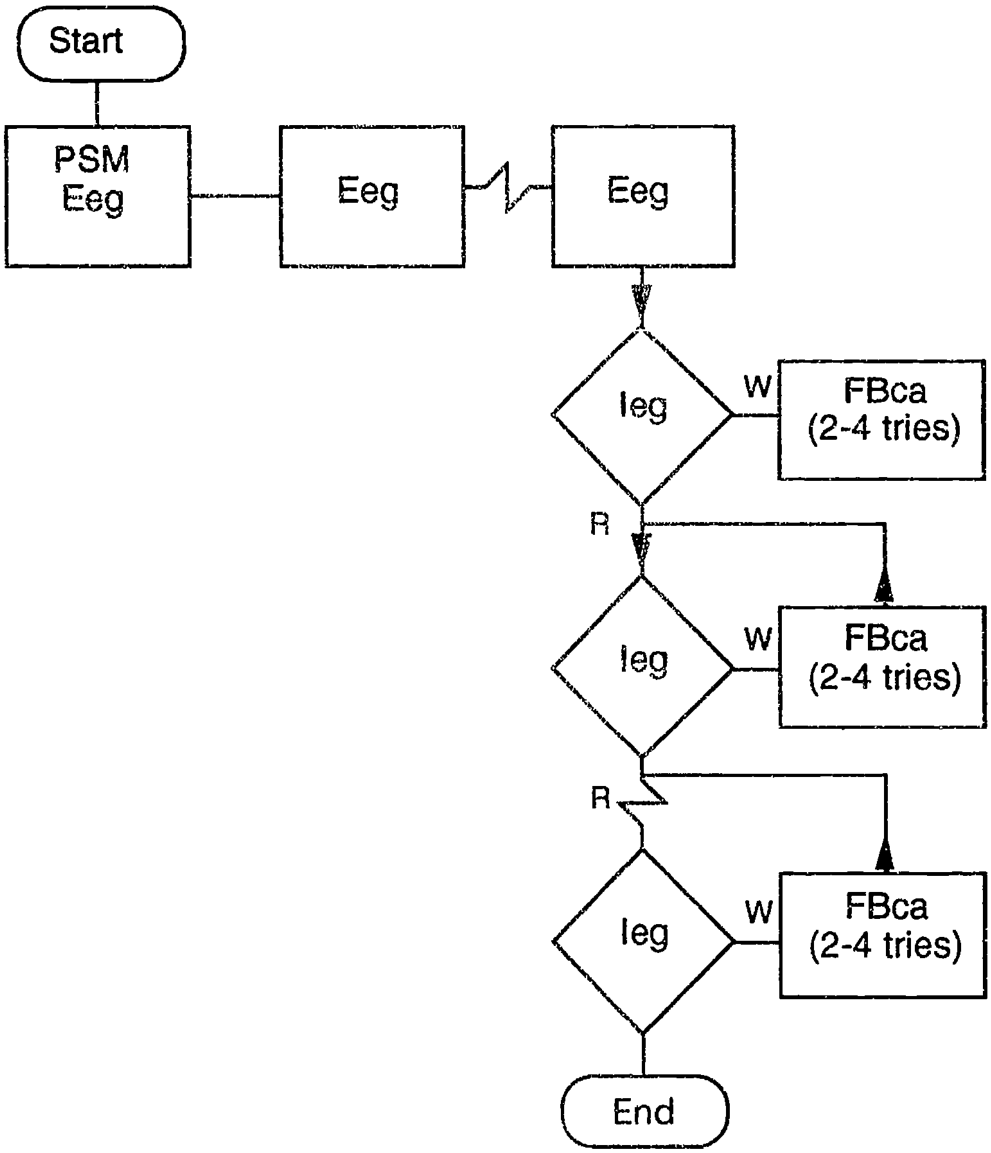


Figure 6. An instructional flowchart for a CBT program

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The Structure of Interfaces and Users' Mental Models in Computer-Based Interactive Courseware

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Abstract

This paper has identified instances of learners' mental models (understanding of the interface) of an interactive videodisc training course using a hypertext format and a WIMP (Window, Icon, Menu, Pointing device) interface. Further, the study explored the interrelationships among the users' individual differences with respect to learning styles, previous experience with computers, their mental models, their content exposure, and their performance in a computer-based, interactive video learning environment. Subjects, Instruments, and research procedures are described. Statistical analysis procedures included linear and multiple regression analyses of the user's performance scores, individual differences, mental models, and content exposure. The implications of the findings from both qualitative and quantitative perspectives were addressed to related research and courseware interface design issues. Recommendations for further research were made.

Background

As the utilization of computers by naive end-users has become widespread, increasing attention and effort have been placed on producing more "user-friendly" hardware and software. A well-designed user-friendly computer-based system permits users to experience mastery of the system, ease of using it, competence in performance of practical tasks, enjoyment, and even eagerness to show it off to others. Many of us experience precisely these reactions with respect to another major technology in our lives, namely, our automobiles. Regrettably, experiences of frustration or anxiety are still common among many computer users (as well as among some drivers). Bailey (1983) said that in the past, program designers generally seemed to assume that users would soon be transferred, promoted, or quit; thus they felt free to design programs from their own viewpoint rather than that of users. Carroll (1990) maintains that even in this age of "user friendly" software, many, if not most, computer users work at varying levels of incompetence rather than competence. Computer users in fields as diverse as banking, healthcare, and communications struggle to understand the structure and functions provided by various application programs and to learn the correct operating procedures for programs that are supposed to help them accomplish important tasks. While the difficulty involved in learning how to use word-processing, spreadsheet, or telecommunications programs is considerable, any confusion involved in using programs designed for education and training is especially detrimental. After all, interactive courseware are designed to help people to learn, not bewilder them.

This problem can be especially acute when interactive courseware are designed as hypertext environments that allow learners to explore the content and activities in the program according to their own needs and interests. According to Shneiderman and Kearsley (1989), hypertext "is a database that has active cross-references and allows the reader to 'jump' to other parts of the database as desired" (p. 3). Hypertext, hypermedia, and multimedia are all being designed and used for instructional purposes; in each case, the materials allow learners to navigate through the contents and activities via largely unrestrained exploration. However, there is a price for the freedom these types of systems permit. Users of hypertext materials may become confused and quickly lose track of what is going on, what they can do, and/or where they are located in the program. The resulting frustration prohibits learners from taking full advantage of the learning opportunities presented by these types of interactive courseware.

Interactivity and Exploration

The major advantage of interactive learning materials over other instructional media lies in the unique feature of "interactivity." To be interactive, the exchange of information, responses and feedback between the user and the computer should be as individualized, adaptive, and personal as possible (Price, 1991). A ideal form of interactivity would approximate the exchanges that occur between a human tutor and a student. The computer makes the idea of learning interactively possible by allowing meaningful communication between the learner and the learning materials. Maximizing the effectiveness and efficiency of learner-computer communication, i.e., interactivity, leads to increased learner satisfaction and to enhanced performance and productivity.

Interfaces are the communication vehicles for user-computer program interaction. Various types of interfaces have been created between users and computer-based systems to serve as bridges within the interactive process. In the earliest days of computing, print-outs were the major means of perceiving the opportunities for and results of interactivity, but today the computer screen is the most common vehicle for perceiving interactivity. When users view a screen and respond to computer systems, different interaction patterns evolve depending upon their unique cognitive processes and individual physical activities.

Courseware that employs a hypertext interface encourages learners to explore content and activities at their own discretion. The hypertext interface seems to be particularly powerful because humans freely explore their environments in everyday life for several reasons. The stimulation we receive when exploring is one of the primary motivations for human activity. It is fun because it fosters our curiosity to know more about phenomena, it results in direct interaction with phenomena, and it provides us with continuous challenge.

Cognitive Load and Mental Models

Working with a computer program requires different mental efforts than performing the same learning task via print or by other formats, e.g., watching linear video. In order to make any meaningful response to computer courseware, the learner must cope with and integrate three cognitive loads or demands, i.e., (a) the content of the information, (b) the structure of the program, and (c) the response strategies available. These threefold demands imply that there are physical, perceptual, and conceptual contacts happening during learner-courseware interactions. Users acquire and structure information delivered via interfaces, conduct mental operations, and accomplish physical activities during their interactions with computer programs. The limited capacity of working memory to hold only five to nine chunks of information simultaneously (Miller, 1956) makes it difficult for users of complexly structured courseware to reason when numerous cognitive load factors have to be handled at once. Users easily feel overwhelmed by abundant menus, option commands, icons, windows, functions, sequence controls, etc. (Robert, 1989). This complexity increases the cognitive load. It also increases the risks of confusion, especially when users confront hypertext materials which by their very nature include more interactive options than many other types of programs. The possibility of user disorientation is a major concern in the popular hypertext materials that feature a network-like, more flexible and complex structure (Byles, 1988; Conklin, 1987; Edwards & Hardman, 1989; Kuhn & Streitz, 1989; Tsai, 1988/89).

"Mental model" theory is an attempt to model and explain human understanding of objects and phenomenon (Gentner & Stevens, 1983; Johnson-Laird, 1983). The construction of a plausible mental model "eases the interpretation and memorability of information" (Gardiner & Christie, 1987). Since our understanding of human perception does (or should) play a crucial role in the design of interfaces, research on mental models is a promising approach for analyzing the human-computer interaction and eventually improving interface designs.

Users seek new information in ways that depend on and are limited by their current mental model and learning goals (Tweney, 1987). The existence and value of the mental models concept (Brehmer, 1987; Moray, 1987; Rasmussen, 1990) can be summarized by the premise that the quality of interaction within system operation depends upon the functionality of the mental models users have of the system. Mental models contribute to the understanding of overall system configurations, their elements, and their functional interrelationships.

The risk of learner disorientation in hypertext or other complex computer-based materials is decreased by the quality of the mental model of the interactive program possessed by the learner. Users acquire knowledge about a computer program and how to use it through experience, by instruction, and/or by exploration. The better we understand the ways users interact with computer programs, the more we can develop effective and efficient programs. Research on mental models in human-computer interaction can identify salient characteristics of cognitive processes and help in the development of research-based guidelines for the design of effective courseware, thus linking the technology and instruction fields together. Hence, there is a need to identify the user's understanding about interfaces in terms of mental models to provide principles and/or guidelines for computer-based courseware design.

The Study

The overall purpose of this study is to contribute to the understanding of how people learn in hypertext-based interactive courseware with respect to users' understandings and exposure of the courseware. There is little or no strong theoretical support for design of this type of courseware, and therefore this is largely an exploratory study. Specifically, this study utilized correlational methods for gaining insight into the relationship among the users' individual differences, their mental models of the structure of WIMP (window, icon, menu, and pointing devices) interfaces in interactive courseware, their actual navigation activities during use of interactive courseware, and the results of that use. Analysis procedures included multiple regression analysis of the user's performance scores, individual differences, mental models, and content exposure. Qualitative analysis based on users' expression of the interfaces and users' explanations of the specific content exposure were used to categorize the instances of users' mental models of the course and interaction errors.

Five major questions were explored in this study:
(1) What are the idea clusters and instances of the mental models that users form of the WIMP interface in hypertext interactive courseware and how frequently do they occur?
(2) What individual difference in selected learning styles, interfaces preferences, and previous computer experience are related to differences in users' mental models?
(3) How are differences in users' learning styles, interfaces preferences, and previous computer experience related to users' content exposure?
(4) How are different levels of users' mental models related to users' content exposure?
(5) How are the individual differences, mental models, and/or content exposure of users related to the prediction of performance scores?

Subjects, Instruments, and Procedures

The design of this study included observational and correlational methods. These methods were selected since no manipulation of a treatment variable was appropriate (Tuckman, 1988) and because of the exploratory nature of the research. Raw data were treated as continuous variables in this study. Linear and multiple regression methods were used to explore relationships between the specified variables and to determine the extent to which a criterion variable could be predicted. The criterion variable was the performance scores of users of interactive courseware that employed a WIMP interface within a hypermedia instructional treatment. The three possible predictor variables examined were individual differences among learners, their mental models of the courseware, and their content exposure while using the courseware.

The sixty five participants for this study were recruited as volunteer subjects in the Summer of 1991. The sample group in this study included 36 females and 29 males. Subjects ranged in age from 20 to 57 years of age with a mean age of 33.06 years. The computer systems used in this experiment were the Apple Macintosh II and Macintosh SE personal computers that use a non-traditional user interface, including features such as window direct manipulation, icons, pull-down menus, and a one-button mouse as a pointing device. This type of interface is commonly referred to as a WIMP interface for Windows, Icons, Menus, and Pointing devices. The interactive courseware used in the study was the "Macintosh Fundamentals" (MacFun) course (Apple Computer, Inc., 1990). MacFun is an award-winning, interactive videodisc, self-paced training course delivered on Macintosh computers interfaced with Pioneer videodisc players. MacFun was authored using HyperCard V2.1. Students view text and graphics materials on the Macintosh monitor and video on a separate monitor. Audio emanating from both the videodisc and the HyperCard stacks is heard through a headset. The course was developed by Training Support, Apple Computer, Inc., for training its own employees and authorized Apple sales personnel. The stated goal of this course is to help users become self-sufficient, well-rounded users of the Macintosh computer. The course which features extensive technical content and assessment tests provides as many as thirty hours of interactive training. Over ten thousand trainees have already completed the course. This courseware was selected because its user interface had been evaluated extensively and revised several times (Gustafson, Reeves, & Laffey, 1990). Version 2.0 of the MacFun course was used in this study. MacFun includes twelve content modules and an Orientation module. Learners proceed through the modules in whatever order they wish. The "Desktop Operations" module was the target module used for tracking learner interactions and performance scores in this study. This target module was modified by the researcher by adding on-line pop-up questions for certain activities initiated by the learners.

Individual differences measures were obtained from a PreCourse Questionnaire and the Group Embedded Figures Test (GEFT). The PreCourse Questionnaire queried subjects about their personal background, previous computer experience, and personal attitudes toward and knowledge of windows, icons, menu, and pointing device (WIMP) interfaces. After completing the PreCourse Questionnaire and taking the GEFT, each subject navigated through the MacFun course individually at his/her own pace. MacFun consists of twelve content modules named 1) Computer Basics, 2) Introduction to Applications, 3) Macintosh Families, 4) Desktop Operations, 5) Maintenance, 6) HyperCard, 7) Peripheral, 8) Printers, 9) Storage, 10) Telecommunications, 11) Networking, and 12)File Transfer. An Orientation module serves as a front-end tutorial for the MacFun course. The objectives of each module, the structure and contents of each section, and the functions of various interface options are explained in the Orientation module. Each subject was requested to complete the target Desktop Operations module as the minimum requirement, but each was free to explore any other modules he/she wished before entering the target module, Desktop Operations.

Upon completion of whatever sections of the MacFun course he/she wished and before entering the target Desktop Operations module, each subject completed the PreModule Questionnaire which was designed to collect data concerning their mental models of the MacFun course. The subjects' mental model construct was treated as a predictor variable with respect to their content exposure and subsequent performance, and therefore subjects had to complete the PreModule Questionnaire before actually beginning the target Desktop Operations module. Each subject's completion of this instrument was assured by requiring the entry of a specific password that only the researcher knew before the module could be entered.

The teach-back technique used by Van Der Veer and his associates (cf., 1989) was used in the PreModule Questionnaire. This technique is an approach to elicit the mental models of users via asking users to explain a computer program to new learners. They should describe the program clearly and with as much detail as possible so that it is understandable to new learners. Three open-ended teach-back questions presented via a paper-and-pencil instrument were used to collect multiple perspectives of subjects' mental models:

1. Give an overview of the MacFun course in such a way that it is understandable to a new learner without experience with computerized tools or computer-based learning materials.
2. Suggest some guidelines for how to navigate through the MacFun course to new learners who have been IBM PC or compatible computer users but have never used Apple Macintosh computers before?
3. How would you explain to new learners how to interact with the following sample screen from the MacFun course?

These questions were designed to reveal the learners' perspectives of the structure of the whole course and their impressions of the specific interactive functions of commonly used icons. Non-directive questions asked subjects to explain the structure of the course and to identify the functions of the icons used in the MacFun course. They were also asked to make recommendations for new learners of Macintosh computers.

On-line data tracking routines were incorporated into the MacFun HyperCard stacks to collect data regarding what subjects did in the course, i.e., what screens they viewed, what options they activated, what responses they made, and how long they spent on each screen. This data was regarded as a measure of the exposure to the content of the module experienced by each learner. The content exposure including screens seen and icons used as well as their answers to on-line pop-up questions were automatically recorded into a HyperCard stack named "JIH" for each subject. The data handling function provided by the HyperCard based courseware allowed the investigator to track the data about subjects' activities in the course. On-line pop-up questions (Hassett, 1990; Koubeck, et al., 1987; Norman, 1983) were incorporated into the Desktop Operations Module of the MacFun course to ask for the reason(s) why subjects engaged in certain interactive behaviors. Sixteen pop-up questions asked the subject's explanations for the reasons why he/she did not complete certain activities. Four questions asked the subjects' explanations for the reasons for unnecessary actions in reaction to certain screens. If subjects clicked the "Because..." reason, a box appeared that allowed them to type in a unique response. Performance in the Desktop Operations module was measured using the twelve items of an on-line performance test (Self-Assessment) incorporated by Apple Computer, Inc. into the module. The results of the test were automatically recorded in each subject's record by the data tracking code.

Data Analysis

A qualitative analytical approach was used to identify the specific aspects of users' mental models. Because such a qualitative approach depends upon the naturally occurring perspectives of the environment without any preconceived directional or specific outcomes (Lincoln & Guba, 1985), the major concern is with thorough description and valid interpretation. This was accomplished by data triangulation and cyclic categorizing processes to increase the validity (Denzin, 1978; Goetz & LeCompte, 1984). The reliability of the study was threatened by the fact that the investigator was the sole data interpreter. To counteract this threat, the data related to subjects' mental models was analyzed through a cyclic process of analytic induction. An analytic induction strategy aimed at identifying categories of phenomena and the relationships among them was employed in the following manner:

Step 1. First of all, the answers to the teach-back questions were segmented into idea units by the researcher. Each idea unit and the ID number of the subject who included the idea unit in his/her answers to the PreModule Questionnaire questions were written down on a 1"X 3" piece of paper.

Step 2. After being identified, all the idea units were grouped and organized as idea clusters or groups by the researcher. For instance, the idea unit "mouse" and the idea unit "a box with a ball" were classified into the idea cluster labeled "mouse." The researcher's analytical judgment guided this organization.
Step 3. The idea clusters were then grouped into categories. For example, the idea clusters "Macintosh or computers as course content," "components of computers," "definitions, functions of components," and "features, capabilities, operation, or application of computers" were categorized into the group labeled "goal/objectives." On the other hand, the idea cluster "Macintosh as a delivering system" was classified into "hardware/software features" group. It should be obvious that the researcher's own mental model obviously influenced this categorization process.
Step 4. The classification of categories and their associated idea clusters and idea units was conducted several times in a cyclic manner to verify patterns in order to get more refined mental model constructs. The investigator identified ten major categories of the subjects' mental models: (1) Goal/Objectives, (2) Course Structure, (3) Specific Contents, (4) Instructional/Learning Strategies, (5) Hardware/Software Features, (6) Authoring Tool, (7) Window, (8) Icon, (9) Menu, and (10) Pointing Devices - the mouse. Groups 1-4 are related to the "instructional" aspects of the MacFun course. Groups of 5-6 dealt with features of the computer-based instructional "media" itself. The last four groups, groups 7-10 focused on the features of the windows, icons, menus, and pointing devices interfaces.
Step 5. Scores for subjects' mental models were computed according to the accuracy and richness of their answers. Any accurate answer related to an associated idea cluster earned one point. Answers referring to the same idea cluster counted only as one point. Incorrect answers earned nothing, e.g., the subject's answer of "go to main menu" in reference to the Double Up Arrow icon was incorrect. The correct answer should be "to the first menu of this module". Another incorrect answer was the "example how to do something" in reference to the Pre7 icon. The Pre7 icon actually provides users with the comparison between the new operating system 7.0 and the previous system 6.0x. These two inaccurate answers earned no points at all. After analysis of the narrative data that was taken from a subject's answers to the teach-back questions, a mental model "score" was calculated.

A descriptive statistic approach was used to calculate the frequencies of each category and idea cluster in the four levels of the WIMP interface. Both quality (highest level) and quantity (number of levels described) aspects of the mental models were examined and calculated. The subjects' answers to the on-line pop-up questions were classified into five categories according to the properties of those answers: (1) insufficient knowledge/attention of users, (2) decline of memory of users, (3) miscommunication with course interface, (4) unintentional action, and (5) intentional action. These categories are defined below. Some subjects had insufficient knowledge about how to conduct an interactive activity such as executing a simulation, using a pull-down menu, or dragging an object. Others subjects paid insufficient attention to the interface because they did not notice they could do certain things. The increased cognitive demand on the subject's memory may have forced the decline of his/her memory. Several subjects thought they had finished all "More Info" icons on one screen, or they got lost in the course. One subject thought a whole section completed with a check mark beside the menu option indicated it had been seen before, but it was not completed yet. Subjects who misunderstood the meanings conveyed in the interface were classified as committing miscommunication errors. Accidental clicks were classified as unintentional actions. Intentional actions of subjects happened when they skipped some sections/options provided in the course because that they didn't want to, they knew the content, they were curious to try something out, or they just wanted to quit.

Users' ı 'sufficient knowledge of or attention to the course interface led to omission of user-program interactive activities. The decline of users' memory resulted in losing their original intention and failing to complete desired actions. Users' miscommunication with the program led to actions which were appropriate for the analysis of the information conveyed by course interface but inaccurate for the course itself. Unintended actions occurred when users accidentally made any action such as clicking the mouse unintentionally. Intentional actions cccurred when users skipped any section or activity of the course based upon their own inclinations.

Pearson Product-Moment coefficients (r) were calculated to determine the interrelationships between the variables that constituted individual differences, mental model constructs, content exposure, and performance scores in all possible paired combinations. Multiple regression procedures were used to provide insight into the relationships among users' individual differences, mental models, content exposure, and performance scores. Multiple regression procedures were used for both descriptive and inferential purposes. First, multiple regression was used to examine the linear dependence of users' performance scores on the three main predictor variables, i.e., individual differences, mental models, and content exposure. Second, the question of whether the sample observations can be generalized to larger populations was addressed. For example, the null hypothesis that the predictor variables have no effect on learning outcomes was tested at a pre-specified .01 level of significance. Cohen and Cohen (1975) recommend the use of an alpha level of .01 for studies of this type when individuals (as opposed to classes) are used as the unit of analysis.

Discussion and Conclusions

For Question 1. Ten categories of users' mental models of an interactive videodisc training co 'rse using a hypertext format and WIMP interface have been identified according to their idea clusters. The ten categories are: (1) goal/objective, (2) course structure, (3) specific contents, (4)instructional/learning strategies, (5) hardware/software features, (6)authoring tool, (7) window, (8) icons, (9) menu, and (10) mouse as the pointing device. Given the training function of the Macintosh Fundamentals courseware, it is not surprising that four categories are related to the "instructional" aspects of the course. Two categories dealt with features of the computer-based instructional media itself, viz., hardware/software features and authoring tool features. Given the unique and powerful interactive interface of the Macintosh environment, it is also not surprising to find that four categories focused on the features of the WIMP interface. The frequencies with which these categories were included in the mental models of the subjects in this study varied considerably. For example, only seven learners included the category of course structure in the mental model they expressed whereas all sixty-five learners included the icon category of the WIMP interface in their mental model.

No learners included all ten categories in the mental model they expressed. The range went from two learners who had as many as eight categories included in their mental model down to one user who only had two categories expressed in his/her mental model. The last four categories of the mental model categorization scheme were further classified into task, semantic, syntactic, and interaction levels for the idea clusters regarding the WIMP interface. The highest total score for this classification was 30 possible idea clusters/levels within the mental model. The range of inclusion went from one learner who scored 16 down to two learners who scored 4. Twenty-three out of the 65 users formed mental models with idea clusters in the interaction level.

These results support previous findings by Ackermann and Greutmann (1990) that individual variation among the mental models held by computer users is great. The results also support Norman's (1983) conclusion that each individual's mental model is incomplete in nature. However, this study does not provide unassailable evidence that the mental models of the specific courseware used in this study held by the subjects were captured by the measurement methods used in this study. As described below, reliability and validity studies of these measurement techniques remain to be done. This study also does not address questions concerning the mental model the subjects constructed of the content of the target module, i.e., desktop operations, that may have conflicted with or supported the mental model they were constructing of the course itself. It seems reasonable that there should be some overlap between the two mental models, especially with respect to the features of the WIMP interface.

Future research should address this issue because it is very relevant to the problem of the cognitive demands of interactive instruction. On the one hand, a user-friendly interface in the courseware should minimize the amount of cognitive load dedicated to understanding how to use the courseware and maximize the amount of cognitive load that can be dedicated to the content of the course. The question of whether this actually occurs in intriguing, especially when there is so much similarity between the features of the courseware interface and the content of the courseware. This similarity could result in reinforcing support for some learners and interference for others.

For Question 2. Considerable variation on the field dependence/field independence learning style was found among this same of learners, with sixteen subjects being classified as field dependent and twenty-six subjects classified as field independent. The learners' ratings of the WIMP interface also varied considerably, although most subjects expressed positive preferences for the WIMP interface. Only twelve subjects (18%) expressed either negative or uninformed attitudes toward the WIMP interface. Substantial variation existed among the subjects with respect to experience with computer systems and experience with the Macintosh specifically. The mean value for computer experience was 43 months with a standard deviation of 51. The mean value of Macintosh experience was 11 months with a S.D. of 18.

A statistically significant ($p < .01$) positive relationship was found between learners' WIMP ratings and the richness of their mental models of the courseware and WIMP interface. These results indicate that learners who rated the WIMP interface positively, based upon their preexisting attitude toward or knowledge of it, also tended to form richer mental models in terms of both accuracy and richness. This can be interpreted to mean that the learners' ratings of a WIMP interface is one predictor of the mental model constructs of users. Of course, this finding may simply be a function of the positive relationship existing between knowledge of a phenomenon and attitudes expressed toward it. In other words, those learners who has previous knowledge of and experience with the WIMP interface expressed the most positive attitudes toward it. In turn, these same learners were able to express more accurate and richer mental models of the interface because of their previous knowledge and experience.

Positive relationships ($p < .01$) were detected between learners' WIMP ratings and their degree of Macintosh experience and their amount of field-independence. In short, field-independent users and experienced Macintosh users tended to value the WIMP interface higher than those subjects who were classified as field-dependent and had little Macintosh experience. The advertising department of Apple Computer, Inc. should not find these findings to be surprising, given that they have consistently promoted the Macintosh as the computer preferred by independent-thinking people. However, there are multiple plausible interpretations of these findings, and one can quickly become engaged in "which came first" arguments. For example, one might argue that field independent people are more likely to choose the Macintosh computer with its WIMP interface over machines with more structured interfaces (e.g., MS-DOS systems), and that this choice and their subsequent experience with the Macintosh leads to a positive rating of the WIMP interface. It is easy to see that other plausible explanations can be derived from the findings. In any case, the interrelationships among selected learning styles, computer experience, WIMP ratings, and mental model constructs remains to be clarified.

For Question 3. No statistically significant relationship was detected between learners' FD/FI learning style, preferences for the WIMP interface, and previous computer experience and their content exposure at a .01 level. These results indicate that learners' learning style, interface preferences, and previous computer experience were not significant predictors of content exposure within this type of interactive, self-paced course.

Only twenty-three (35%) of the learners completed three fourths of the maximum 284 possible instructional screens including 227 content screens, 35 animation demonstrations, 9 video segments, and 13 pre-7 system comparisons. The reasons why the subjects did not go through most of the Desktop Operations module can be addressed by reviewing their answers to the on-line pop-up questions incorporated into the module. Their responses were classified into three categories:

(a) intentional action of skipping some sections/options provided in the course because that they didn't want to, they knew the content, they were curious to try something out, or they wanted to quit;

(b) insufficient knowledge about how to conduct an interactive activity such as executing a simulation, using a pull-down menu, dragging an object, or insufficient attention on the interface because they did not notice they could do that;

(c) increased cognitive demand on their memory, e.g., they thought they had finished sixteen information icons on one screen, or they got lost in the course. (One user thought a whole section completed with a check mark beside the menu option indicated it had been seen before, but it was not completed yet.)

The factors involved in reason (a) above may be beyond the influence of course designers, but the factors related to reasons (b) and (c) can be affected by courseware design. Although this study does not provide sufficient detail to specify what design features should be modified, it is clear that there is room for improvement in either the actual interface instances and/or the orientation to these instances provided in the course.

Interestingly, the subjects in this study did not use the nine video segments to the maximum extent. Only twenty-five (38%) of the 65 users saw five or more video segments. One explanation concerns users not noticing or forgetting to click on the video icons because of their relatively rare appearance in the module. The use of separate computer and video monitors, and the possible discomfort involved in moving one's attention from one screen to another may be a factor. Most likely, the content of video itself was a major reason for users' failure to use the video segments regularly. Gustafson, Reeves, and Laffey (1990) found that trainees generally gave poor ratings to the video aspects of an earlier version of this course. Fifty-two (80%) of the learners never used the "Key Services" options (bookmark, notebook, snapshot, glossary, map, and help) included in the module. This result is supported by previous findings (Gustafson, Reeves, & Laffey, 1990) which reported minimal use of these options by trainees using the first version of the MacFun course. This congruence of these findings suggests that the cost-effectiveness of including sophisticated student services features is questionable. On the other hand, perhaps the course orientation does not provide learners with a sufficient understanding of the function and value of these options.

For Question 4. There were six content sections in the Desktop Operations module named (1) Introduction, (2) Desktop operations explained, (3) Disk, folders, and files, (4) Using Macintosh menus, (5) Customizing your system, and (6) Putting it all together. (The "Self Assessment" test was a seventh option on the main screen of the module.) Subjects were free to complete as much or as little of these sections as they wished. There was considerable variance with respect to learner completion of the various subsections of the module ranging from the forty-seven (72%) of them who completed at least 80% of the available screens in the "Putting it all together" subsection down to the twenty (31%) who completed at least 80% of the "Introduction" subsection.

Perhaps the most interesting findings related to the question of the relationship between mental models and module navigation involves recent changes in the Macintosh operating system. In the Spring of 1991, Apple Computer, Inc. introduced a major new operating system called "System 7." Because of considerable differences between this new operating system and the previous "6.0x" operating systems, not all Macintosh software operates in the new environment. In addition, the new system demands much more RAM memory than older system versions. Therefore, many users have chosen to continue to use the older operating systems.

The designers of the "Desktop Operations" module were faced with the dilemma of deciding how to handle content differences between the old and new operating systems. They opted to put System 7 procedures into the main sections of the module, and to provide an "pre7" option in the form of an icon on the navigation sidebar whenever it was relevant. A positive relationship ($p < .01$) was found between the levels of users' mental models and the number of pre-7 options used by them. This may be explained by the positive relationship existing between previous Macintosh experience and mental models described under question 2 above. Those learners with previous experience with the Macintosh most likely gained that experience using a "Pre7" version of the operating system since System 7 had been available only a short time when this study was conducted. Hence, they were the subjects most likely to want to compare the new system with the one they already knew. Less experienced users of the Macintosh (who also possessed less complete mental models of courseware and WIMP interface) were less likely to want to explore these differences.

In summary, it seems reasonable to conclude that learners with a richer mental model of the course will explore more of the course content than those with less complete understanding of the course structure and interactive options. An alternative explanation may be that experienced Macintosh users are more likely to have richer mental models and also have a greater desire to explore the topic of "Desktop Operations." Additional research is indicated with radically different content, preferably content that has little or nothing to do with the actual courseware delivery system.

For Questions 5. As described above, learners who had more experience with the Macintosh tended to rate the WIMP interface higher, learners whose WIMP ratings were higher tended to form richer levels of mental models, users with a richer mental models construct tended to view more comparisons between new "System 7" operation procedures and those employed in previous system 6.0x versions. Not surprisingly, these same learners tended to earn higher performance scores. However, the multiple regression results derived from the examination of the predictive value of individual differences, mental models, and content exposure on performance were not impressive. WIMP ratings and the number of pre-7 options used were the only two significant predictors of performance score ($p<.01$).

It was still uncertain what kind of interrelationship exists among these variables or what other factors might be involved in predicting performance in this type of hypertext courseware. There are several flaws in the research design that may have prohibited stronger findings. Although the mean time of over three hours actually spent in the MacFun course far exceeds the 30-60 minutes of treatment used in most research of this kind (Clark, 1989), it may have been insufficient for some of the learners to develop a sufficient mental model of the course. Another problem stems from the fact that the subjects in this study were volunteers. It is much more desirable to conduct this type of study with trainees or students who have relatively strong intrinsic or extrinsic motivations for participation in a course. Sample size is also a weakness in this study. Further research employing multiple regression techniques with larger sample sizes might yield richer data to address the major research questions.

Another problem with this study relates to the validity of the performance measure, i.e., the "Self Assessment" test built into the "Desktop Operations" module. Perhaps users who saw more screens and accessed more animation demonstrations and video segments did "learn more" from the content of the screens, videos, and animations, but failed to demonstrate the performance on the Self-Assessment test. The questions in this test covered only three of six subsections of the module and did not reflect the video content in the Desktop Operations module. A more comprehensive test with stronger articulation between the module content and the test items might yield more impressive findings. The weak findings of the predictive power of mental models with respect to performance did not support the findings of previous studies on facilitating learning performance (e.g., Brehmer, 1987; Mayer, 1989; Moray, 1987). One possible explanation is that users' mental models may be more predictive in more complex computer environments, such as a simulation program, a problem solving program, a data base application, or a design tool which requires users to apply more sophisticated interactive skills/techniques. Still, considerable variation was found in the mental models held by the subjects in this study, and it would be interesting to examine the relationship between these mental models and a better performance measure.

Implications of This Study

Based upon the results and conclusions of this study, several implications are evident:

1. The coded inspection capabilities for users' content exposure and the on-line pop-up questions used in this study could serve as a new feature of program-control to advise learners to go through certain "essential" content and/or orientation activities within computer-based learning systems that permit the degree of learner control found in the Macintosh Fundamentals course.
2. The constructs of the mental models identified in this study could serve as a tool for the purpose of courseware, manual, and tutorial evaluations as well as a basis for further research on learner-courseware interactions in computer-based learning systems.
3. The teach-back technique and the on-line pop-up questions could serve as a new methodology for examining learner-courseware interactions in computer-based learning systems.
4. The need to add many student services functions such as notetaking, snapshot, and bookmarking in a computer-based learning system should be examined with respect to the cost-effectiveness of their inclusion.
5. Video segments in the these types of hypermedia interactive courses should be integral to the content and activities of the course. If they are not integral to the course, learners will most likely ignore them. The higher expense involved in producing and providing video in this type of courseware makes it all the more important that these components are essential.
6. A better course orientation should be designed including more descriptions and practice with all of the interactive techniques such as how to use mouse to drag an object, how to use pull-down menus, etc. More importantly, the orientation should demonstrate the use and value of the student services functions, and the utility of animation and video segments. Courseware designers should let users practice the skills of navigating through the course and support their navigation with a users' manual, on-line tutorial, and/or on-line help information.
7. Descriptions and demonstrations about the windows, icons, menus, and pointing devices interfaces should be one of the major options in courseware driven by a WIMP interface to enhance users' attitude toward and knowledge on the specific interface as well as their performance scores.
8. In any screen with many icons/options available in this type of course or other program, memory aids should be provided to indicate user status. For example, a check mark, a

dimmed icon, or a semi-darken icon can be employed to make up for users' decline of memory.

9. In the menu options screen, the combination of advisement for users' progress such as a sentence of "You completed __% of this section" or a progress bar and the check mark " could help decrease the users' cognitive load (Peters, 1989).

Recommendations for Further Studies

The following recommendations and suggestions for further research are based on the results of this study:

1. A study replicating this effort with actual trainees and larger sample sizes should be conducted.
2. A study using a single-screen delivery platform with a WIMP driven interface for instance, an IBM PS/2t driven by Windows or a Macintosh II with a video card for single screen integration, should be undertaken to ascertain whether results are similar to those found in this study.
3. This study looked at users' field independence, their experiences with computers, and their WIMP interface ratings as variables of individual differences. Other variables should be examined such as learning needs or goals, computer experience other than the instrument type, and users' self-esteem with respect to their computer literacy.
4. More data resources of users' mental models and interactive behaviors collected by a variety of approaches should be explored, e.g., observing users learning to navigate through a courseware under the guidance of manuals or a front-end tutorial program, asking users to explain the courseware to a new learner as the co-experimenter, and/or observing the users and co-experimenter navigating through other sections of the courseware or another similar course via verbal protocol, questionnaires, interviews, and on-line computer coding. Such research could yield a taxonomy of users' mental models in a hypermedia learning environment, the patterns of their content exposure, and other factors possibly existing in the human-computer interactions.
5. A study should be conducted to determine idea clusters, categories, and levels of mental models held by designers of interactive courseware. These results should be compared with the results of the mental models formed by users/learners using the course these designers created.
6. This study should be repeated with the same interface but radically different content.

Assumptions and Limitations

Assumptions

1. Previous experience with computers is a reasonable estimate of a subject's expertise.

2. The personal constructs or mental models that learners construct of the course or WIMP interface can be assessed via teach-back, paper-and-pencil questions. User's answers to teach back questions can accurately reflect their mental models.
3. The subjects who ranged in education attainment from a high school diploma to a Ph.D. degree had the capabilities to describe the MacFun course in such a way that it is understandable to other new learners.
4. The subjects gave the real explanations for the reasons why they did not complete certain activities or unnecessary actions in reaction to certain screens.

Limitations

1. One general, fundamental limitation is that the conceptualization of learners' mental models is dependent on the investigator's and/or the courseware designers' own mental models.
2. The MacFun interactive courseware consists of thirteen modules. The subjects of this study were able to control their own pace and learning paths through the sections of the module, therefore the navigational history and maturation of the subjects in the particular courseware continually changed. Mental models are more likely to be dynamic entities and have multiple forms. The collected users' understanding about the courseware in terms of a mental model is only one of the multiple models that can exist over time for the specific individual. The findings may not generalize to either smaller, simpler, larger, or more complex courseware in terms of the size and structure or to less learner-controlled programs.
3. There was a possible contamination of the treatment in that some subjects may have been exposed to the design of the MacFun course before participating in this study. This previous exposure could have occurred in the context of a graduate course such as EIT 714 - Design and Development of Interactive Instructional Materials. Or they may have viewed parts of the courseware in a laboratory setting open to many of the students used as subjects in this study.
4. The amount of time that subjects spent in the MacFun course before eliciting their mental model varied considerably (mean time = 82 minutes, standard deviation = 44 minutes). The briefest amount of time was 1 minute and the longest amount of time was 220 minutes. Whether subjects who spent relatively brief periods in the course before their mental models were assessed had sufficient time to construct a meaningful mental model is not known.
5. The user-courseware interface investigated in this study consists of WIMP patterns on a monochrome monitor of the Macintosh computer system. The findings may not generalize to Macintosh color monitors or to other computers using WIMP interfaces.
6. The delivery system for the MacFun course includes one Macintosh computer with its own monitor and a separate monitor for display of videodisc material. The findings may not generalize to single screen computer systems.

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Effects of Building Expert System Rule Bases on Cognitive Structures

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Abstract

Researchers and businesses are investigating the systems and cognitive effects of having students and employees construct expert system rule bases that represent their knowledge. Expert systems are cognitive tools that engage learners in cognitive and metacognitive learning outcomes. This study investigated the changes in domain-specific cognitive structure that result from students constructing rule bases. These changes were idiosyncratic and not related to the expert's (teacher's) cognitive structure.

Expert Systems as Mindtools

Rule-based expert systems are an application of artificial intelligence, where the knowledge of an expert is distilled into a set of rules that can be used to guide decision making in solving problems. Expert systems are useful tools that are used extensively in business to help users make decisions. However, they may support learning and instruction in a variety of ways (Jonassen, Wilson, Wang & Grabinger, in press), including expert and student modelling for intelligent tutors, instructional design advisors, internally generated feedback, cognitive simulations, and cognitive amplification tools or *mindtools* (see Figure 1). The research reported in this paper focuses on the mindtool application of expert systems.

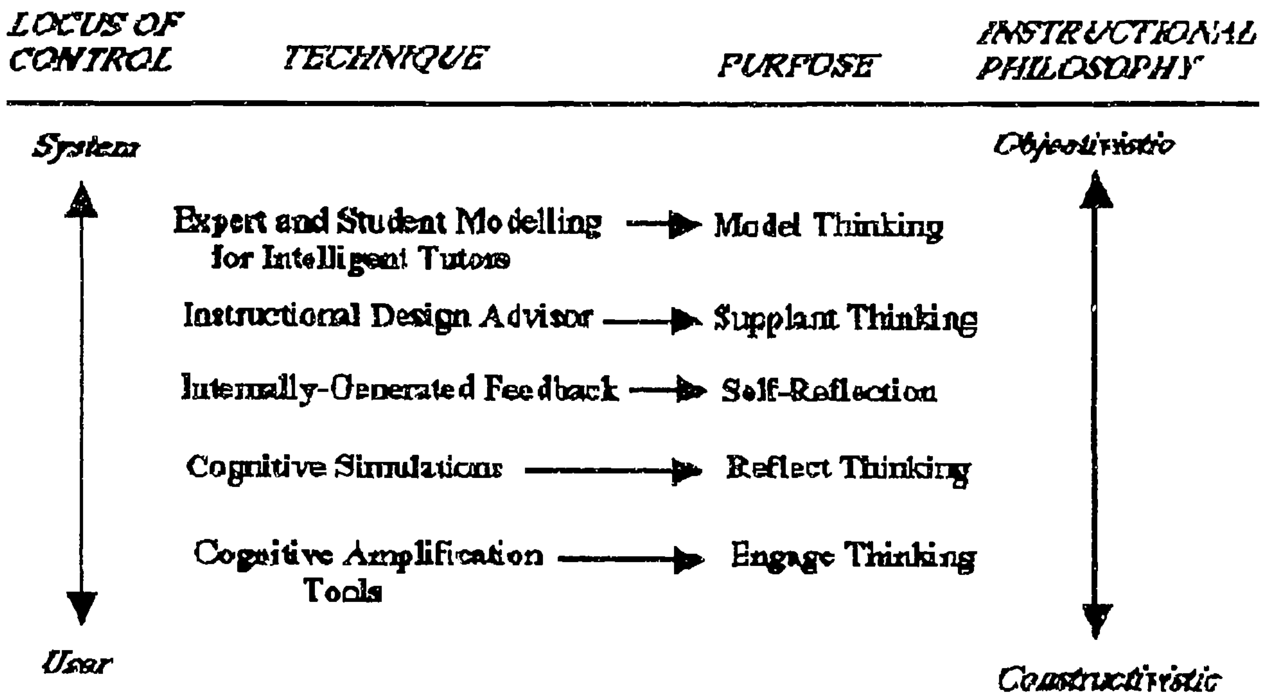


Figure 1
Range of Expert System Applications

Mindtools are computer-based application tools that engage learners in critical thinking. They include expert systems, databases, constructive hypertext, semantic networking, spread sheets, and microworlds of various types. When used to analyze content structures of learning materials or personal knowledge structures, mindtools function as computer-based learning strategies that engages and supports generalizable cognitive processing (Jonassen, in press; Kommers, Jonassen & Mayes, 1992). Mindtools can be used to analyze or represent a subject matter, or to help learners organize their thoughts as they prepare to write a paper to produce a product. Such tools help to make abstract subjects and ideas more concrete and manipulable.

Cognitive Outcomes of Expert System Construction

Expert systems can serve as computer-based mindtools that a learner can flexibly make use of, similar to hypertext, semantic mapping, and other organizational tools. The analysis of subject matter required to develop expert systems is so deep and so incisive that learners develop a greater comprehension of their subject matter, engaging in analytical reasoning, elaboration strategies such as synthesis, and metacognitive strategies such as validating (Jonassen & Grabinger, 1992). Building expert system knowledge bases is a generative and constructivistic process that facilitates the acquisition of conceptual as well as procedural knowledge. Trollip, Lippert, Starfield, & Smith (1992) believe that the development of expert systems results in deeper understanding because they provide an intellectual environment that:

- demands the refinement of domain knowledge,
- supports problem solving, and
- monitors the acquisition of knowledge.

The first requirement, the refinement of domain knowledge, is met because building expert systems requires generative processing of information. According to the generative hypothesis (Wittrock, 1974), information becomes meaningful to the individual insofar as it is related to prior knowledge. Building expert systems requires the knowledge engineer to expose the prior knowledge of the expert. This entails identifying declarative knowledge (facts and concepts), structural knowledge, the knowledge of the interrelationships of ideas in memory (Jonassen, Beissner, & Yacci, in press), and procedural knowledge (how to apply the former). Building experts systems, we believe, entails converting existing declarative knowledge into procedural knowledge and applying it. Finally, Trollip et al believe that environments should provide a mechanism for monitoring their own knowledge. This entails metacognitive awareness of their knowledge, which is the highest order of intellectual processing (Flavell et al, 1977).

An important distinction of building expert systems, vis-a-vis other mindtools, is that the process concentrates on depicting procedural knowledge, whereas others focus on declarative and structural knowledge changes. Psychologists usually represent procedural knowledge as a series of IF-THEN rules (E. Gagne, 1985); such a representation mode is obviously well-suited to expert system codification. As learners identify the IF-THEN structure of a domain, they will tend to understand the nature of decision making tasks better; this deeper understanding should make subsequent practice opportunities more meaningful. We would not want to suggest that the mere development of an expert system necessarily leads learners to acquire the compiled procedural knowledge of a domain. Merely identifying the IF-THEN rules involved in a process does not ensure acquisition of the procedural expertise, which would require extended practice opportunities in realistic performance settings.

Finally, Trollip et al. (1992) believe that environments should provide a mechanism for monitoring their own knowledge. Reflecting on what they know using rule-based expert systems as a formalism requires learners to reconceptualize and restructure their knowledge as well as simply making learners aware of how much they do know. This process entails metacognitive awareness of their knowledge, which is a necessary component of problem solving (Flavell, 1976).

Assessing Knowledge Structures

Structural knowledge is the knowledge of how concepts within a domain are interrelated (Diekhoff, 1983). If schemas are defined by their interrelationships to other schemas, then explicit awareness of those interrelationships and the ability to explicate those relationships is essential for higher order, procedural knowledge. It is not enough to *know that*. In order to *know how*, you must *know why*. Structural knowledge provides the conceptual bases for *why;* it describes how the declarative knowledge is interconnected. Procedural knowledge is predicated on these interconnections between ideas. Structural knowledge enables learners to form the connections that they need to describe and use scripts or complex schemas.

Structural knowledge has also been described as "cognitive structure", the pattern of relationships among concepts in memory (Preece, 1976). Cognitive structure in learners is a reflection of subject matter structure. Structural knowledge can be thought of as the understanding of one's cognitive structure.

This research seeks to identify the structural knowledge outcomes of building expert systems, that is, the degree of individual knowledge restructuring that occurs as a result of building expert systems. To what extent is knowledge restructured when learners synthesize procedural understanding by making explicit their own knowledge structures or the knowledge structures of experts.

METHOD

Assessment Instruments

The cognitive structures of seventeen students in a graduate education course on individual differences, learning and instruction were pretested using *relationship proximity judgments*. Perhaps the most accurate method for assessing structural knowledge is the use of Pathfinder networks (Goldsmith, Johnson, & Acton, 1991). Pathfinder Nets use a scaling algorithm for transforming semantic proximity matrices into network structures in which each object in the structure is represented by a node in the network and the relatedness between objects is depicted by their physical closeness (Schvanenveldt, Durso, & Dearholt, 1985; 1987; 1989). The algorithm searches through the nodes to find the closest indirect path between objects. The algorithm retains only the links with a minimum-length path between two concepts, so in the resulting net, not all concepts are not directly connected to all other concepts, as is implied by other types of dimensional representations.

Procedure

The research was conducted in the context of a course on analyzing learner characteristics and relating them to learning outcomes and instruction techniques. On the first night of class, students assessed their knowledge structures related to content domain. Pathfinder networks were generated by each of the subjects before instruction. This involved each of the students rating the semantic relatedness of 23 concepts that were most integral to the instructional content (see Table 1). The rating program asks the student to rate the similarity of each pair of concepts on a scale of 1-9, with 1 representing low or no relatedness and 9 representing a high level of relatedness. This process was difficult because some of the concepts were new to the student.

learning	learning styles	leveling/sharpening
instruction	mental abilities	anxiety
individual differences	field independence	frustration tolerance
intelligence	cognitive flexibility	locus of control
cognitive styles	impulsivity/reflectivity	achievement
cognitive controls	cognitive complexity	risk taking
personality	category width	structural knowledge
prior knowledge	visual/haptic	

Table 1
Key Concepts in Pathfinder Networks

After pretesting, students in the class were taught to use a production rule expert system shell, Primex 1, which consisted of an editor, Prolog compiler, and a set of advice windows which provided the advice, explanations of the reasoning, and traces of the sessions. The only assignment and requirement for the course was to develop a medium sized expert rule base (200-300 rules) which would provide a novice teacher advice on which instructional strategies would be appropriate to use to teach students with different learner characteristics a set of 4-5 stated learning outcomes. This task required evaluating each learner characteristics for possible interactions with stated learning outcomes, identifying possible instructional strategies that could be used to capitalize, challenge or remediate those different learners. At the conclusion of the course, they were posttested with both instruments.

In each of the subsequent eight classes, learners self-evaluated themselves on mental abilities, cognitive control, cognitive style, learning style, and personality instruments and then discussed their conceptions of each of the individual differences listed below:

- fluid intelligence
- structure of intellect abilities
- field independence
- cognitive flexibility
- impulsivity/reflectivity
- category width
- visualizer/verbalizer
- extraversion/introversion
- leveling/sharpening
- conceptual style
- Grasha-Reichman learning styles
- Gregorc learning styles
- anxiety
- ambiguity tolerance
- locus of control

Discussions also focused on the types of learning outcomes that would most likely interact with each of the individual differences and the types of teaching methods that could be used to preferentially and compensatorally match instruction to each individual difference. That is, the discussions supported the reasoning necessary for building their knowledge bases. The students were building their knowledge base as the instruction and discussions occurred. By the end of instruction, each student had completed at least 200 rules and most had completed substantially more.

At the end of instruction, students generated proximity ratings and Pathfinder nets to assess how their knowledge structures had changed as a result of the course.

RESULTS

Pathfinder Nets generated by each student at the end of the course were compared with the students' nets at the beginning of the course. Both pretest and posttest nets were compared with an experts representations of the content using the same constrained set of concepts (see Figure 1 for the layout of the Pathfinder net). Finally, each student's beginning and ending nets were compared with a net that was generated to represent the causal strength of relations between each of the concepts. That is, similarity ratings represented the degree of causality implied by the relationship between concepts (see Figure 2 for a layout of the Pathfinder net).

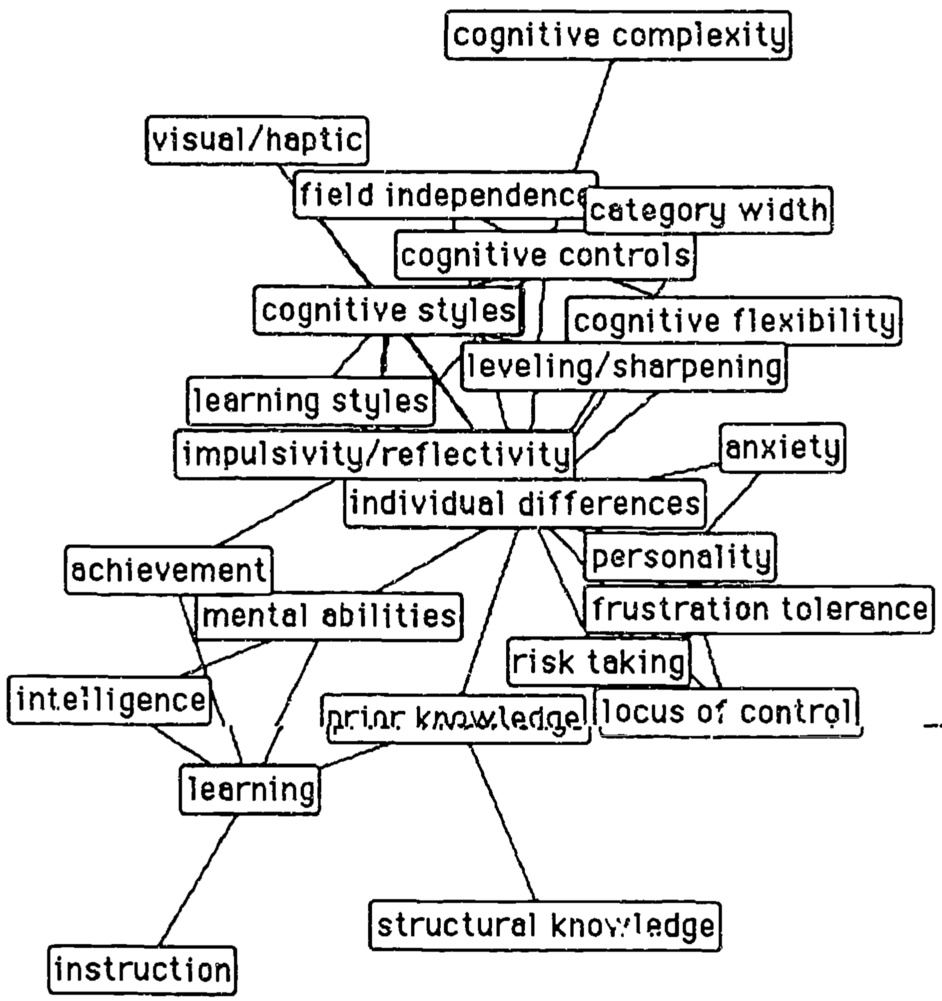
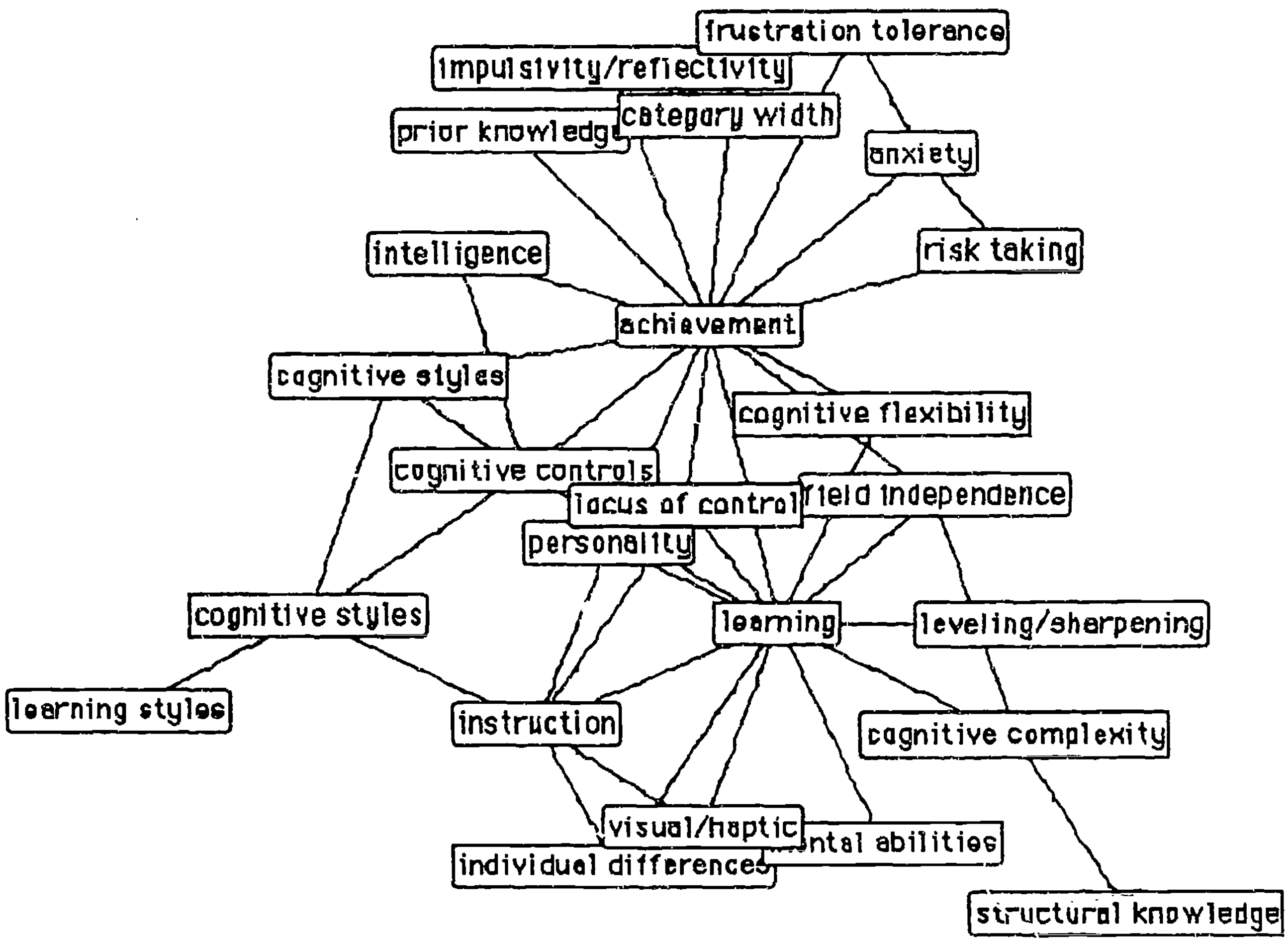


Figure 1
Expert Pathfinder Net

These comparisons were produced using a set-theoretic method for quantifying the configural similarity between two nets using a common set of nodes known as C. The C measure examines the degree to which the same node in two graphs with a common set of nodes is surrounded by a similar neighborhood of nodes.



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igure 2
Pathfinder Net Representing Causal Links

This neighborhood comparison is performed for each node in the two graphs and the results averaged across nodes to compute an overall similarity index. Two graphs are similar to the degree that the patterns of edges that define how two graphs are linked are the same. The edges describe the paths that exist between the nodes. The C similarity rating measure has been found to be more predictive of final course grades than raw proximity ratings and multidimensional scaling solutions (the most accurate method used previously), and as a measure of structural similarity, it is consistent with a configural notion of cognitive structure (Goldsmith, Johnson, & Action, 1991).

Pretest-posttest comparisons and expert-posttest comparisons were averaged across each group and the groups means were compared using t tests. Similarities were calculated for student's beginning and ending Pathfinder nets. The nets showed some similarity

(M=.238(.115)), indicating that while students' conceptions of the knowledge domain clearly changed, the posttest were still affected by the pretest ratings. Similarity between students' pretest and postest nets and the expert net were calculated. The average similarity rating between students' nets and the expert nets increased significantly from pretest (*Mr*=.149) to posttest (*Mr*=.187), t=2.485, p<.05. Next, similarity between students' pretest and postest nets and the causal model net were calculated, but the average similarity rating s did not increase significantly from pretest to posttest, t=.917, p>.05.

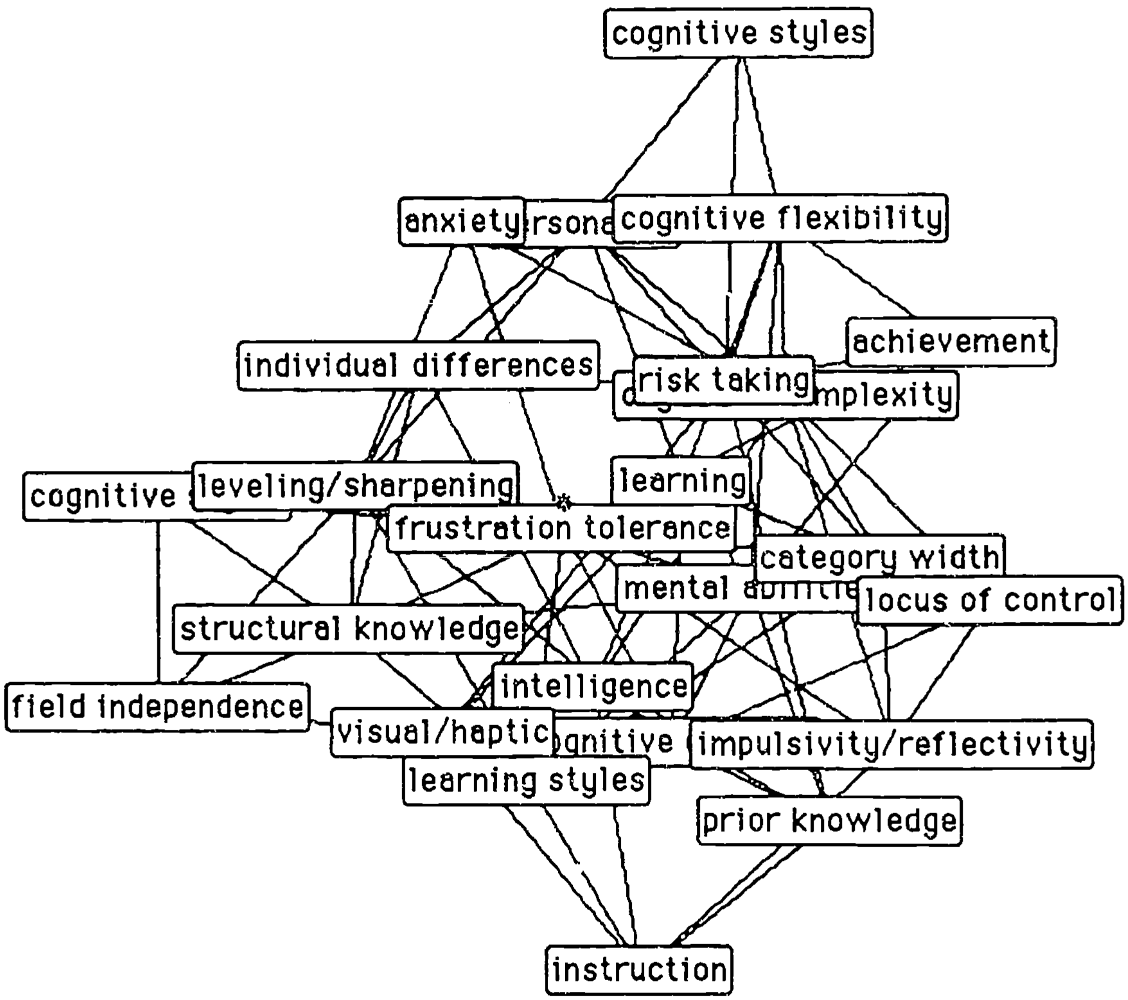

Figure 3
Student Pretest Pathfinder Net

Additionally, the nets were compared visually in order to interpret the reasoning of the students. For instance, Figure 3 shows one of the student's pretest nets in which the concepts are clustered together in an undistinguished manner. The clusters do not describe meaningful or appropriate relationships between the concepts. The connections between the nodes are confused and inappropriate. There is no central node. Posttest nets, on the other hand, contained multiple clusters with logical connections between the nodes. In this case, achievement, learning and instruction are the central nodes, indicating more similarity to the casual model net in Figure 2.

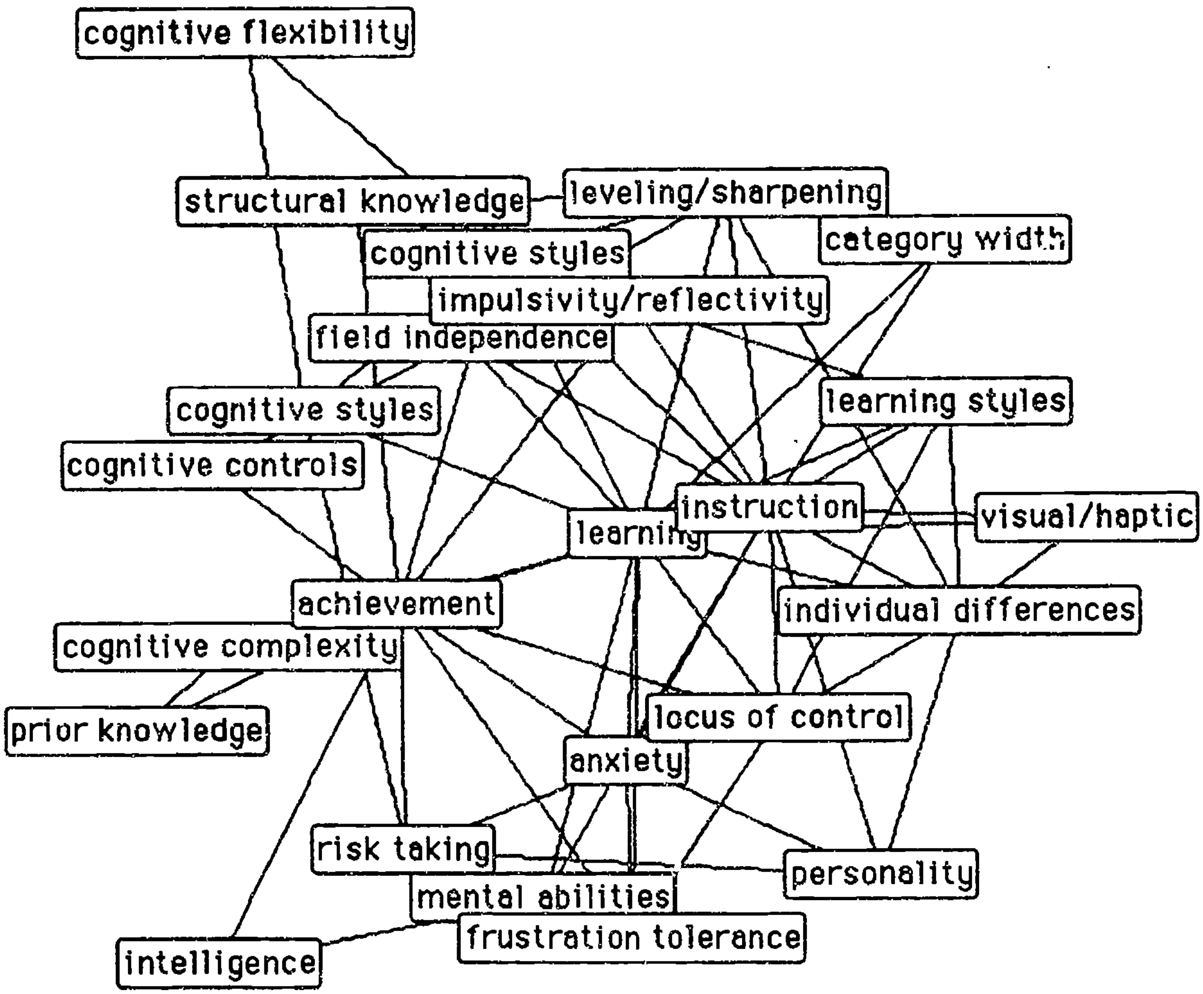

Figure 4
Student Posttest Pathfinder Net

DISCUSSION

It is clear that the cognitive structures of the learners changed as a result of instruction. They changed significantly toward the teacher/expert's model cognitive structure, which is similar to other research which showed that students' cognitive structures become more congruent with an expert's structure as a result of explicit instruction (Shavelson, 1972, 1974; Shavelson, R.J. & Stanton, 1972; Shavelson, R.J. & Geeslin, 1972). However, this study sought to determine how student's cognitive structures would be influenced by the formalism that they were using to represent their knowledge, in this case, expert systems. Relative to that question, no consistent effects could be determined. That s, strength of causal relations were not eviden tin the nets that students generated at the end of instruction. While the students knowledge structures clearly changed, those changes were mediated by a variety of individual differences, which ironically was the topic of the course in which the were working.

Obviously, this study needs to be replicated using other formalisms to ascertain whether or not different representation formalisms produce different structural changes n students memory. That study is planned, using a semantic networking formalism (using the SemNet program). Comparing the effects of different representation formalisms on cognitive structural changes will hopefully provide evidence about the strength of these formalisms.

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A Methodology for Creating an Intelligent Authoring/Instructional System (IA/IS)

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Abstract

A tool-supported methodology to assist in the creation of complete instructional systems is introduced. The three disciplines of software engineering, artificial intelligence, and instructional design are integrated to create an Intelligent Authoring/Instructional System (IA/IS). Then, the ten-step methodology is specified. Acquisition tools provided in the IA/IS are used by the authoring team to extract the knowledge required in the IA/IS's three co-operating knowledge-bases. This system is an intelligent courseware development environment as well as an intelligent tutoring system.

1. Introduction

There is very little in the literature about a methodology for creating an ITS. Two articles were found that describe a methodology related to ITS. Clancy's article [CLAN87] describes the methodology used to develop NEOMYCIN and could be generalized to apply to developing any diagnostic expert system, but it can not be generalized to apply to tutoring systems in general. Baker [BAKE91] discusses the task of developing a methodology for assessing the technology used in ITS. She states that one of the reasons there is so little empirical validation of the existing ITS is that most of the research has been so focused on one specific module of the system that there are very few whole systems that have been produced. When it becomes feasible for courseware designers to create instructional systems in a timely and cost-effective manner, the increase in the number of complete instructional systems created will make it possible to gather the empirical evidence needed to properly evaluate the instructional principles incorporated into these systems. To address some of the problems associated with the creation of these complex systems, this paper introduces an integrated tool-supported methodology for authoring ITS.

In Section 2 of this paper, I discuss the rationale for using an integrated tool supported methodology and, in Section 3, the system architecture for my model is introduced. The ten step methodology is presented in Section 4. Then, the system is evaluated, first, as an intelligent instructional system in Section 5, and then, as an authoring system in Section 6. A prototype of this system is described in Section 7, and, finally, my conclusions are presented in Section 8.

2. Integrated Methodology

In order to build an ITS it is necessary to integrate three different disciplines; software engineering, artificial intelligence, and education.

- *Software engineering* is needed to develop a methodology and a set of tools to provide assistance in building these complex systems in a timely, cost-effective way. The educational effectiveness of any tutoring system is enhanced by the inclusion of appropriate graphics, animations, and sound that can be created using authoring tools.

- *Artificial Intelligence* techniques are necessary in order to create an adaptive system that models the student and monitor his progress.

- *Educational* considerations are necessary to ensure that the content, form, and sequencing of the instructional presentations will eventually be able to satisfy the instructional objectives of the courseware developer.

The methodology provides tools to acquire the knowledge needed in each module and defines an architecture to integrate the contributions provided by the different experts who make up the authoring team. The concept of an Intelligent Authoring/Instructional System, IA/IS, is introduced in this research. Figure 1 shows that an IA/IS fits in the intersection of the three disciplines of software engineering, artificial intelligence, and education.

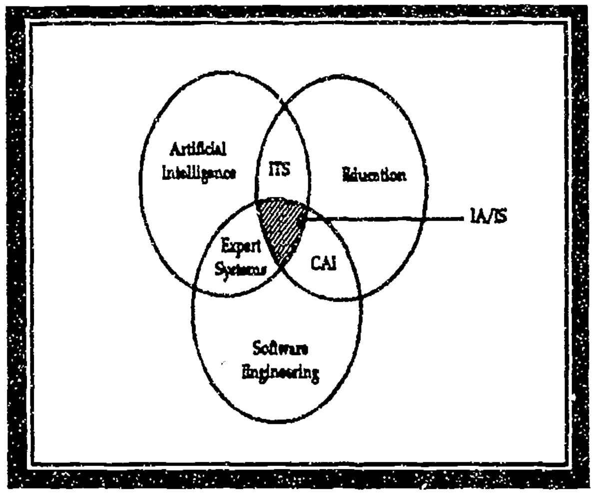

Figure 1. Relationship between AI, software engineering, and education.

3. A Model for an Intelligent Authoring/Instructional System (IA/IS)

In the model that has been developed [KERN90], the knowledge that is acquired from the authoring team is stored in three knowledge-bases that co-operate in determining the interactive instructional materials that are presented to the student. The authoring team consists of a content expert, an instructional design expert, and a courseware developer. This team uses acquisition tools provided by the IA/IS to gather the required knowledge. This insures that the data is stored in a form that can be accessed by the other co-operating components of the system.

3.1 Two Modes of Operation

Figure 2 shows the data flow diagram for the system in authoring mode. The acquisition tools are used to extract the required knowledge from the members of the authoring team. Each of the

The methodology consist of the following steps:

1. *Acquire a prescriptive instructional theory* based on theoretical considerations from an instructional designer. This is accomplished with the use of the Prescriptive Theory Acquisition Screen that is part of the Instructional Strategy Acquisition Tool. An instructional strategy is prescribed [LAND83] based on the subject to be presented, the type of learning desired, and a description of the intended student population.

2. *Acquire a description of the targeted student population* from the courseware developer. The Course Design Acquisition Tool contains a Student Parameter Acquisition Screen to obtain this information. The parameters describe the student population in terms of (i) previous knowledge of the content area, (ii) general aptitude, (iii) how meaningful the content is, and (iv) interest in learning. A Learner Control Metric is calculated from these factors. The higher this value [STEI89], the more control the student has to determine the sequencing of the presentations and the rate of progress through the course.

3. *Acquire a priority sequence* for searching the indices of the case-based instructional strategy system so the system can access the "closest match" to the current sub-objective. There is a Priority Acquisition Screen in the Course Design Acquisition Tool to set these priorities. When an exact match is not available, the author can set the priority of the following factors; (i) complexity of the subject matter, (ii) type of learning required, or (iii) unique qualities of the student population. The highest priority will determine the primary search key, then the secondary search key, and, finally, the tertiary search key.

4. *Acquire the performance objectives* for the instructional system from the courseware developer. The Course Design Acquisition Tool, also, contains an Objective Acquisition Screen for acquiring these performance objectives.

5. *Sub-divide the course objectives* into sub-objectives until at the lowest level each objective is just one concept or skill that can be presented to the student as one unit of instruction [GAGN88]. The Sub-Objective Acquisition Screen of the Course Design Acquisition Tool is used to accomplish this.

6. *Retrieve the "closest match"* to suggest an instructional plan to the courseware developer. There are three Plan Requirement Screens that are part of the Course Design Acquisition Tool to describe the current instructional plan in terms of subject, type of learning, and student characteristics. The search priorities set in step 3 will be used to direct the search through the instructional material that has been previously developed.

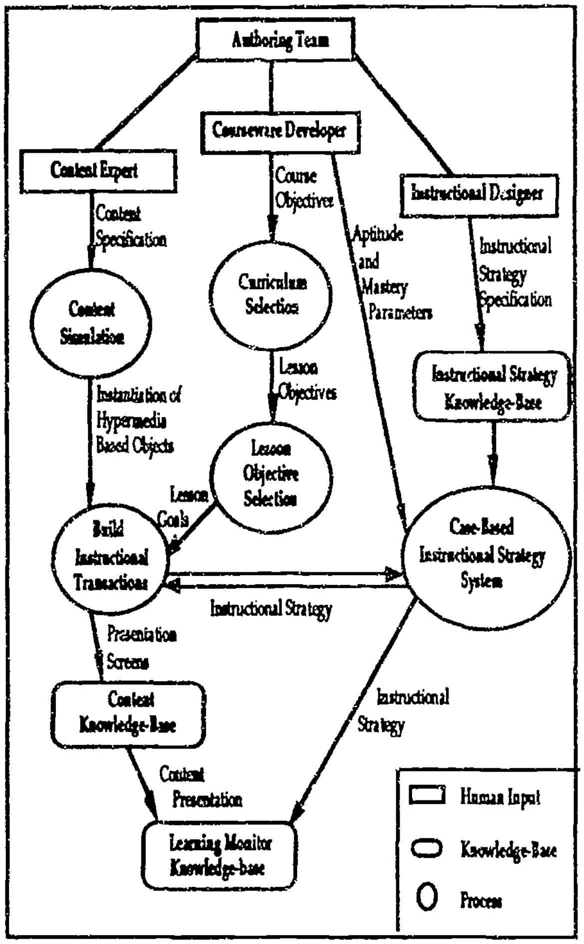

Figure 2. Data flow diagram for the IA/IS in authoring mode.

experts is queried and given advise as his knowledge is extracted for use in the IA/IS. The knowledge that is extracted is refined until it is in a form that can be incorporated into one of the knowledge-bases.

In instructional mode, the Learning Monitor supervises the sequencing of the instructional presentations to the student. Figure 3 shows the flow of data during this instructional mode. The student's interaction with the system is used by the Learning Monitor to gather statistics about the student's knowledge. Periodically, the statistics are used to update the parameters in the model of the student and compare the student's knowledge structure to the content knowledge structure created by the content expert. Attention is paid, not only, to the student's knowledge as evaluated from tests, but also, to the pattern of references to other related presentations to infer the relationships the student is making between the different "chunks" of content knowledge he is attempting to learn.

4. Steps in the Tool-Supported Authoring Methodology

The tool-supported methodology to author an ITS [KERN92] consists of ten steps to acquire the knowledge required by the system. Refer to Figure 2 to follow the data flow as the system is created.

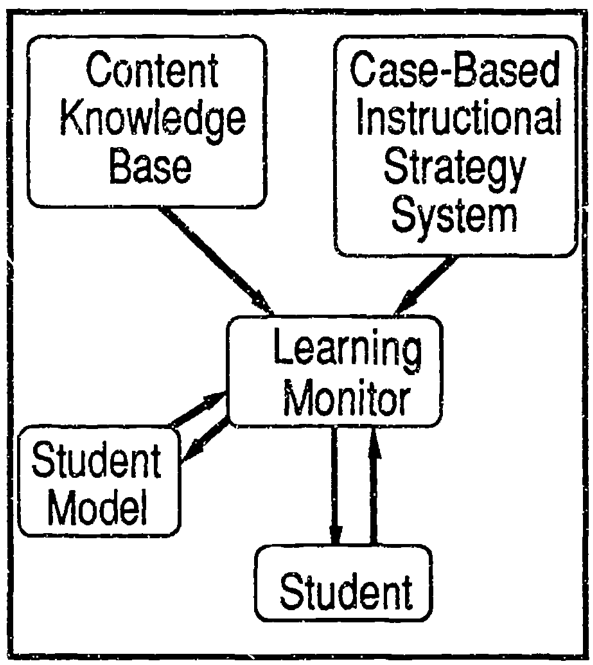

Figure 3. Data flow diagram for the IA/IS in instructional mode.

7. *Modify the prescribed instructional plan* to satisfy the current objective. The Instructional Strategy Acquisition Tool contains an Instructional Plan Modification Screen to specify these changes. The author can reuse as much of the previously developed instructional material as he deems appropriate and make modifications as necessary.

8. *Acquire the content material for the presentation screens* required for each of these sub-objectives from the content expert. The Content Acquisition Tool includes a Template Selection Screen and five different Template Screens from which to choose. The templates include the following types of instructional displays (i) present information, (ii) provide an interactive demonstration, (iii) drill, (iv) question, and (v) test.

9. *Switch to instructional mode* when the instructional materials for all of the course objectives have been created. At this point the emphasis changes from authoring to instructing.

10. *Evaluate the instructional materials* and make appropriate modifications if defects are revealed. If the instructional materials are found to be defective, the author can return to steps 6, 7, and 8 and make changes to the instructional strategy and/or the instructional materials.

This is an iterative, recursive methodology. Step 5 is done recursively until you reach the lowest level sub-objective for which the instructional materials are created. Then, steps 6, 7, and 8 form an iterative loop that is repeated to create the instructional materials for each of the sub-objectives specified in step 5. If step 10 reveals a defect in the system, it is corrected by repeating the loop containing steps 6, 7, and 8. The author is finished when he is satisfied with the instructional effectiveness of the tutoring system that has been created.

5. Evaluating an ITS

In order to be judge educationally effective as a tutoring system, the IA/IS must satisfy the goals of four sets of actors; the content experts, the instructional design experts, the courseware developers, and the students. To be considered intelligent [BURN88], the instructional system must pass the following tests for intelligence. The instructional system must (i) "know" the domain knowledge well enough to draw inferences and to solve problems, (ii) be able to assess the student's level of mastery of the domain knowledge, and (iii) adapt its instructional strategy to reduce the differences between the student's performance and the embedded content expert's performance.

The IA/IS addresses these issues with the following AI techniques:

- The content knowledge is stored in Cognitive Associative Structures (CAS). This is a hypermedia structure that emphasizes the relationships that exists between "chunks" of the content area. A CAS has the capacity to store both declarative and procedural knowledge. The Authoring Team can include all the knowledge that is necessary to draw inferences and solve problems.

- A model of the student's knowledge is stored in a student version of the content CAS. This CAS is initialized using parameters supplied by the Courseware Developer about ability level and prerequisite knowledge of the intended student population. As the student interacts with the instructional system, changes in his knowledge structure are inferred from his responses, and the model is adjusted accordingly. Parameters are maintained to evaluate, not only, the student's mastery of the content "chunks", but, also, to infer the relationships that are being strengthen by the pattern of references to related "chunks" of knowledge.

- Differential modeling techniques are used to indicate differences between the expert's version of the CAS for the content knowledge and the student's version of the CAS [WILK88]. A performance-oriented comparison would give a problem to the student and then compare the method the student uses to solve the problem to the method specified by the content expert. In contrast to this approach, a knowledge-oriented comparison compares the structure of the student's knowledge to the structure of the content knowledge specified by the content expert. This IA/IS takes the knowledge-oriented approach because in the long run, performance will be more correct if the knowledge structure is carefully developed. In Van Lehn's study of subtraction errors made by school children [VANL88], he found that "bugs" are caused by correct execution of an incorrect procedure. This supports the conclusion that faulty knowledge is the most likely problem, not faulty performance.

- a case-based instructional strategy knowledge-base is consulted to improve the instructional effectiveness of the system when defects are revealed [HAMM89], [HAMM91].

6. Criteria for an authoring system

An authoring system must be more than just a high-level programming environment and a graphics editor [MERR85]. It must, also, offer assistance in the instructional design process. The IA/IS includes a case-based instructional strategy system (C-BISS) that is initialized with generic prescriptive instructional strategies. The C-BISS suggests a strategy to the author based on the description of the intended student population and the type of learning that is desired. The author is free to make modifications to the suggested strategy. These modified prescriptions are then added to the C-BISS.

The IA/IS, also, contains basic instructional templates. These include a template for each of the following instructional methods: (i) presentation of information, (ii) interactive demonstration, (iii) drill, (iv) question, and (v) test. The author can modify these templates and add new templates as necessary.

7. A Prototype IA/IS: HOBIE

I have built a prototype IA/IS, called HOBIE (Hypermedia Object-Based Intelligent Educator), to demonstrate this methodology and system architecture. The tools to extract the knowledge from the authoring team were developed on an Apple Macintosh SE computer using HyperCard as a graphics editor and programming environment.

The instructional system was created using my tool-supported methodology. The curriculum was designed as an introductory component for an undergraduate course in assembler language. The content area is an introduction to the binary and hexadecimal numbering systems including two's complement notation and data representation formats. It includes presentation of new material, interactive demonstrations of the conversion algorithms, drill, and testing of the student's knowledge.

8. Conclusions

The principles of software engineering [GHEZ91] must be applied to the process of creating complex software systems. The development of a methodology is instrumental in ensuring the inclusion of these principles in order to promote the successful development of an effective ITS. The principles of separation of concerns, modularity, abstraction, anticipation of change, and incrementality are incorporated into the ten step tool-supported methodology introduced in this paper.

The software qualities of user-friendliness, reusability, and evolvability have also been provided for in the IA/IS in the following ways. The use of well-developed tools and a graphics editor increase the user-friendliness of the system. The author can recall similar sub-objectives that have been satisfied in the past, modify the previously developed instructional material and reuse the modified version to satisfy the new sub-objective. The ability to switch back into authoring mode whenever the instructional mode reveals a deficit in the instructional system, allows the instructional system to evolve into a more effective system as it is being used.

This methodology offers assistance in the authoring process and will encourage the creation of complete instructional systems. As more systems are available for use, it will be possible to empirically validate the instructional strategies that are most effective in a computer-assisted learning environment.

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Does ITS Help, Help? and, Is an ITS Error Diagnosis a Remedy?

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Abstract

This paper describes the results of three separate experimental evaluations of an intelligent tutoring system (ITS) called Modified Advanced Learning for MSE (MALM). This system, designed to teach troubleshooting and operations procedures to military communication personnel, was systematically altered in order to examine the impact of specific ITS capabilities. Specifically, we focussed on the systems advice function and error feedback function. In order to understand the impact of these experiments, we review past evaluations, provide a brief description of MALM, and detail methods and results of the three experiments.

This paper presents the results of an experiment with Modified Advanced Learning for MSE (MALM), an Intelligent Tutoring System (ITS) for teaching troubleshooting and operations procedures for Mobile Subscriber Equipment (MSE, a communication network used by the Army). We begin the description of these experiments with a brief discussion of evaluations that have been conducted on ITSs. This discussion will focus on both the results and methods. In addition, in order to understand any generalizations that might be drawn from the results of this collection of experiments, the ITS used will be described in more detail.

After twenty years of ITS research, it is surprising how little effort has been given toward evaluation. Perhaps this is because of the old AI maxim, "If it works, then it is NOT AI." Perhaps it is because results of evaluations are less than expected and researchers are hesitant to place these results out for public consumption. Perhaps there is little money or motivation after large scale development efforts to conduct any formal evaluations. Whatever the reasons, there are surprisingly few evaluations reported. One of the most complete reviews was written by Legree and Gillis (1991). In this paper, they conclude that the effect size of ITSs is approximately 1.0 relative to lecture approaches to instruction and human tutoring. This result is true if the ITS coverage is large enough (in terms of time) to have an effect, whereas small scale evaluations (short treatments) tend to indicate no differences.

To begin this review, we will describe the large scale evaluations. Kurland, Granville, and MacLaughlin (1990) conducted a large scale evaluation of the MACH III ITS that was used for Army training. This ITS was considered large scale because the content covered 32 hours of material. The method of evaluation was to compare a group of soldiers that learned from "traditional" instruction with a group of soldiers that learned from the MACH III tutor. The results of this evaluation indicate that the MACH III tutor has an effect size of 1.0 relative to regular class instruction. Anderson, Boyle, and Reiser (1985) evaluated their Lisp tutor by using both regular classroom instruction and the ITS. In addition, they included a human tutor group. Their results also indicate about a 1.0 effect size and the treatment lasted between 11.4 and 26.5 hours. Orey (1991) used a similar evaluation strategy to evaluate his whole-number subtraction tutor. The effect size was a little less than 1.0 and the treatment was 4.5 and 6.2 hours. Raghavan and Katz (1989) compared a group who had access to their economics tutor (Smithtown) with a group who did not have access. Not surprisingly, the ITS group took less than half the time to complete assignments. Legree and Gillis (1991) suggest that the best way to perform evaluations of ITSs is to compare the system to lecture and human tutoring. This notion, while suggested by others (e.g., Anderson, et al., 1985), is based on Bloom's (1984) 2-Sigma Problem.

According to this view, the average child who is individually tutored, will score 2 standard deviations higher on achievement tests than the average child in a lecture-based class. The problem is to find a cost effective alternative to one-on-one tutoring. In fact, some have suggested that this is a goal of ITS research and development (Anderson & Reiser, 1985). One of the results of looking at evaluation from this perspective is that others attempt to make effect size estimates. Whereas the above research would indicate approximately 1.0 for an effect size for ITS, Kulik and Kulik (1987) would suggest a 0.31 effect size for CAI. Others would reduce this figure to approximately zero (Clark, 1985). These studies have focused on broad measures of impact on achievement. As has been mentioned elsewhere (Orey, 1991), Clark (1983) and Reeves (1986) have described many dangers in using these ill-defined groups for comparison purposes. However, we have chosen to use similar groups for the first two experiments described in this paper. We do not use this approach in the third experiment. We chose to use a more detailed analysis for this experiment. The reason for this is that Legree and Gillis (1991) suggest that the smaller the treatment, the less likely to show differences. We suggest that the gross measures may be a contributing factor. Therefore, examining a more refined approach would create the possibility for finding any differences that might exist.

The architecture of MALM was based on a problem solving perspective and it makes use of some of the latest computer-based instructional technologies: ITS, learning environments, and hypermedia. These techniques are combined so that problem solving in a MSE context can be explored in the somewhat safe and inexpensive environment of an IBM PC computer.

MALM was designed for high bandwidth diagnosis using a model tracing technique. It was implemented in a hypermedia environment that allowed the learners to explore the environment, much like that in a learning environment. The knowledge base representation combines a frame based representation and a rule based implementation. Problems are generated using an automated parsing process and instruction is provided when errors and help occur. These aspects of MALM were added (for a more complete description of MALM, please refer to Orey, et al., (1992)) to the already existing system that was developed by Galaxy Corporation (Coonan, Johnson, Norton, & Sanders, 1990). We also removed the advice and error feedback and created a version which presenteed the entire solution process on one screen. The learners needed to determine what they had and had not done. This linear list of steps became our CAI-like Linear Advice (LA) version. If we take Kulik and Kulik (1987) at face value, then the effect size estimate for the LA version of MALM would actually be slightly higher than 0.31. Therefore, the comparisons between groups would be harder to detect differences because they are closer to same effect size.

Methodology

Introduction

Regardless of the differences in prior knowledge between the available subjects at the University of Georgia and the target users that MALM was designed for, the purpose of this evaluation was to determine the effectiveness of both error feedback and the advice function in MALM. In the formative evaluation conducted in the Spring of 1991 at the University of Georgia, frequent access to advice was observed during the process of solving problems among subjects (see Orey, et al., 1992). It was assumed that the advice function played an essential role in helping participants without content knowledge to solve problems in MALM. Because of this reliance on the advice function, the summative evaluation primarily focussed on the effect of the advice function and error feedback function in MALM. In order to examine the effect of the advice function, a detailed analysis was performed. It compared ITA with LA. The specifics of the experiment are described below.

Materials

Essentially, there were two versions of MALM that were created for this evaluation, the ITA and LA versions. Of all the problems that were created, we chose to examine only one troubleshooting problem. The computer would then collect the needed information for the analysis. It saved every click of the mouse and every keayboard entry.

Participants/Groups

The participants were 10 undergraduate students in Elementary or Early Childhood Education and graduate students in Computer-Based Education or Instructional Technology at the University of Georgia. These participants were split into two equal groups of 5 participants.

There were two groups in the experiment. The ITA group had access to an advice function that adapts to the learner based on actions they perform. In addition, this group had the diagnostic component of MALM to help them to learn from their errors. These aspects of MALM were deemed the most "intelligent" components of the system and were only available to the ITA group during the experiment.

The LA group in these experiments also used only the computer for learning. However, they did not have "intelligent" advice or error diagnosis. Instead, the LA group was provided a screen listing all the steps for correctly carrying out the procedures required for troubleshooting in MSE. Instead of corrective feedback on errors made, the system informed them when an error occurred (not what the error was and why it was incorrect).

Procedure

The procedure for the experiment follows a strategy adapted from Allison and Liker (1982) and described in Legree, Gillis and Orey (in press). This strategy used a lag sequential analysis. In this procedure, the intent is to determine the probability of accessing advice or making an error one, two, or more steps after accessing advice the first time. More generally, what is the impact of the computer's behavior (via messages) on the behavior of the learner's first, second, etc. behavior (interaction) following the computer's behavior. In order to perform this analysis, MALM was modified so that dribble files would be created that would save every step that was performed by learners as they solved the problem. In addition, a transparent button was placed in the top middle of each screen so that the experimenter could indicate when human advice or feedback was provided. In this way, the impact of the advice and error functions could more directly be assessed.

The procedure used was to have each participant solve one troubleshooting subscriber problem. Participants were randomly assigned to one of two groups. A minimal description of the system was provided. The participant was then asked to solve the problem. Whenever the participants arrived at an impasse, they would ask for assistance from the experimenter. The experimenter would provide one declarative statement as help. If this was not enough, the participant could ask again. Each access to help was recorded in the dribble file via the transparent button.

Analysis

We used a lag sequential probability procedure (Allison & Liker, 1982). This is a social interaction analysis which Allison and Liker describe in terms of behaviors of married couples. In other words, does the negative behavior of spouse one affect the behavior (positive or negative) of spouse two at different behavioral lags. For our purposes, there are two important characteristics.

First, the interaction analysis is done between *two* behavior generating entities (for them two spouses; for us-a computer and a learner). Second, the behaviors are categorized as dichotomous (this is *not* a requirement according to Allison and Liker, but it works for us).

The dichotomous data for Allison and Liker was positive and negative. We chose to categorize learner behaviors as correct or incorrect. Actual possible behaviors of the learners could be categorized as 1) performing a correct problem solving action; 2) navigating through the system; 3) accessing information; 4) seeking advice; and, 5) performing an incorrect problem solving procedure. We then classified behaviors 1 through 3 as correct and behaviors 4 and 5 as incorrect. Obviously, the first behavior should be considered correct and the fifth incorrect. The other three could be debatable. However, we considered that actively using the system was normal problem solving behavior (navigating and accessing information). Clicking on the Help button, on the other hand, we considered incorrect because we felt that this was one of the two ways to resolve an impasse. The other way was to commit an error. Using this classification scheme, the analysis was produced.

The next step in the analysis was to consider which of the computer's behaviors were important analysis. Because we considered advice and error feedback to be the most "intelligent" components of the system, these were included in the analysis. In addition, we chose to examine the impact of human advice. These behaviors need to be compared with some base behaviors. Because the computer does *not* respond following a correct action, we chose to compare the other behaviors with those following a correct step.

We chose to examine learner behaviors from one to ten behaviors following the computer behavior. A 2 X 2 contingency table was generated for each lag. One dimension of this table was whether the learner performed a correct or incorrect behavior. The other dimension was the computer's behavior. In the computer advice analysis, these two behaviors were computer advice or correct step, (which actually was *no* behavior). Therefore, there were ten 2 X 2 contingency tables for computer advice behavior versus no behavior, ten for error feedback behavior versus no behavior, and ten for human advice feedback versus no feedback. This yields three analyses (computer advice, error feedback, and human advice). In addition, there were two groups (ITA and LA). Each analysis generates ten 2 X 2 contingency tables. Each group was analyzed using the three analyses. The result was that there were 2 groups times 3 analyses times 10 contingency tables, or sixty 2 X 2 tables.

The first research question to be addressed is: Is the learner's behavior different following the computer's behavior (or human tutor) than following no behavior at lags 1 through 10? In order to answer this question, chi-squares were calculated for each contingency table. An alpha level of .05 was used. This was done for all sixty tables each with its own question.

The second research issue was to consider whether learner behavior patterns differed for the LA and ITA groups. This analysis was performed at each of the thirty points (the three categories [computer advice, error feedback, and human advice] times the ten lags). Allison and Liker (1982) suggest a procedure for calculating a F-score for comparisons between groups. This procedures was applied to this evaluation and an alpha level of .05 for two-tailed tests was used.

Results and Discussion

We attempted to examine the impact of advice and errors on learner's behaviors. In addition, we examined the difference between learner behaviors when using the ITA version versus the LA version. To begin this analysis, refer to Table 1 for the overall numbers. The pattern of results here are similar to those in the learning phase of Experiments 1 and 2. That is, the ITA group (range 10-29) used the advice function more frequently than the LA group (range 6-11). In addition, the number of errors that occurred in the two groups were about equal (ITA range 1-26; LA range 1-23). These two results are similar to the results found in the first two experiments. However, Table 1 also includes the number of time the learner asked the experimenter for help. We did not keep track of human advice in the other experiments and it appears that the LA group needed that form of help much more frequently, almost 2.5 times more frequently.

As suggested earlier, the advice function in the LA version of MALM may not be very useful. The experimenter frequently mentioned that the LA participants would not be able to complete any problems without experimenter assistance. This fact would render the LA version useless in a remote implementation of the software (no one to ask for help).

The next part of the experiment involves the results of the sixty contingency tables (see Table 2). We will begin with the impact of computer advice. First, look at the lags of 1 and 2 for the ITA group in Figure 1. The gap between the two lines would suggest that there is something different in the two events. The quantitative analysis bears this out. Both of these are statistically significant at .01 level ($c^2 = 7.33$, df =1, at lag 1). This result would indicate that the learner's behavior following computer help is different from when the computer does not do anything. Further, the numbers would indicate that the learner tends to do something correct following computer help (58 times correct out of 79 at lag 1) whereas the opposite occurs following an event where the computer does nothing (8 times out of 34 at lag 1). The pattern is also evident at lag 2 (54 times out of 79 and 14 times out of 34, respectively). Although there are some other gaps between the two lines, none prove to be statistically significant.

Table 1. *Means and standard deviations (in parentheses) for accesses to computer advice, human advice and total number of errors for the five (5) participants in each group.*

	Groups	
Type of Interaction	ITA	LA
Computer Advice	15.8 (7.6)	7.4 (2.1)
Error Feedback	13.8 (12.0)	11.4 (9.5)
Human Advice	4.2 (2.2)	1.04 (4.3)

Note: ITA=Intelligent Advice, and LA=Linear Advice

Next, refer to Figure 1 again, but this time focus on the LA group. Here again a lag of 1 proves to be significant (c^2 =7.76, df=1). This result also indicates that learners using the LA version tend to do something correct following computer advice (26 times out of 35) and tend to do something *incorrect* following a correct step (20 times out of 34). However, it does not persist to a lag of 2. There is another significant lag at 8 (c^2 =11.20, df=1). In this case, the learner is more likely to make an error 8 steps after accessing help (18 times out of 34) and more likely to do something correct 8 steps after performing a correct step (21 times out of 24). We are not sure what this means. Our impression after seeing several people use the different versions is that advice does not have any effect 8 steps following accessing it (and 18 times out of 32 is close to a 50-50 chance).

However, why did learners using the LA tend to do something correct 8 steps following access to advice?

The next issue to consider regarding Figure 1 is whether the pattern of results differs between the ITA and LA groups. Z-scores were calculated, as suggested by Allison and Liker (1982), for each lag and appear in Table 2. The critical value at the .01 alpha level is 1.96. As can be seen, only lags of 8 and 9 exceed this value and what this means is not at all clear. At lag 8, the fact that LA learners tended to perform a correct step 8 steps following a correct step (88% of the time) explains why the test statistic was significant especially since the other possibilities at lag 8 are at about 50 percent correct. However, what this implies about the effects of the LA versus ITA version is not at all clear. Ten lag behaviors were included for no apparent reason. Now that there were significant differences at lags 8 and 9, it is not clear how to interpret this. At lag 9, it is even more confusing. Seventy-two percent of the behaviors 9 steps following a correct step were correct for the ITA group whereas Seventy-one percent of behaviors 9 steps follow advice were correct for the LA group. This disparity accounts for the significant Z-score. Again, what this means for actual differences between ITA and LA is not clear.

Table 2. *The chi-squared values for the sixty different lag possibilities and the z-score difference measure between groups.*

	Groups								
	Computer Advice			Error Feedback			Human Advice		
Lag	ITA	LA	Z-Score	ITA	LA	Z-Score	ITA	LA	Z-Score
1	24.35**	7.76**	1.10	6.93**	1.56	0.99	4.78*	8.37**	0.07
2	7.33**	0.12	1.41	0.05	1.32	1.00	0.80	1.82	0.08
3	3.17	0.04	0.94	0.19	2.23	0.80	1.28	0.68	0.32
4	0.67	3.12	0.89	0.00	0.26	0.42	0.55	0.03	0.46
5	0.38	2.93	0.94	0.18	0.03	0.41	2.09	0.40	0.63
6	0.28	0.44	0.17	0.00	0.00	0.03	0.74	0.00	0.68
7	0.04	0.34	0.31	0.94	0.13	0.91	0.18	0.05	0.16
8	0.07	11.20**	2.74**	0.26	7.35**	1.81*	0.05	3.76	1.27
9	2.29	2.00	2.04**	3.35	0.75	1.88*	1.11	0.27	1.14
10	2.55	0.27	1.41	0.71	2.49	1.72*	0.01	3.98*	1.19

* p<0.05
** p<0.01

The other "intelligent" aspect of MALM that we examined was its ability to provide appropriate feedback. The LA version only provided the fact that an error occurred whereas the ITA version explained why the error was incorrect, what the error was, and recommended correction. In Figure 2, the results on error feedback for the ITA and LA groups is shown. The first result to discuss is the lag of 1 for the ITA group. This result was statistically significant (refer to Table 2). However, rather than tending to do something correct following error feedback (34 times out of 69 for lag 1), the effect is really manifest in the fact that learners tended to do something incorrect following a correct step (26 errors out of 24 times at lag 1). The remaining 9 lags seem to be closely related (the lines nearly overlap in Figure 2 except at the most significant lag of 9).

The second point about the results is in regard to the LA group. There is no significant difference between behaviors following correct and erroneous performance until lag 8. Like the results of computer advice described above, this effect is largely due to the fact that learners in the LA group tended to do something correct 8 behaviors after performing a correct step. Why this occurred is ambiguous. The remaining lag behaviors tend to be similar.

The third aspect of the results to be examined is whether there exists a difference between behaviors related to error feedback for the two groups. Once again. statistical significance was not indicated until lags 8, 9, and 10. And, as described for computer advice, it is unclear what this result might mean. A statistical explanation might suggest that by chance alone, some of the thirty Z-scores calculated might be significant (5 significant Z-scores out of 30 calculated is more than a chance level).

As a final comment about errors, there seemed to be a great difference for the ITA group between performance following computer help and correct steps at lags 1 and 2 of Figure 1. This disparity seems to be as great as the disparity found in the LA group portion of Figure 1, the disparity found in the ITA group portion of of Figure 2, and the disparity found in the LA group portion of Figure 2. We would suggest here that this is the most powerful result of the analysis to this point in favor of intelligent tutoring systems. That is, computer help has an impact on performance for lags 1 and 2 for the ITA group. This impact is not nearly as great for computer help for the LA group nor is it that great for error feedback for either group. This result might suggest that "intelligent" help may be a useful feature to include in a system. Error feedback does not, on the other hand, seem to have much of an impact on learner performance.

As described above, human advice was not only invaluable, it may have been essential for the LA learners. How this advice impacted on the lag behaviors will be described here. Referring to Figure 3, the ITA group had only one significant difference between behaviors following human advice (11 correct out of 21) and those following correct performance (8 correct out of 34) and that was at a lag of 1 (refer to Table 2 for list of chi-squared values). Again, this result is primarily due to the fact that learner's in the ITA group tended to perform an incorrect step following a correct step.

The LA group had two significant lags, one at lag 1 and the other at lag 10. At lag 10, the LA learners tended to do something correct following a correct step (15 out of 22) and something incorrect following human advice (26 errors out of 45). As with the other analyses, it is not clear how to interpret this difference. However, the difference at lag 1 would suggest that human advice had a differential effect on the LA group's performance. In fact, the performance of the LA group following human advice (37 correct out of 51) is much better than performance following a correct step (14 correct out of 34). Further, the performance following human advice for the LA group at lag 1 is similar to the performance of learners following computer advice at lag 1 for both the LA and ITA groups (73%, 74%, and 73%, respectively). However, this was not true of the ITA group receiving human advice (52%).

A possible explanation for this result may be that the type of information that was asked for by the ITA learners may be different than the type of information requested by the LA learners, or provided by either version of MALM. MALM provided procedural information. This analysis has examined procedural performance. Perhaps, the LA learners used the experimenter to access more detailed procedural information than that provided by the LA version of MALM. The ITA learners, on the other hand, may have used the experimenter to access conceptual, declarative, or some other form of knowledge. There is, however, no evidence to substantiate this interpretation. It should be noted that there was no statistical difference between the ITA and LA groups on the human advice part of the analysis (see Table 2).

Conclusions

In initial experiments, we found that learners in the ITA group used the help function more frequently than the learners in the other groups. We designed this experiment to more closely examine what occurs when learners are using the help system. In addition, we examined the error diagnostic component and the learners' need to ask for more help from the experimenter.

Computer advice seemed to have had more of an impact on learners in the ITA group than the LA group at lags 1 and 2. As described above, this may be due to a lower performance percentage following a correct step. However, this lower percentage may be due to the power of the advice function. By the end of the session, many ITA learners' interactions followed the pattern computerAdvice-navigation- correctStep-computerAdvice. This pattern is not surprising. The advice messages in the ITA version were stated generally as, "The next appropriate step is to do X. To do this, you need to access device Y ..." Therefore, the learners accessed advice, navigated through the system to the appropriate device, performed the correct step, and accessed advice again. This pattern did not occur with the LA group. In fact, the LA group exhibited no common patterns until the very end of the problem. At this point, it was common that the learner followed the pattern " computerAdvice-navigation-correctStep -navigation-correctStep". This pattern is not surprising either. The computer advice for the LA group listed all the correct steps to solve the problem on one screen. By the end of the problem, the learners had become sufficiently knowledgeable of the system to be able to use this advice. The conclusion to be drawn from this result is that the ITA advice is more helpful to learners who have less knowledge. Once they have acquired a working knowledge of the system, the LA function may be sufficient for the learners. However, more detailed advice may still be needed when learners begin to solve slightly different problem within the domain.

Errors feedback, on the other hand, does not seem to have much of an impact. This is of concern given that ITS designers spend a great deal of time in the design and acquisition of information to give capture errors and provide feedback. Referring to Figure 2, the LA group was performing at about 50 percent correct step level following feedback and following a correct step. The ITA group had a significant difference at this first lag. This difference is due to the relatively poor performance following a correct step. Following error feedback, the ITA participants performed at about the 50 percent level. There can be a variety of conclusions to draw from this. One is that MALM's error feedback mechanisms were of a poor quality, and these results cannot be generalized to all systems. Another would be that the content under study does not lend itself to using error feedback. Still another is that error diagnosis is a waste of time and should not be continued. Or, finally, another would be that the error feedback did have an effect on learners, but our measures were not sensitive to the differences. Regardless of the explanation, there ought to be more detailed analyses of the impact of error feedback on learners using ITSs. This functionality is one of the most costly components of an ITS and we are having difficulty finding effects.

We kept track of human advice and participants in the LA group used human advice much more frequently than the ITA group. The experimenters agreed that the participants in the LA group would not have been able to do anything if the experimenter did not intervene. The ITA version could be sent to people who do not have access to human advice and they could solve problems within MALM. The LA version could not. This makes the ITA version worth doing without even examining the other aspects of the system. Therefore, in the final analysis, if someone was considering the idea of developing an ITS, the results of these experiments tend to support this decision with a few qualifications.

As a final point to this study, we recommend the use of the methodology used in this experiment. The analysis technique was based on the an analysis technique for the study of human-human interactions. We have modified it to analyze human-ITS interaction. Others could modify it to examine any human-computer interaction. In later papers, we will examine how to use this methodology to study the interaction patterns of learners using hypermedia programs.

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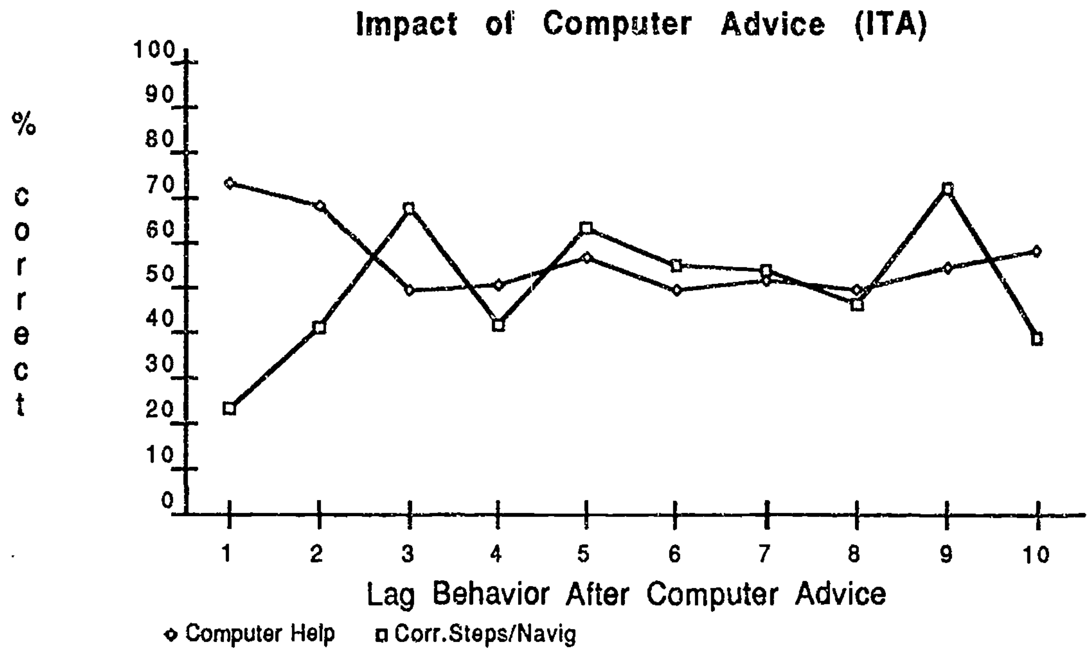
Figure 1. The analysis of computer help for the two groups.



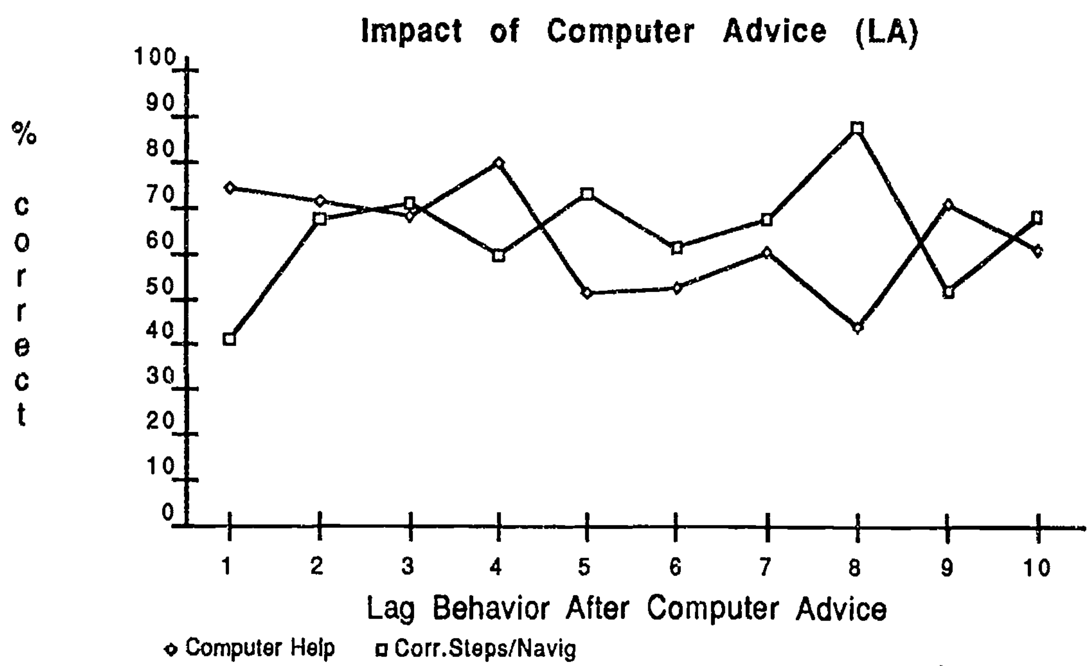
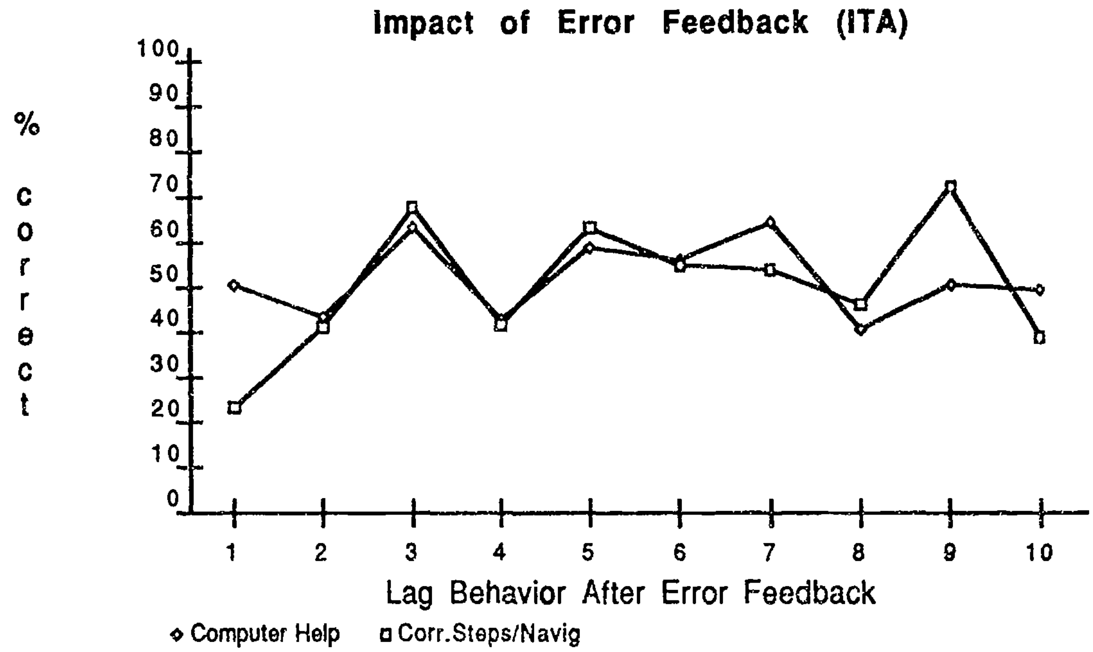


Figure 2. The analysis of computer error feedback for the two groups.



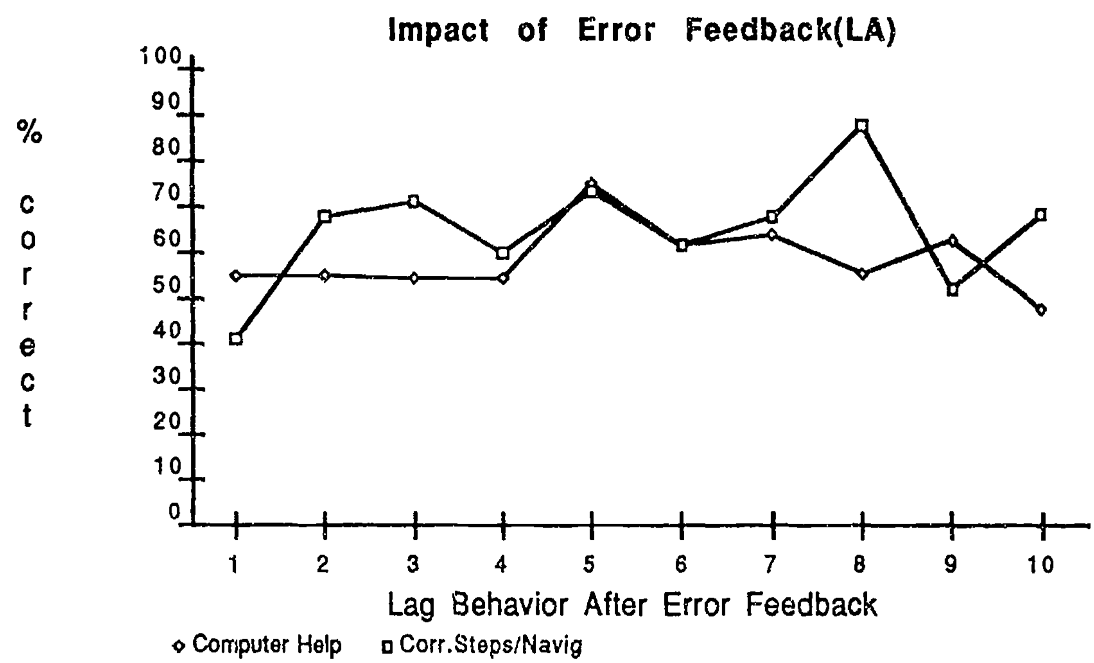
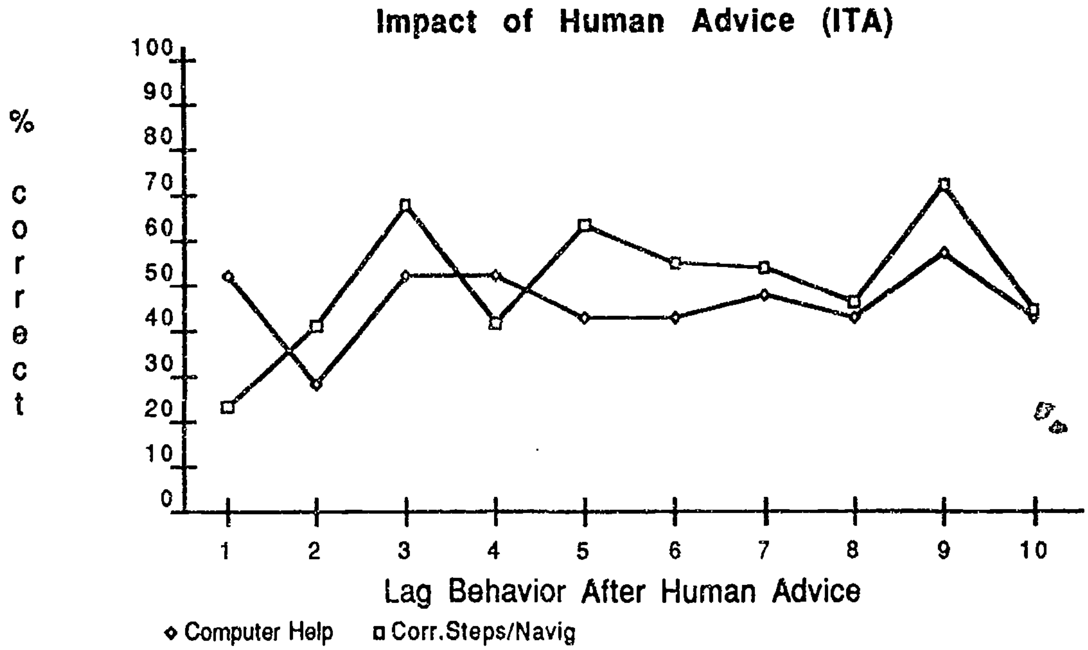
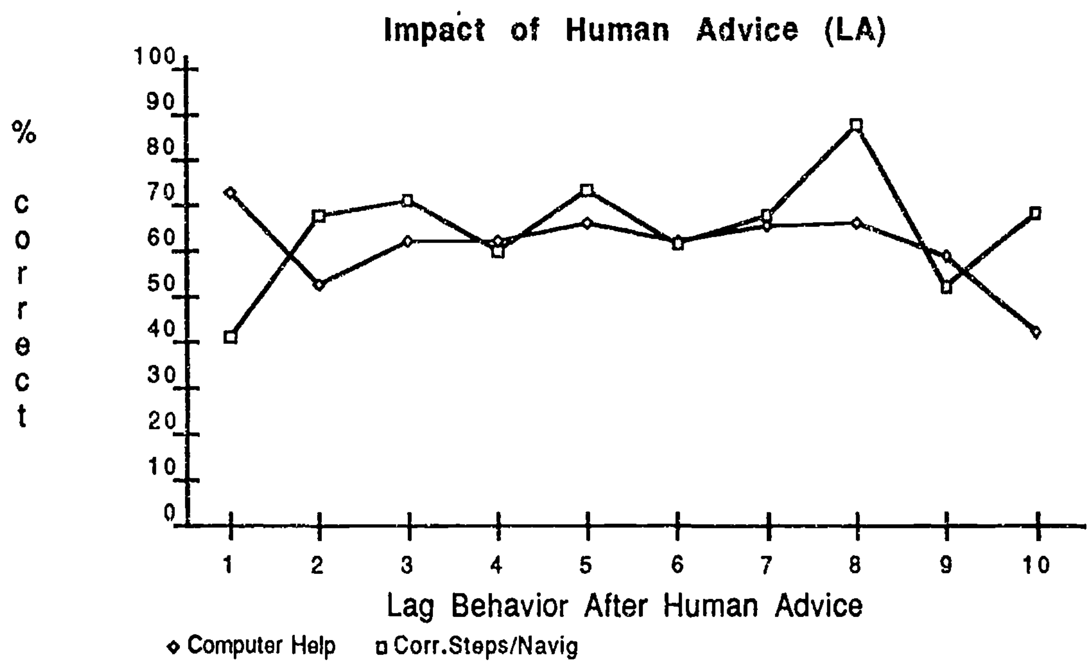


Figure 3. The analysis of human help for the two groups.





Research and CBI in Business: The Need for Dialog

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Thomas C. Reeves, Ph.D.

Abstract

T..s study determined if and how research in Computer-Based Instruction is transferred to business and industrial settings and practices; and if the results of those practices ("real world" applications) come back to the researchers in the universities. Interviews (a qualitative data collection method) were conducted with two groups: researchers (professors) of Instructional Design, and instructional design professionals/practitioners in large corporate settings. A general interview guided approach was utilized to elicit responses to questions pertaining to the nature of educational research and its influence on the business practice of CBI and Instructional Systems Design (ISD). Findings indicate two disparate views (academe vs. business/industry) on the subject. Specifically, from the perspective of business and industry, educational research does transfer to them in a number of ways. The feedback to the researchers is lacking however, and is mainly their blame. From the view of the practitioners, the researchers need to be more proactive, and less arrogant. While business and industry feel that the research going on in the universities is not very focused in on their immediate future needs, it is valuable, and should continue to be supported even more so than it is now. University researchers should take more risks, be more tuned in to the needs of practice, and take advantage of the fact that they can fail with little repercussions. From the perspective of the university researchers, it seems that research as a whole is not meant to be all applied and directly transferable; but rather a contributor to a knowledge base of general theories, models, principles, and hypotheses. Unfortunately, much of it is poorly conceived, and makes the transfer process that much more difficult. Of that research which is substantive and applicable to business practice, the researchers are of the opinion that only a handful of companies use it. And only a select few of those that do use it make any effort to give feedback (via presentations, publications, etc.) to the field as a whole. From the viewpoint of the researchers, business and industry needs to be more aware of

the purposes and limitations of research, and not assume that there will always be some sort of direct transfer or application.

Introduction and review of literature

This study is designed to determine if and how research in Computer-Based Instruction is transferred to business and industrial settings and practices; and if the results of those practices ("real world" applications) come back to the researchers in the universities.

To provide a context for understanding the nature of this study, a literature search was performed to determine the status quo regarding the possible transfer of educational research to business and industry, and the relationships between universities and corporations. The following sections deal with the issues of educational research transfer to education systems, technical research transfer to business and industry, and university partnerships with business and industry for educational reasons.

Educational research transfer to educational systems

Educational research does have a direct influence on policy-makers and practitioners in our educational system. While the relationship between educational research and educational practice -- and even the contributions of social science research as a whole -- has often been tenuous and uncertain, its does exist.

For instance, Shavelson (1988) argues that educational research contributes to policy and practice via three avenues: by helping construct, by challenging, and by changing the way policy-makers and practitioners view particular problems. Shavelson states:

> I have seen how, for example, research on teaching has changed the way practitioners and policy-makers view teaching, how research on military recruiting in community colleges has challenged policy-makers' notions about current recruiting efforts and their potential payoff, and how school and teacher

> effectiveness research has changed the way policy-makers think about, collect, and interpret statistics (indicators) on the "health" of education (p. 4).

Unfortunately however, these influences on practitioners and policy-makers is not "frequent enough or as effective as it might be."

Confusion abounds as to the role educational research should play. Should it directly and immediately apply to a particular issue, problem, or decision; or should it produce knowledge, which allows policy-makers to make rational actions based on this knowledge, which in turn will lead to "good" education which benefits all groups in society uniformly and equally? It seems that either option is unreasonable, and sets up misleading expectations.

Nevertheless, most people would agree that as education is an applied field, educational research, in the aggregate, should lead to improvements in the practice of schooling. This is the expectation of most legislators and foundations who provide the bulk of the resources for educational research. In particular, these supporters expect improvement in school achievement, especially among those "at risk" (Slavin, 1990).

Slavin (1990) argues:

> One of the most important reasons that the impact of research on education seems so haphazard is that education research is primarily engaged in a search for variables that may relate to improved outcomes...

Widescale change in education practice, however, will come about via the implementation of models. Models are instructional or school organizational programs composed of many individual variables which may not have come from research (Slavin, 1990). While some models (e.g. cooperative learning, mastery learning) do have a conceptual basis, education research on models is lacking because the academic reward system favors research which builds theory through variables. Slavin suggests that when models such as cooperative learning are published in the select journals, it is only because they speak to well-defined and easily identified bodies of theory.

Technical research transfer to business and industry

There's a new way for industry to tap the most sophisticated research in the world: that performed in universities. Joint ventures with universities make sense for both parties: corporations acquire exclusive access to powerful research and development (R&D), while the universities gain a new source for research support.

Most collaborations between industry and universities are in fields such as biotechnology (not education or computer-based instruction). These collaborations can take a number of forms, such as partnerships, joint ventures, and the formation of neo-public companies. This marriage between commerce and academe is typically for the procreation of commercially exploitable and profitable products. Examples include Monsanto's multi-million dollar joint venture with Washington University (St. Louis), and Hoechst A.G.'s support of the molecular biology department at MIT (Bartlett, 1988).

The number of companies turning to universities for research is growing. One reason is that there tends to be more innovation in university research than in industry. Although non-academic employees bring much to their workplace, they tend to lose some creativity over time. Another reason university research has a special appeal, is that universities provide a strong research base, which many corporations lack due to a shortage of technical professionals (Aaron, 1988).

Tapping into university research can take several forms. Unlike the formal processes mentioned previously (e.g., joint ventures), some industries are less formal in their approach. For instance, a company R&D executive may read a professor's paper, contact her or him, and proceed from there. Attending academic and consortium meetings, conferences, and symposiums; and reading journals, studies, and papers are also ways of discovering new technologies and theories. And for those who are "strapped for time" and can not attend conferences and the like, there are companies like University Science Partners Inc. that act as agents to bring university technology to the commercial sector (Aaron, 1988).

Universities have been also been quite proactive in forming relationships with business and industry. Technology transfer from universities to business is becoming big business for academics. Many schools have an office of technology transfer, and some, like the University of California, have two. The University of Washington holds science and technology expositions -- featuring the latest in biotechnology, sensing technology, biomedical instrumentation, and image processing -- solely to attract venture capitalists (Aaron, 1988).

It is quite clear that this country is in a competitive struggle with other industrial countries for markets in advanced technologies. The United States has not realized the full potential of these technologies, and the university-industry relationship is part of that unexploited potential.

University partnerships with business and industry for educational reasons

While not as not as strong in magnitude or number, there do exist collaborations and interfaces between business and industry and educational institutions and foundations in the area of educational technology.

One example is a unique partnership that was forged in the Santa Clara Valley of Northern California for the shared use of a telecommunications delivery system to provide a cost effective means of providing telecommunications delivered education and training to company work sites (Capell, Dermody, Maier, & Monfort, 1986). The unique partnership brought together a group of companies for the purpose of sharing services and resources that are of mutual benefit. Through the efforts of a non-profit organization, the Industry Education Council of Santa Clara County, a partnership model for sharing telecommunication resources was established that could lead the way to business/industry/public sector partnerships throughout the country. The innovative partnership in Silicon Valley proved to be very successful in providing industry with highly effective but low cost instruction in the workplace. This example is but one that demonstrates that diverse entities can work together effectively for the mutual benefit of all concerned.

Other university-corporate collaborations are like the ones found at Arthur Andersen & Co. and IBM. Arthur Anderson uses the research and staff of the Institute for the Learning Sciences located at Northwestern University (Evanstan, Il). This group, headed by Roger Schank, provides research findings, models and theories to Arthur Andersen. Additionally, one Professional Education Division instructional designer attends the Institute as an "intern" each year. While there, the person works toward a master's degree.

IBM's ISD Competency Center (a part of IBM's US Education division) has an Academic Council comprised of six noted professors in Instructional Systems Design. They serve as a combination think tank and review board. For instance, they assist in setting education agendas, and review high level design documents.

While these "joint ventures" have no commercial appeal like those in other fields like biotechnology, there is clearly a transfer of educational research and expertise going on.

Another area where education can be improved through partnerships with business and industry is that of education reform (Theede, 1985). Our American educational system desperately needs to improve and respond to the impending needs of change. In order to avoid becoming a "Nation at Risk," a reorganization of our educational system is necessary. This reorganization must provide for greater networking between education and business and industry. While coordination between business and industry and education is not new, it will require that new role responsibilities be defined so desired outcomes are realized. In order to achieve excellence in education, there needs to be greater corporate participation of business and industry in the universities' educational preparation programs.

A shared philosophy between business and industry and education must contain a functional relationship based on serving the needs of each partner through wise planning and use of available resources to produce mutually beneficial outcomes. In order to meet these challenges, Theede suggests a cyclical interaction and reciprocity process: a) Establish philosophical base, b) Set partnership category (fiscal support, material/equipment, personnel resources, staff development, research & development, or new information), c) Identify general goals, d) Determine role responsibilities, e) Action plan is developed, f) Action plan is implemented, g) Evaluation (start back with 'a').

What does this all mean? From the university perspective, it means than improvement requires change. Secondly, the charge for improvement, accountability and excellence is established at the university level. And lastly, the excellence needed to improve education will not happen without a greater partnership with business and industry.

Methodology

A qualitative approach was used to determine if and how research in Computer-Based Instruction is transferred to business and industrial settings and practices; and if the results of practice come back to the researchers in the universities. Specifically, the methods used were interviews.

Two different sets of questions were used in this study: one for university professors/researchers and one for practitioners in a business setting. Responses to the business setting form were elicited via a focus group interview. The participants, who were all in the practice of instructional technology in a large accounting firm, were as follows: a director of a technology group, a manager in the same technology group, an experienced senior instructional designer, and a principal/associate director of the same technology group.

Responses to the professor/researcher form were elicited via a general interview guide approach. One professor of instructional technology was interviewed face-to-face. The individuals were not randomly selected, but were chosen based on the personal relationship the investigator has with them.

Results: Business and Industry

What is the role of university educational research as you see it?

......As an ISD person in doing CBT, I don't use it. Research from the fields of Human Factors and Cognitive Psychology is more appropriate in understanding interactivity issues. My goal is to assure that people learn the material so they can perform. The key issue is learning the material, not using the software, or how to use it. I can recall a piece of educational software that contained a 20 minute lead-in just on how to use it.

......Research from journalism and advertising are helpful as far as page layout and screen layout are concerned. Research from text design is helpful as well.

......Academic research should not be constrained to academic research for corporate needs. They should not be limited. The challenge we face in business and industry is to cherry pick the research, that is, to get the approach research for our needs. Its our responsibility.

......There is a real disconnect between what corporations do, and what it is that researchers research.

......Some research transfers, some is ignored.

How should it contribute to educational practice in business and industry?

......Educational research should take more risks if it has the proper and adequate funding. Academe has less pressure to complete a project. Its no big deal to start something, say its doesn't work, and start over again in an academic setting. Academe can afford risk taking that corporations can't.

......Researchers in universities can start a project over again from scratch. Corporations can't. Universities can do research, so do it! Industrial settings are more constrained by money.

......Our role is to get the research, see what works, and tell the rest of our colleagues what to apply.

......Researchers should produce research which makes the professional more productive and give them more leverage.

......Corporate support of research is not brand new. A lot comes out of the Dept. of Defense and Dartmoth University.

Does educational research transfer to your organization's practice? If so how; if not, why?

......Yes it transfers.

......Conferences. Our staff is highly encouraged to join professional associations and go to the conferences. When they return, they are encouraged to write a paper to distribute to their department. Also: technology forums with key speakers, recruiting of ISD'ers with Ph.D.'s and MA's., personal contacts, competitors, other universities, journals, vendors of technology.

Describe its impact (if so).

......There certainly is an impact. But its not obvious. There is company inertia; the effects don't appear over night. Educational research is just a small part of the variance in how we do things.

How do you suggest that more educational research gets to you as practitioners?

......More research on what it is we're doing. What is being researched now has very low pay offs in the next five to ten years.

......But just because it has no immediate financial payoff, doesn't mean its meaningless.

......There is a 10 year cycle from something to go from the research lab into practice.

Do you feel that the relationship between your organization and university researchers in instructional technology is adequate?

......Its probably never adequate because unless you're in contact with them on a monthly basis, you have to wait for an article to be published, which is usually a year after the person wrote it.

......Journals do act as a filter though.

......Personal contacts also act as a filter too.

Do you feed the results of putting research and theories into practice back to the researchers in the universities? Why or why not?

......No. Unless researchers and academics come out and see what we are doing. Also, our interns go back and talk about what's going on.

......We don't want to share everything. We keep things that work well for us private.

......Plus business and industry is much further ahead than what the universities are doing. Some companies for instance have to take a 4 year engineering student [one with a BA] and train him for a year before he's useful. So in some respects, that makes us in competition with junior colleges.

......It's a matter of competitive advantage.

......Those that come and see what we're doing though, can see it all. Most simply go "ooh ah."

......There's a lack of interest for universities to get feedback in some cases. They can be arrogant at times. For instance, one academic called me once so we could get together so he could tell me what we can do here based on his research. If he only knew. Some universities also have a distaste for stuff from the private sector.

......Sometimes we do call the authors of articles we read in the journals. Plus we know a lot of people in the field.

......Money plays a significant role in facilitating the communication process. The feedback process is not as simple as picking up the phone.

Any other comments?

......More transfer!

......Universities should continue to do research, and not cut back. Universities need more federal dollars. You are valued.

Results: University

What is the role of university educational research as you see it?

......Discovery of new knowledge. Theory and model building, some is action orientated; a continuum of purpose.

......Contributing to the knowledge base. However, some research is better than others. We don't do a good job of theory building, but an ok job on model building.

......Only 2 or 3 names come to mind in our field in terms of model building.

......Basically we are poor in theory building, reasonable at model building, and do very little action orientated research.

How should it contribute to educational practice in business and industry?

......Different ways. There is an expectation that it all will transfer, which is unfounded. There is not always a direct application of what we do. Research provides alternative explanations. For instance, if a child can not read, it isn't necessarily because he's stupid. Research contributed to what we know about dyslexia.

......Research points out complexities but not necessarily prescriptions. But its still worth doing.

......There's a quality problem with research. Some is poorly conceived and is nonsense and therefore should not effect practice.

......Direct applications of research will always be limited. Conditions always vary in the field, and you can't always match them. To put the results of educational research to use, I suggest collecting a body of things which we can make generalities with.

......An effect is there, but it isn't direct. Research provides general principles, general hypotheses, etc.

Do you feel that educational research transfers to business settings? If so, how; if not, why not?

......Some places, to some degree. At places like Arthur Andersen it does.

......The transfer takes place via people in industry who have received some formal training in research. They keep up with what's going on via journals, conferences, etc.

......The military for instance has an active research program.

Describe its impact (if so).

......Fairly limited. A lot of places don't get research findings in a systematic way.

How do you suggest that educational research gets to those practitioners who aren't getting it?

......They need to realize that what they want from educational research, they aren't going to get. We need to communicate what the realistic results of research are. Plus we need to do a better job of interpreting what we do. Practitioners in business and industry need to think in research terms -- how it (research) can be used and its limitations.

......We need to do a better job of communicating the power and limitations of research. We also need to cut the trivial stuff. It isn't as simple as cutting the jargon.

Do you feel that the relationship between you as a researcher and the business practice of instructional design is adequate?

......The relationship could be enhanced. We need to stop blaming them though.

Do you feel the results of putting research and theories into practice is fed back to the researchers in the universities? Why or why not?

......To some extent. Some folks in business and industry do write up what they do and go to conferences to present it. Some, like the military, do not encourage dissemination.

......It varies with corporations. The IBM's, Apple's, and Arthur Andersen's do send their people to conferences. They are the exceptions. The others need to make an effort.

Any other comments?

......A lot of places could benefit from what we already know, but we don't know a hell of a lot. The research base is not that big, but better use could be made of it.

Discussion

It seems clear, from the perspective of business and industry, that educational research does transfer to them in a number of ways. The feedback to the researchers is lacking however, and is mainly the blame of the researchers. They need to be more proactive, and less arrogant. While business and industry feels that the research going on in the universities is not very focused in on their immediate future needs, it is valuable, and should continue even more so than it is now. University researchers should take more risks, be more tuned in to the needs of practice, and take advantage of the fact that they can fail with little repercussions.

From the perspective of the university researchers, it seems that research as a whole is not meant to be all applied and directly transferable; but rather a contributor to a knowledge base of general theories, models, principals, and hypotheses. Unfortunately, much of it is poorly conceived, and makes the transfer process that much more difficult. Of that research which is substantive and applicable to business practice, only a handful of companies use it. And only a select few of those that do use it, make any effort at giving the field any feedback (via presentations, etc.). Basically, business and industry needs to be more aware of the purposes and limitations of research, and not assume that there will always be some sort of direct transfer or application.

Conclusion

It is hoped that this study will spark more probing in the area of Computer-Based Instruction research transfer, as more is needed. It is clear that practitioners in business and industry, and researchers in universities, do not see "eye-to-eye" on a number of issues. The possibility of a conference of researchers and practitioners on this topic of research transfer and feedback is a very good idea -- necessary it would seem -- and has caught the interest of many people already.

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What L. S. Has Learned

Steven D. Tripp

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Abstract

LS has taught business statistics at the University of Kansas for 26 years. He has received many awards for his teaching and is now a Chancellor's Club Teaching Professor. This paper is a distillation of a two-hour interview with him concerning his methods and experiences.

Introduction

LS is University of Kansas Chancellor's Club Teaching Professor of business statistics. He has received many awards during his 26 years of teaching and is frequently requested to lecture on his use of technology in teaching. After seeing one such lecture, I approached him about doing an interview concerning his teaching methods and experiences. The two-hour interview was videotaped and transcribed. This article is a distillation of that interview.

The theoretical basis for this article is two-fold. The first argument has two parts. It has been argued that technology precedes science in most cases (Basalla, 1988). Carroll (1990) argued that in fields like instructional design the artifact also precedes the theory. Carroll's argument about instructional design is based upon the work of people like Basalla who have studied the history of technology. I will first discuss Basalla's thesis and then return to Carroll.

Historians of technology like Basalla have found that technology is very rarely the product of programmatic scientific research. The roots of technology characteristically lie in earlier technologies or ultimately in analogies to nature, and often the moment of invention is clouded in ambiguity. Machines like the steam engine did not appear fully-formed as the result of deduction from scientific principles. Basalla's argument, bolstered by a detailed analysis of not only the steam engine, but also barbed wire, the cotton gin, and many other interesting examples, is that technological evolution is literally a kind of evolution. As such it requires that four conditions be present: *diversity, continuity, novelty, and selection.* Basalla shows that, in the case of steam engines for instance, it is very hard to determine where and when a technology was invented, because all technology derives from earlier forms and its survival and development require that numerous fortuitous and local conditions be present. For example, early steam engines drove pumps at coal mines which coincidentally produced fuel for the engines. This fortuitous connection afforded an ecologically friendly niche which provided the continuity necessary for the steam engine to be developed. Of course, theoretical knowledge of the vacuum and its practical applications probably contributed to the evolution of the steam engine, but it in no way determined the application. Neither was there a systematic program of research. As a result, Basalla's position seems to be that *the evolution of technology does not require, and indeed historically has not involved, the systematic application of theoretical principles.* If technological evolution is like natural evolution, all that is required is a few people with interesting ideas (novelty) and an atmosphere in which various ideas can be tried out for a while (diversity), a means of insuring continuous development (continuity), and a mechanism for choosing good designs and eliminating bad ones (selectivity). In Basalla's terms LS's course is a form of technology. It has its ecological niche at the University of Kansas. However, without some formal record of his methods, it will not have the opportunity to spread and survive in the face of a selective environment. This paper is a way of encouraging the development of a particular technology.

Carroll's argument about instructional technology is based upon the thesis that science typically derives from technology. Thus, the successful lesson precedes and forms the basis for a theory of instructional design. Carroll argued that there are no psychological principles from which one can rigorously deduce instructional designs. The notion that there are is based upon the mythology that technology derives from science, which Basalla and others have exploded. Indeed, the few psychological laws that exist (e.g., Hick's Law, Fitts' Law) are unmentioned in instructional design texts. Carroll argued that instead of instructional design being based on psychology, a psychological theory of instruction should be based upon actual instructional designs, leading to what he calls design-based theory. Thus, a theory of instructional design should be based on interesting and successful instructional designs. LS's course is one such design.

The second theoretical basis for this article is related to the learning and teaching of complex, open skills. Originally, the distinction between closed and open skills referred to skills learned in predictable versus unpredictable environments (Poulton, 1957). Skills can be classified in many ways (Colley & Beech, 1989) but the closed-open distinction is most relevant here. For instructional design purposes, we may think of closed skills as those which embody a standard or "correct" procedure and open skills as having no one "correct" form. Since there is no one correct form the selection of examples for instruction is problematic. I (Tripp, 1992) have argued elsewhere that complex professional open skills of the type found at the top of Jones, Li and Merrill's (1990) enterprise hierarchy are traditionally learned by being exposed to "masterful" work. The use of traditional evidence is required by the fact that little is known about the acquisition of complex, professional skills. Beech & Colley (1989) reported that, "One gap in our knowledge of the development of expertise in most fields...is that there is much still to be discovered about how experts acquire and structure their knowledge" p. 328. What is known is that mastery of complex skills is difficult. Baltes and Smith (1990) stated that achieving expertise requires at least, "...10 years and a well-designed program of practice, training, and mentorship" (p. 99). The acquisition of skills is often attributed to processes like analogy (Anderson, 1982) and imitation (Annett, 1989). For analogy or imitation to take place the student must have internalized some kind representation of the skill to be learned. For complex skills there is evidence that such representations are like

Roschian prototypes. For example Sternberg (1990) treats wisdom as a complex skill and concludes that people carry and use Roschian prototypes of wisdom in their heads. Such prototypes can only have come from exposure to exemplary cases of the complex skill in question. Anecdotal evidence that this is true can be found in the reflections of many skilled professionals who attribute their mastery of a skill to the influence of the work of some "master" of their craft. Such masterpieces consist of products (poems, buildings, bridges, paintings) and performances (music, movies, videotapes, live concerts, lectures, etc.). To cite just one example, consider this account of the influence of R. B. Woodward. Nobel Prize Laureate Robert Burns Woodward was one of the greatest chemists of this century (Woodward, 1989). Woodward's lectures were legendary and C. E. Woodward quotes Barton as follows:

> It was a brilliant demonstration of how you could take facts in the literature which seemed obvious and just by thinking about them, as he so ably did, interpret them and obtain results and then go into the laboratory and *prove* it was the right result. That we thought was the work of genius.... Ten years later [at Imperial College] our second year undergraduate students could do the problem, and ... about 25% of them could get it right. Now does that mean that in 1958 we had 25% mini-Woodwards in the second year class? No, of course it didn't. What it meant was that Woodward *had taught us organic chemists how to think.* (p. 240)

Such education resembles the master-apprentice relationships which prevailed in the crafts for centuries. It follows from this argument that instructional design should be taught in part by exposing students to masterful instructional designs. However, a course taught by a master teacher is largely unrecorded, so there is little possibility of it influencing instructional designers. Even if it were videotaped, there is at present no mechanism for distribution of that recording. Great instructional designs live and die with their inventors. Thus, one of Basalla's criteria for technological development, continuity, cannot be satisfied. This paper, while not being an actual recording of LS's teaching, is an attempt to ensure continuity by making LS's technology known to instructional designers. By interviewing a professor with many years of teaching experience, and who has been honored for the quality of his instruction, and communicating that professor's insights to others technological evolution may be encouraged. Additionally, because

LS has incorporated technology into his teaching, his insights may be especially interesting to the members of this organization.

Historical Background

Nothing begins at zero. Almost 30 years ago LS inherited a business statistics course which was taught in several sections of 50-60 students each. Due to some changes in staffing the sections were soon combined into one large lecture with more than 100 students. LS had had no teacher training, but had served as a teaching assistant while doing graduate work at another university. One thing this experience taught him by negative example, was that public speaking skills were important for a teacher. LS believes that much of his skill has come from watching other people teach and consciously copying their strengths. He happened to be part of a summer program that involved teams of teachers who sat in on each others classes. One of the teachers was very skilled in the case teaching method. LS now incorporates cases into his classes where possible. Most of LS's instructional design, however, seems to have come from years of tinkering and experimenting with different techniques and from a relentless desire to improve.

Beliefs

Underlying any technology of teaching are the web of beliefs that cause an instructor to look at the problem in certain ways and prescribe certain solutions. LS has some fundamental beliefs about teaching. First he believes that large one-section introductory courses can be as good as or better than small multi-section courses. Second he believes that carefully identifying problems can lead to better outcomes.

One aspect of identifying problems is specifying the decision-maker's goals. As an instructor, LS believes that it is not his role to "teach," or to convey skills and knowledge. Rather, his responsibility is to induce the students to learn. By adopting this perspective, four fundamental observations become apparent to LS. First, students must be active to learn. If we lived in an ideal world where students came well-prepared to class, in a mood to engage in active discussion, and armed with thoughtful questions, lecture would suffice. LS believes we do not live in such a world.

The second observation LS makes is that if we wish to induce our students to learn then we must know our students well. We must recognize that many students would not be taking our courses if they were not required. Many have a poor attitude. Unless a realistic picture of the students is drawn, success is unlikely. A second aspect of knowing our students, is knowing what we want them to accomplish. This means thinking in terms the knowledge and skills we want students to master, not in terms of the material we must cover. LS thinks that for introductory courses, there are several common goals that we should have. First, the course should be challenging. Second, the course should increase the students' literacy in the subject matter. Third, students should develop an appreciation for the importance of the subject. Lastly, the students should gain some understanding of why the teacher finds the subject exciting. Additionally, although the course may be called an introduction, it may well be the last course on this subject students will take. Because of that, it is important that the course have a well-organized ending. In fact, LS believes that most courses have a short beginning, a long middle, and little or no ending. Given the type students we often face LS believes that much more emphasis should be placed on the beginning and ending of courses. It is there that most of the rationale and therefore the motivation for the subject is generated.

LS's third observation is that is one thing to tell students to learn and it is quite another thing to actually get them to do so. For that reason, motivating students becomes a major part of course planning.

The final observation is that students have individual learning problems and therefore some method must be devised to deal with these problems on an individual basis. LS believes that solving problems in class is a waste of time for many students because they could have done it themselves. Also, when students have learning difficulties they often do so for individual reasons, and therefore answering their questions in a recitation session is often not useful to other students. How LS deals with these problems will be discussed in the next section.

The Course

LS's course is a four credit class that meets twice a week for two hours with a short break between the hours. Typical enrollment is 300 students impatient to get on to the "real" business courses. When students walk into the 400-seat auditorium they see a large stage with three projector screens up and running. The screen on the right may display a hand-written note telling the students to open their books to page 247. The screen on the left displays a laser-printed transparency of the homework assignment. The screen in the center displays a computer generated "slide-show." LS believes that being set up early and neatly communicates his seriousness about the course and generates motivation. At exactly 9:30, he begins the class with a "Good Morning" and expects the students to respond. This signals that the class has begun and also sets the expectation that students are to respond to the teacher's words.

During the class, LS illustrates his lecture with computer-based slides. These have evolved from actual 35-mm slides which he used for many years. The slides had certain advantages over a blackboard. First, they are easier to read in a large auditorium. Second, they lead to better organization of ideas. Third, they allow eye-contact between the instructor and the students. An instructor writing on a blackboard is out of contact with his students. There are some disadvantage of such slides. First, they take time to prepare. And secondly, they tend to put too much information up at one time. A teacher writing on a blackboard is naturally paced by the time it takes to write each word. For that reason, LS had his slides produced so that they only reveal one line at a time, and thus he can pace the amount of information being revealed. When he changed to computer-based slides, he retained this technique. An added advantage of using a computer is that he can produce the "slides" himself and also make modifications easily and quickly. He would like to move on to the use of animation and other techniques. He doesn't feel constrained by the order of the prepared screens. Because there are always unpredictable questions LS keeps an overhead projector ready to ad lib any displays he might need.

After motivation, the second most important thing LS does, he thinks, is designing the homework assignments. It is also the most time-consuming, requiring up to an hour a day. He does not prepare a list of assignments in advance. Rather he collects informal feedback from his TAs and adjusts each new set of assignments based upon that information. His TAs collect the assignments before each class and correct them before the next class.

LS's selection of problems is interesting. As we all know the questions at the end of the chapter range from easy to difficult, with the first few being easy and the later ones being difficult. LS assigns the easy questions *before* he lectures on the topic. This induces the students to read ahead. The difficult questions are assigned *after* the topic has been completed, as a kind of review. Thus each set of homework problems covers a range of topics from what was done last week, to the current topic, to what will be covered next week. The homework assignment also contains the title of the next lecture, so that students see the connection between the different topics. LS does not give his students objectives, except indirectly by pointing out that certain topics are important.

LS makes his homework assignments do double duty by presenting students early in the course with statistical evidence that those who do well on the homework tend to do better on the final grade. This has the effect of motivating the students, while demonstrating in a relevant way, not only the practical usefulness of statistics, but also the need for presenting statistical information graphically. One semester he tried not grading the homework. Test scores fell off noticeably. Now he uses those numbers to justify his methods.

Testing is also an important part of LS's course. He gives three intermediate exams and a final, all of which are cumulative in their coverage. All exam questions are public and old exams are on file in the library. LS gives a lot of exams because he feels students do not have the discipline to stay current if they are not pushed to do so. Grading is on a strict 90, 80, 70-point basis, but the curve can be adjusted by giving partial credit if necessary. LS has a clever way of motivating students to keep trying right up to the end of the course. He announces that no student will receive a lower grade than his grade on the final. Thus even a student who has done "C" work throughout the semester, still has a chance of getting an A or B if he does well on the final.

LS believes that a course should have a structure like a well-constructed staircase. That is, is should consist of a series of steps of about equal height or difficulty. Since some topics are intrinsically hard than others, he adjust the perceived difficulty by adjusting the amount of time spent on each topic. Another way of adjusting the difficulty is by adjusting the path by which you reach a topic. Some paths provide more preparation and some less.

LS uses teaching assistants extensively to support his course. By arrangement with his dean he gets one TA plus one TA for each 50 students enrolled. Thus for 300 students he gets seven TAs. The TAs are undergraduates, chosen from his students from the previous semester. They are introduced at the beginning of the semester, and it is explained that they are being paid and have been selected from the best students of the previous semester. Thus, he uses these positions as motivation for students to do well in his class. The TAs are half-time 20-hour per week employees. In addition to grading papers and tests, they attend every lecture, and they help him set up his equipment. They also hold 8-10 office hours per week when students can get help on their homework. The offices are open 35 hours per week to provide help and that help is directed at allowing the students to complete their homework before it is due. Since TAs serve only for one or two semesters they maintain enthusiasm and patience for what can be a tedious job.

In addition to the use of the computer as a screen display device, LS has experimented with other technology. He has recorded a number of audio tapes which are made available in the university language lab. These tapes covers topics which may be a prerequisite to his course, but which students have failed to understand completely. Other tapes are concerned with problem-solving techniques. A third set cover advanced topics which cannot be covered in class. There are no handouts with these tapes because he want the students to actively take notes. Another technique used is to pose questions and asking the students to stop the tape and think about the answer.

Besides the tapes, LS has experimented with computer-assisted instruction. These programs are intended to illustrate some of the major theoretical concepts from the course. The concepts are presented in an interactive way allowing the students to experiment with various sets of numbers.

Conclusion

LS says that he does some of his best teaching while he is sleeping. What he means is that by creating an environment which motivates students to study and in which they can get help, he is ensuring that students are learning while he is home in bed. LS claims he knows nothing about learning theory, but that he is sure that different people learn differently. The trick is to get them to do that learning. Evidently, LS has discovered that trick.

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Michael Oakeshott's Philosophy of Education and its Implications for Instructional Design Theory and Practice

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Abstract

Michael Oakeshott, a political philosopher, wrote extensively about education. Much of what he wrote may have interesting implications for instructional systems design. This paper is an explication of two aspects of Oakeshott's writings. The first deals with the nature of knowledge and its relationship to teaching and learning. The second deals with Modern Rationalism and how Oakeshott's conception of rational behavior impinges on the act of instructional design.

"Learning is the comprehensive engagement in which we come to know ourselves and the world around us. It is a paradoxical activity: it is doing and submitting at the same time" (Fuller, 1989, p. 43).

"The counterpart of the teacher is not the learner in general, but the pupil. And I am concerned with the learner as pupil, one who learns from a teacher, one who learns by being taught" (Fuller, 1989, p. 44).

"Education in its most general significance may be recognized as a specific transaction which may go on between the generations of human beings in which newcomers to the scene are initiated into the world they are to inhabit "(Fuller, 1989, p. 63).

Introduction

Michael Oakeshott, an English political philosopher, was greatly interested in the question of how people learn political skills. From this he developed a general theory of knowledge and its acquisition in educational settings. One of his basic assumptions is that there are always important aspects of skill that can never be reduced to rules or principles. Because of this, real skill can only be acquired through a kind of apprenticeship by being immersed in a tradition of action. Additionally, Oakeshott is particularly critical of Modern Rationalism, which he believes commits the error of believing that actions based upon principles are superior to actions based upon tradition. This paper attempts to explicate and evaluate these two themes and then discusses their implications for instructional design theory and practice.

Knowledge

Michael Oakeshott believed that all knowledge is constituted in various kinds of abilities. Abilities may be described in terms of propositions or rules, but the ability always precedes the rules. Any propositional description of an ability is always an abridgment of the ability. The ability always implies knowledge far beyond what can be expressed in propositions. Rules do not exist prior to an activity, nor do they govern it or provide an impetus for it. Real knowledge only exists in its use. When an ability involves making or doing and it is significantly composed of physical movements we call it a skill. Complex skills may be composed of simpler skills. In addition, when an ability is not significantly composed of physical movements we may still describe it as skillful.

However we do not usually describe as skills activities composed primarily of mental operations. Complex abilities, such as those associated with engineering, exploring, composing, acting, teaching, and so forth would fall in this category. Such abilities are complex systems of simpler abilities, grouped and aimed at a specific focus. It is this conjunction of what we know and the way we use it that constitutes a crucial feature of Oakeshott's epistemology. Knowledge does not exist apart from its application. Indeed, "What we are aware of is not a number of items of knowledge available for use, but having powers of specific kinds..." (Fuller, 1989, p. 51). Abilities (knowledge) consist of two components: information and judgment. Information consists of facts, rules, concepts and principles. It is impersonal. Information can be independent and inert. It only becomes useful knowledge to the extent that it is related to particular skills or abilities. An important component of information is rules and rule-like propositions which are related to abilities.

Every ability has rules. Rules are related to abilities in one of two ways. First they may be a prerequisite to being able to perform. For example the correspondences between the alphabet and Morse Code must be known before messages may be sent by telegraph. Secondly, rules may constitute a criterion for determining the correctness of a performance. Oakeshott says that a grammar of a language is an example of this kind of rule. It is not required to perform in the language, nor is it necessary to detect mistakes, but it can serve that purpose. There is a third kind of rule-like proposition which may be called a principle. Principles are used to explain a performance; they are never a component of the performance itself. Oakeshott uses the example of the mechanics of riding a bicycle. The principles of balance and motion are usually completely unknown to the rider, nor do they embody a criterion of the performance. They belong to a separate ability, the ability to explain a performance.

To summarize, all knowledge is embodied in abilities, and all abilities have an informational component. However, this informational component of knowledge, whether it be facts or rules, never constitutes all of what we know. For any concrete ability to be realized it must contain a component which Oakeshott calls judgment.

Judgment consists of practical knowledge—knowing how. It is the tacit component of knowledge. Judgment when combined with information gives us knowledge and allows us to act and understand. Judgment cannot be taught or learned separately from information. It is acquired from the situation of learning itself, through a kind of apprenticeship. It cannot be resolved into information. With simple skills this judgment component may be relatively small, but as we ascend to higher levels of cognitive skills, the component of knowledge attributable to judgment is much greater. For Oakeshott abilities do not exist in the abstract. They are to be found only in concrete examples. And since each concrete example of an ability displays the style of its performer, style is an important aspect of any ability. In a sense each ability is like a language. It is confined by its grammatical rules, but each speaker will have his own way of expressing himself. In Oakeshott's opinion to ignore this aspect of knowledge is to miss "three-quarters of the meaning" of a performance.

To summarize, for Oakeshott knowledge is embodied in abilities. Abilities consist of information and judgment. Information consists of facts and rules. The part of knowledge called judgment is tacit and implicit. It cannot be completely codified, but it is the spring of all action. True knowledge is impossible without it.

Learning and Teaching

Education for Oakeshott is a specific kind of interaction between teachers and learners. He is careful about how he uses words and especially stresses that he is concerned not with the learner in general, (because learning takes place constantly, both formally and informally), but rather with the learner as pupil, the learner as counterpart to the teacher. The function of the teacher is to initiate learners into the inheritance of human achievements. This inheritance is not a world of abstraction, it is a world of beliefs. These beliefs are expressions of the human mind and form an interlocking structure we call culture. The initiation of students into this world is the job of teachers.

Oakeshott recognizes that learning may occur accidentally without the attention of the learner or the intention of the teacher. However, such learning is not the result of teaching. Teaching is a deliberate act designed to promote the initiation of the pupil. It has an order and arrangement.

There is an oft-raised question in educational circles of whether education should be the imparting of information or the cultivation of the ability to learn and think. Oakeshott recognizes this dilemma and tries to resolve it this way: He sees this question as a difference in point of view between the pupil and the teacher. The student naturally comes to education with the desire to acquire information. He is focused on that which he does not have. The teacher, seeing that information alone cannot suffice, seeks to impart a way of thinking which will allow that information to grow and prosper. Thus, education is properly concerned with both information and learning to learn but those concerns tend to be emphasized differently by differing points of view.

Although Oakeshott is concerned with introducing students to their cultural inheritance, he does not regard education as putting students in touch with the dead. Inevitably, much of our cultural inheritance will be the product of past generations. However, the purpose of education is not to celebrate the past, but to release the student from "servitude to the current dominant feelings." Oakeshott recognizes that a teacher may be excused if he finds no enthusiasm for the political and material standards of the current culture, but if that person has no confidence in the past he cannot be teacher, for he has nothing to teach. Education, for Oakeshott, is an emancipation from the "tyranny of the moment" and a step towards becoming human.

Education in the inheritance of human achievement cannot takes place in the abstract because that inheritance has no master structure. Our culture was not designed, but rather evolved as the result of uncountable individual actions. It cannot be taught in principle, but must be learned in its details. Also, teachers can only present that inheritance in parts. It is too large and too contingent to allow inclusiveness. Teaching and learning, therefore, are always focused on specific human achievements.

Since there are two aspects to knowledge, information and judgment, there must be two types of teaching: instructing and imparting. Oakeshott believes that the teaching of information, called instruction, is best done by direct communication. Very often this consists of communicating facts which have no immediate application. Because children are quite experienced at obtaining information which has immediate application, there would be no need for teachers if all information were of this kind. Since much information is not readily applicable, we need teachers to communicate this information to students. The teacher's job is first to select and organize that information. The teacher then has two more tasks. He must decide the order in which the information is to be presented and then cause the student to practice with this information so that it may be recalled accurately and readily.

Education for Oakeshott does not end with this practice. Oakeshott believes that all human activity involves knowledge which is beyond explication in rules. It is this component, which Oakeshott calls judgment, that must be imparted. It can never be communicated directly. Also, it is precisely this judgment that allows people to do, make, understand, and explain, in other words, think. Learning to think can be taught, but not in the absence of information. That is, it is not taught outside of a lesson on arithmetic or Latin grammar. It is a by-product. Thinking is a style of doing, an idiom, which is revealed in the area of action not covered by rules. It is learned by recognizing its effect in specific cases. Thus Oakeshott argues that an important part of any learning situation is the *style* of the teacher.

To summarize, Oakeshott believes that education is a deliberate initiation of pupils into their cultural heritage. Since knowledge has both explicit and tacit components, education consists of instructing and imparting. Instructing is direct and formal. It requires that the teacher select what is important, decompose that information, and arrange it in an order which respects its prerequisites. The teacher must then cause the student to practice. Imparting, on the other hand, is indirect and informal. Teaching judgment is teaching how to think and thinking is a way of acting. For most complex activities, the tacit component of knowledge is more important than the explicit component.

Rational Conduct

The second important aspect of Oakeshott's philosophy of education is his interpretation of what it means to say that a person's behavior is rational.

The systems approach to instructional design is often presented as a rational approach to instructional problems. An instructional designer following the systems approach is said to be acting rationally. Michael Oakeshott (1962) asked in an essay entitled "Rational Conduct" what it means to say that a person is *acting* rationally as opposed to *arguing* rationally.

We have a fairly clear idea of what a rational argument is like. It is based on empirical propositions. It uses logical patterns of reasoning. It draws conclusions based upon acceptable inferences and deductions. It avoids contradictions. However, it is not at all clear what we mean when we say that someone is *acting rationally*. This is an especially interesting question for instructional design theorists because instructional design is usually assumed to be a rational form of behavior.

Oakeshott points out that the word, rational, has been applied to many forms of behavior. Some examples are rational agriculture, rational diet, rational education, and rational dress. Professor Oakeshott dwells especially on the latter category and examines a certain kind of girl's clothing called bloomers which were introduced in the late nineteenth century (Oakeshott, 1962). Bloomers were a kind of clothing considered to be 'rational dress' for female cyclists. They were clothes designed to serve a specific purpose; namely, to allow women and girls to ride bicycles unencumbered by traditional dress.

Michael Oakeshott asks why bloomers were thought to be rational. He answers that it seems to be first because they were adapted to circumstances—they were a successful solution to a specific problem. Also, the solution sprang from an independent reflective consideration of the problem. Thus, a 'rational method' is a form of deliberate conduct aimed at a purpose and governed only by that purpose. Based on this analysis he believes the following is a fair account of what people often mean when that talk of rational conduct.

- It is a manner of behaving. It does not depend on success.
- It is behavior deliberately directed to the achievement of a formulated purpose.
- It leads to a simple end. If it leads to a complex end it must be presented as a series of simple ends.
- Rational conduct requires the availability of means and a way of selecting them.
- It is not capricious or impulsive. It follows an explicit principle.
- Its aim would be, first, to determine a purpose to be pursued, secondly, to determine the means to be employed to achieve that (and no other) end, and thirdly to act. (1962, p. 88)

This may sound quite reasonable to most readers but, *Michael Oakeshott believes this account is completely wrong*. Thus he writes that:

> "If this is 'rational' behavior, then it is not merely undesirable; it is in fact impossible. Men do not behave this way, because they cannot. No doubt those who have held this theory have thought they were describing a possible form of behavior; and by calling it 'rational', they recommended it as desirable: but they were under an illusion. No doubt, also, wherever this theory is current, behavior will tend to conform to the pattern it suggests, but it will not succeed. ... My view is that this is not a satisfactory notion of rational conduct because it is not a satisfactory account of any sort of conduct." (1962, p. 89)

This conclusion is based in part upon his previously described theory of knowledge. Knowledge is embodied in abilities, and abilities always have a tacit component which cannot be explicated. Thus behavior cannot be based upon explicit principles or overt analyses. Behavior is always the expression of knowledge which is in part implicit.

Michael Oakeshott believes the designers of the 19th century bloomers did not act rationally in their sense of that word. The clothing they designed was not governed solely by mechanical and anatomical considerations. In fact, they were also governed by 19th century English feelings about what a girl's clothing should look like. None of this was made explicit by the designers—indeed, most of those feelings could not be made explicit, because as Oakeshott explains, action is not a manifestation of knowledge, but rather, knowledge is a manifestation of activity. When a person acts, "...his actions are determined not solely by his premeditated end, but by what may be called the traditions of the activity to which the project belonged" (1962, p. 99). "'Rational' conduct is acting in such a way that the coherence of the idiom of activity to which the conduct belongs is preserved and possibly enhanced" (1962, p. 102). An idiom of activity is a tradition or a knowledge of how to behave appropriately in particular circumstances. The rules of behavior of any tradition are a mere abridgment of the activity. We know more than we can say. Traditions of activity are constantly changing things, changed by the activity itself. "No action is by itself 'rational' or is 'rational' on account of something that has gone before; what makes it 'rational' is its place in a flow of sympathy..." (1962, p. 109).

Michael Oakeshott finally argues that he is using the word *rational* in the way it is normally used. He argues that when courts of law use the 'reasonable man' standard (the standard that a reasonable man would have acted thus) they are saying that the man's behavior conforms to acceptable standards. This is a *post hoc* judgment; it has nothing to do with what he may have thought before he acted.

The core of the erroneous conception of behavior is a predisposition which Oakeshott calls Modern Rationalism. The characteristics of the Rationalist are easy to enumerate. The Rationalist believes in the independent mind, free from any authority except reason. The Rationalist believes that traditions, habits, customs, etc. are enemies to progress. Progress for the Rationalist is the result of disengaged reasoning about problems. Indeed, the Rationalist sees the world as a series of "problems" awaiting rational solutions. This partly explains why Rationalist educators deem "problem solving" to be an important part of education. The Rationalist never wants to repair things. That would require real knowledge. Instead he wants "fundamental change." The Rationalist cannot see change unless it is self-conscious change. Thus, the Rationalist wants to replace tradition (which changes constantly) with principles (which by their nature are inflexible). Because the Rationalist derives his solutions from cold reasoning unclouded by prejudice, he finds it difficult to believe that anyone who thinks freely and honestly could disagree with him.

Oakeshott believes that judgment, the tacit component of knowledge acquired though experience, is from the Rationalist's point of view not knowledge at all. Thus, the Rationalist emphasizes the superiority of technical knowledge, the knowledge employed in overt reasoning. Indeed, for the Rationalist there is no knowledge but technical knowledge. He is like a foreigner who sees nothing but the surface characteristics of a society. For the Rationalist, education is nothing more than training in technique, that part of knowledge that can be learned from books.

Oakeshott asks, Why is the Rationalist image attractive? There are several reasons. First it serves as a pedagogic device. We tend to believe that in order to teach something we must first reduce it to set of propositions (the grammar of a language, the rules of research, the scientific method—Oakeshott does not deny that this may be helpful, only that it is sufficient). Another impulse to the rationalist position is a desire for mental honesty. That is, a disinterested mind, free from prejudice, is considered to be a desirable thing. Still another source of support comes from the desire to begin from a position of certainty, a position which only independent propositional knowledge seems to deliver. Lastly, the call for rational conduct reflects an inability to deal with change. Rather than deal with actual situations, Rationalists seek to wipe the slate clean. Nothing ever begins from zero but many reformers hope to do so. They reject the present situation as worthless and have nowhere to turn but the "rational" mind.

Rationalism may be summarized as an attempt to achieve mistake-proof certainty through the use of pure technique, uncolored by prejudice. It seeks to substitute an overt method for the covert judgments of tradition. Rationalism, for Oakeshott, is a relic of the belief in magic in that it seeks an unattainable level of certainty.

An Evaluation of Oakeshott's Theories

In recounting Oakeshott's theory of knowledge, constructed in the early 1960's without reference to psychology, one may be struck by how generally compatible it is with current psychological and computational theories of knowledge. To take one prominent example, Anderson's (1983) theory of cognition posits two main types of knowledge: declarative and procedural. The two types of knowledge resemble Oakeshott's information and judgment in many ways. Declarative representations consist of cognitive units. Units may be propositions, strings, or images, much like Oakeshott's facts and rules. Declarative learning is abrupt and direct, just as Oakeshott would have it. Procedural learning, on the other hand, is gradual and inductive, just like the acquisition of judgment. Procedural knowledge consists of productions (IF-THEN structures) which are executed automatically when the IF clauses are satisfied. Procedural knowledge does not use short-term memory, and thus is tacit. Learners are not conscious of the contents of procedural memory, only the capabilities it affords. Thus, painted in broad strokes like this, there is no obvious conflict between Oakeshott's theory and this empirical psychological theory.

Oakeshott's theory is not without its problems, however. His insistence that knowledge is equivalent to ability seems counterintuitive. He recognizes that we may have information in our heads, but that it doesn't become knowledge until it is incorporated into an ability. Thus, I may "know" that a certain company in Michigan sells epoxy used in wooden boat building, but, according to Oakeshott, that information is not knowledge if it is not linked to an ability. This is fine if you define knowledge that way, but if our dilemmas can be resolved simply by redefining the words we use then we have no problems. Oakeshott is using the word knowledge in a very unusual way. This unusual use of the word knowledge is especially unfortunate because typically Oakeshott is extremely careful about detecting the normal meaning of words and using them without distortion.

In fact, Oakeshott is ambiguous about this question. He states that useless information (information unlinked to ability) is a component of knowledge. It only becomes useful when it attached to an ability. Thus, information is a kind of knowledge. This ambiguity is, in part, a product of Oakeshott's style of writing. He deliberately eschews the technical style of modern academic writers, preferring a literary mode of expression. This makes for pleasant reading, but it does not help resolve certain crucial questions such as the one raised above.

Additionally, Oakeshott's insistence that all activities must find their spring in judgment is problematical. Anderson (1982), for example, attributes skill acquisition to weak problem-solving methods such as analogy. Anderson believes that declarative representations of examples are used to construct action sequences which allow approximation of skilled behavior. If the source of this semi-skilled activity is taken to be the declarative representation then Oakeshott's theory is wrong. Certain types of semi-skilled or novice activity may not have a tacit origin.

If Oakeshott countered that the source of the activity is not the declarative representation, but the use of analogy as a problem-solving strategy, then the question is complicated. Human use of analogy is notoriously hard to explain (Vosniadou & Ortony, 1989). Any two situations may be similar in any number of arbitrary ways. The argument might be made that the use of analogy is a form of tacit knowledge and therefore the activity is still rooted in judgment. However, in these situations there seem to be two activities going on simultaneously. First, the actor is analogizing in order to find a method. But secondly, the actor is executing an activity. If this second activity is thought of as differing from the first, then plainly it is an activity that derives from information not judgment. If this is true then Oakeshott's claim that all activity is rooted in judgment is too strong. Oakeshott position would still hold for skilled activity, but not for unskilled activity. Perhaps he is referring only to skilled behavior, but that is not the impression ones gets.

Another problem is that Anderson (1983) sees all procedural knowledge as first passing through declarative memory and then transformed into productions by the mechanism of practice. It is not clear how judgment enters the mind in Oakeshott's system, but it appears not to pass though declarative memory. Again he is ambiguous on this point. He does assert that certain aspects of judgment, i.e., honesty, patience, exactness, industry, etc., are learned by recognizing them in the actions of a teacher. Thus judgments seem to be consciously acquired. Perhaps they are like the particulars which serve a general purpose which Schön (1988) has written about. However, Oakeshott seems to reserve the term judgment for only those aspects of knowledge which are completely tacit. Anderson, on the other hand, would locate such low-level, and plainly overt, skills as typing in procedural memory, so there is apparently some conflict between these positions. Oakeshott allows that low-level skills have a very minor tacit component, and in the case the case of skills like typing, that tacit component may be so minor that it can be safely ignored from an educational point of view.

Leaving these problems aside, it is interesting to compare Oakeshott's theory with certain knowledge representation theories becoming well-known to instructional systems people. Jones, Li, and Merrill's (1990) computational system of knowledge representation contains elements that parallel Oakeshott's theory. In particular, Jones et al.'s use of enterprises as a central unit of knowledge seems to resemble Oakeshott's use of the word, activities. An enterprise is a complex performance that requires an integrated set of knowledge and skills. This sounds like Oakeshott's decomposition of knowledge into information and judgment. Jones et al., however, specifically decompose knowledge into three basic components: entities, activities and processes. Entities are things: objects, creatures, places or symbols. Activities are actions performed by the student. Processes are actions or relations outside the learner. These three components may be linked by a set of defined relationships. In general, because Jones et al.'s purpose is to create an entirely explicit representation of knowledge they do not consider that knowledge may have a tacit component. Thus, activities and processes in Jones et al.'s system correspond to a form of information in Oakeshott's system. To the extent that I understand the Jones et al. system there is no provision for what Oakeshott calls judgment. This is within the instructional design tradition of treating knowledge and skills as things that can be made explicit and communicated directly. Thus, the component of knowledge called judgment by Oakeshott is not addressed by Jones et al. As with Anderson's psychological theory, Oakeshott's insistence on a central and exclusive role for tacit knowledge distinguishes it from other theories of knowledge.

To summarize, Oakeshott's characterization of knowledge has many superficial communalities with current psychological and computational theories of knowledge. However, his insistence on a central role for judgment, a kind of tacit and traditional knowledge, distinguishes it from other theories. In general, these theories take no account of this kind of knowledge.

Turning to Oakeshott's criticism of Modern Rationalism, it is clear that he differs radically with the standard academic conceptions of skill, expertise, and professional behavior. Oakeshott's criticism of Modern Rationalism rests upon his theory of knowledge. If you accept his assertion that activities are grounded in experience-based judgment, then you will accept that rational behavior cannot be based upon explicit principles. Since recently there has been put forth a hypothesis, roughly compatible with Oakeshott, that learning requires "cognitive apprenticeships" and that "all learning is like language learning" (Brown, Collins, & Duguid, 1989), I will try to evaluate Oakeshott's position by reference to foreign language learning.

It is a commonplace that the fluent speaking of a foreign language requires that you automatize the rules and speak without "thinking." It is also accepted that languages are vast and that no complete grammar is ever likely to be written. Thus, a learner of Japanese, for example, can never learn the language from books and even if you could learn the rules from books you would still not be able to speak properly. Skilled speaking of Japanese requires that you speak "like a Japanese," plainly a vague, though concrete, criterion. Oakeshott would, of course, hold that skilled behavior, like speaking a foreign language, contains a large tacit component, and that the rules of such an activity can never be made completely explicit. Thus, for language learning at least, Oakeshott's predictions seem to hold and if all learning is indeed like language learning as Brown et al. hold then cognitive apprenticeships, if they include immersion in the traditions of action, would be exactly what Oakeshott would recommend.

His argument, of course, is that all forms of skilled behavior are exactly like language learning. Skilled behavior requires that you behave like a native, whether you reside in a foreign country or the country of scientists or plumbers. Rational behavior, for Oakeshott, is precisely this kind of "native" intuition about appropriate behavior. Since speaking a foreign language according to explicit rules would result in a less-skilled form of behavior it follows that any activity based on a set of principles will also be inferior to action based on the traditions of the activity. For Oakeshott, the only way to acquire this authentic kind of rationality is to be immersed in the culture, to have a cognitive apprenticeship.

Many readers will, no doubt, still find Oakeshott's position strange, even weird. They are so accustomed to (they were raised in a tradition of) seeing action based upon explicit principles and methods as the preferred representation of professional behavior that they will find this theory unacceptable. Their conceptions of instructional design are based upon a rationalist theory of knowledge and action. Standard prescriptions for instructional design fairly replicate Oakeshott's characterization of Rationalism. We typically talk about clarifying purposes, determining objectives, selecting means, and acting based upon our analysis. It is important to point out, therefore, what Oakeshott is *not* saying. He is not saying that, in the absence of true and rich experience, intuition is superior to explicit methodology. What he is saying is that true skill, in addition to requiring explicit informational knowledge, also requires massive exposure to the traditions of a domain of activity. Also, he is not saying that behavior based upon explicit principles is doomed to failure. It will often succeed, not because of the principles, but because, at crucial moments, the actors will abandon principles and act according to their intuitive judgments based upon whatever experiences they may have. Since tacit judgments occur nearly transparently it is very easy to ignore or devalue them. One need only set foot in a foreign country to appreciate that most of the actions we perform unthinkingly every day do not "make sense" to other people. *(Question: How many times do you knock on a door in the USA? What does it mean if you vary the number of knocks?)*

Precisely because judgment is transparent, to most instructional designers it is not considered important. However, it has not gone completely unnoticed. Schön (1983, 1987) has recorded the problems of architecture students who complain that most of the decisions made by their teachers are covert. The traditional solution to this problem in architecture has been to require a studio experience of all students. This is interesting because architecture, as a discipline, evolved before the age of Modern Rationalism and the studio experience is precisely the kind of apprenticeship Oakeshott would prescribe. If these examples of language learning and architecture are representative of skilled behavior in general, it appears that

Oakeshott has made a well-founded criticism of the Rationalist account of the proper basis of behavior.

In sum, although Oakeshott's conception of rationality and his criticism of Rationalism may appear strange at first, it follows directly from his theory of knowledge. If correct, he has made a major contribution to knowledge by pointing out that true skilled behavior is acquired by initiation in a tradition, not just by studying technical knowledge encoded in principles. Essentially what he is saying is that tradition is a special form of technology. It is a way of acting and thinking that captures important tacit knowledge which can never be made completely explicit. As such it is an essential component of intelligent action.

Implications for Instructional Systems Design

ISD methodology

On one level at least Oakeshott's ideas seem very compatible with typical ISD methods. His conception of knowledge as ability suggests that knowledge can only exist in actions. Since ISD people are accustomed to thinking that lessons are focused around behavioral objectives, there is an obvious affinity between the two positions. If knowledge is a manifestation of activity, it makes sense to measure knowledge by observable actions. Additionally, Oakeshott believes that complex skills are conglomerations of subskills that can be separated out and approached individually. Skills also have hierarchical relationships with certain facts and rules which are prerequisites to mastery. All of this seems familiar and uncontroversial. Oakeshott's conception of the teacher as a person who selects content, orders it, presents it, and causes the student to practice with it is unexceptional. Even Oakeshott's disinterest in discovery learning, is not a problem for ISD people, who generally prefer direct instruction.

However, when Oakeshott starts talking about imparting judgment to students, he parts company with ISD. Normal ISD has no prescriptions for such knowledge because it is not recognized as knowledge at all.

This need not be the case though. One way of thinking about the imparting of judgments is to use a skills matrix. Peters (1968) criticized Oakeshott by asserting that to the extent that a skill is directed toward a well-defined goal it need not be learned by apprenticeship and could be learned by self-study. Another way of expressing this idea is to make a distinction between open and closed skills.

Originally, closed/open skills referred to those learned in a predictable or unpredictable environment (Poulton, 1957). For instructional design purposes, closed skills may be thought of those which embody a standard or "correct" procedure; open skills have no one "correct" form. For example, the setting of the time on a digital watch, a closed skill, has a defined procedure which, if followed, usually guarantees success. On the other hand, a game such as chess, although having well-defined components, has no set of moves which will guarantee success. Chess-playing, like most game-like activities, is an open skill. (Open skills like chess playing often have closed skill subcomponents.)

	Discrete:	Continuous:
Closed:	• operating many push-button devices. • math operations • typing. • many aspects of written language. • Speaking sentences in foreign language. • repairing simple things • making simple objects—not works of art (carpentry, dressmaking, cooking) • reading & writing (basic skills) • basic computer operations	• controlling many devices that involve motion. (dentist drill, lathe, airplane, sailboat, bicycle) • taking dictation. • refereeing a game (basic level) • basic listening comprehension (foreign language) • swimming (and most non-competitive sports) • auctioneering • surgery • welding
Open:	• writing an essay • painting (art) • planning a lesson • games (chess) • architecture • most kinds of design. • skilled cooking • writing a proposal • skilled computer programming • photography	• acting • singing • teaching • conversing in a foreign language • competitive sports • negotiation/debate • lawyer interrogating a witness • managing a project • leadership • warfare

Figure 1. Skill Matrix: Examples

In order to construct a matrix it is necessary to introduce, in addition to the closed and open dimension, another dimension based on discrete and continuous skills. Discrete skills traditionally are skills under the control of a discrete stimulus. However, for instructional design purposes, they may be thought of as skills which are under no time constraints. By no time constraints, I mean that the procedure may be performed slowly with interruptions and still achieve success. An example of a discrete skill is programming a VCR. One can successfully program the VCR from a manual without practice. Of course many discrete skills, with practice, become smooth and automatic and may appear to be continuous. Typing is an example. However, one may stop or slow down at any time and still achieve a successful product.

In contrast, continuous skills, traditionally defined as skills under the control of a continuous stimulus, may be thought of instructionally as skills performed under the constraint of real-time. The time constraint is a result of the fact that these skills involve reacting to a continuously changing situation which is at least partly out of the control of the actor. Many of these skills involve continuous motion, such as swimming or dancing. The pace of the action is dictated by nature (gravity) in the case of swimming, whereas for dance, rhythm and the presence of other dancers form a constraint. In addition to such physical skills, many business skills, like negotiating or interviewing, are also continuous. The key factor in many continuous skills is that the actor is reacting to a changing environment which is not completely under his/her control. By combining the two contrasting classifications, one can produce a 2x2 matrix of skills (see Figure 1). Note that the examples given may be ambiguous. For example cooking which is called discrete, include continuous skills, like frying. In many cases, the distinction between closed and open is often a distinction between normal, basic skills and high mastery. High mastery of a skill is almost always open.

Viewed from the point of view it appears that Oakeshott probably had open skills in mind when he constructed his theory. It is very improbable that programming a VCR involves any "style" or judgment, in his sense. In general, if the student masters the correct procedure, success is achieved. Originality is not desired.

One important difference between open and closed skills is the kinds of examples that the students may be exposed to. Since closed skills have a correct form the instructor will expose the students to that form. Students can practice by mimicking the correct performance and, very often, simple right-or-wrong feedback will suffice because the student can check his/her performance against the correct model.

On the other hand, open skills, because they have no one correct form by definition, present an instructional design problem. It is here that Oakeshott's ideas are helpful. It appears that real mastery of open skills, in general, does require the kind of judgment that can never be reduced to rules. One way of analyzing this problem is to consider the kind of teaching used in traditional open-skills education. By traditional open skills I mean architecture, art, literature, music, theater and the like.

In general traditional education in open skills has involved exposing the student to "masterworks." It is useful to note that discrete open skills generally result in a physical product, whereas continuous open skills result in a performance. Thus a masterwork can include products such as buildings, books, and paintings as well as recordings of dances, plays, and music. Using this kind of empirical data, we can conclude that open-skills education, if it is to recognize Oakeshott's judgment component of knowledge, must include an apprenticeship which exposes students to masterworks. This suggests that the teacher, although important, is not the only model for judgment. Peters (1968) noted this problem by referring to the work of coaches who elicit skilled performance from athletes without being "masters" themselves. Of course, student-athletes are well aware of the performances of great athletes, and these performances probably serve the same purpose for the athletes as Shakespeare for literature students or Picasso for art students.

Although the prescription of using masterworks to teach open skills is straightforward, its implementation is problematical. In general, the traditional open skills have, over many generations, developed a consensus concerning what actually constitutes a masterwork, and have generated "museums," both literally and figuratively, of examples of masterworks. Even chess players have published collections of great games by master champions of the past which they can recreate and study. For many of the open skills which instructional designers are trying to teach, there exists not such consensus. Thus, there are no "museums" of great negotiators, managers, or even teachers. If Oakeshott's ideas are accepted, the creation of such museums will be a priority. It is here that technical means such as the videodisk or multimedia can be helpful. Since ISD has a long association with technology, this will interface well with current practice.

In spite of the unconventional appearance of Oakeshott's theory, from a traditional ISD viewpoint, I have tried to show that his ideas can be incorporated into standard ISD practice. By viewing judgment as a component of open skills, and taking traditional open skills education as an empirical basis, fairly simple and straightforward implications for ISD can be drawn. Implementation will require the construction of a collection of masterworks but this is well within the capability of instructional technology.

The Education of Instructional Designers.

The systems approach to instructional design has long been considered rational because it sets goals and pursues them based upon empirical principles, free from folklore and superstition. However if Oakeshott's definition of rationality is accepted, ISD must be considered rational only if the instructional systems designer is acting within a tradition of activity known as instructional systems design. This raises questions about the proper education of instructional designers.

If is fair to say that current education consists of introducing students to instructional design principles and then causing the students to practice in semi-realistic and realistic situations. Many students also experience internships. Students are, to my knowledge, not deliberately exposed to the masterworks of ISD.

One way of thinking about how the education of ISD students could be different is to examine the education of architects. The education of architects, a traditional profession, evolved before modern times. Students naturally are exposed to models or pictures of the great buildings of the past. This part of their education occurs almost unconsciously. Another essential part of their education is the design studio.

The design studio experience has traditionally been a component of architectural education. The idea that the architectural studio could serve as a model for professional education has been well developed by Schön in his book, *Educating the Reflective Practitioner*. (The following account is based upon conversations with architecture students and professors.) The architectural design studio, as a pedagogical method, has no parallel in its intensity and involvement, save perhaps the internship of medical students. The studio experience consists of several key components. Among these are a problematic situation, a studio teacher, a jury of experts , and a place, called a studio, dedicated to the design activities of the course. The problematic situation is intended to represent the real world of practice, but be relatively free of its pressures, distractions, and risks. The studio teacher guides the students through their design projects, while sharing his knowledge and experience. He functions less as a teacher than as a coach who demonstrates, advises, criticizes and questions. The jury of experts, recruited from university faculty, serves two roles. The first is to participate in the studio, sharing their suggestions and criticisms with the students. In some ways this resembles a master-apprentice relationship, and it allows the students to see how an experienced professor would deal with real world problems—something they almost never encounter in conventional courses. The second role of the jury is to judge the students' projects at the end of the semester. Projects are displayed and comments are given publicly. The jury's judgment in many cases is the grade for the project.

The final component of the studio experience is the studio itself. A studio is a dedicated workplace. In architectural schools, when students enroll in a studio course they are typically assigned a desk and equipment which "belong" to them for the duration. Since the workplace is restricted to the enrolled students and their teachers there is a highly social component in the studio experience. Students cooperate with each other and learn from watching other projects take form. There is also an element of competition which arises from the fact that all are striving to solve the same problem.

As a result of the studio experience, students can be expected to have gained at least three types of knowledge. The first involves a new ability to represent problems and synthesize solutions. The second involves creative approaches to problem-discovery and problem-solving. The third involves a new critical language which allows them to discuss problems and judge solutions. Although judgment (in Oakeshott's sense) is involved in all three types of knowledge, it is especially in learning the critical language that students become initiated into the traditions of their profession. The educational experience in the design studio involves all three of these types of learning, but it does so simultaneously. Learning takes place primarily through example and experience rather than through explanation. In this way the studio is intended to provide a bridge between theory and practice.

Could this be a model for the education of instructional designers? It is apparent that there are many similarities between architecture and ISD. Both are design activities. Both can trace their roots to activities that emerged in ancient times.

Both require technical knowledge. Both seek to fashion specific artifacts to fit specific situations. The fact that architects design artifacts that exist in space and instructional designers design artifacts (lessons) that exist mostly in time, means that ISD is somewhat more abstract and therefore difficult to acquire. In spite of this difference, it seems apparent that a design studio experience could be easily incorporated into ISD training. A prerequisite to such an experience would be exposure to the masterworks of ISD. As with other recent open skills, there exists no professional consensus on what those works would be. There appears to be no theoretical barrier to the construction of such a consensus if professors of ISD sought to do so.

As for the implementation of a design studio experience, there again appears to be no theoretical barrier. Many practical obstacles will have to overcome, though. There is no physical location currently allocated for design studio experiences. Space is more precious than gold at most universities. There is no tradition of studio pedagogy. Perhaps some skill could be acquired if ISD professors audited (or participated in) architecture studio classes, but this kind of skill will evolve slowly. The students will not know how to act. Architecture students have the benefit of the experiences of generations of students which have set parameters for what is rational and irrational behavior in a studio class. Juries may be difficult to assemble. Schools of Education have no provision for compensation for jury duty. There is no tradition of participation. Jury members will not know how to behave. A graduate student of mine, who was previously a student of architecture, once asked me why we in education are so kind when we criticize students' work. "In architecture," she said, "if we don't like something, we say it 's ugly!" Our behavior was irrational to her because she had not been sufficiently initiated into our traditions. Instructional design juries will need to develop a tradition of criticism which meshes with the culture of schools of education. The obstacles are many but none are insuperable, if there is a will to take the implications of Oakeshott's philosophy seriously.

Conclusions

Michael Oakeshott's philosophy of education is based upon a conception of the nature of knowledge, its acquisition and use. Because he posits a component of knowledge, judgment, which can never be reduced to rules, and can only be learned through a kind of cognitive apprenticeship, his philosophy has implications for ISD. Those implications include prescriptions for the teaching of open-skilled behavior and the training of instructional designers. The purpose of this paper has been to elaborate that philosophy and its implications.

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Selected Abstracts for the

Special Interest Group for Distance Learning and Telecommunications (SIGTELE)

Inter-High School Writing Project

Darlene Chirolas, University of Illinois

A project was undertaken by staff at the Computer-based Education Research Laboratory of the University of Illinois with two Illinois high Schools, (one in Rantoul and one in Chicago) utilizing the communications features of the NovaNET system.

The primary objective desired by both teachers was to motivate the students to write. The second objective was to increase the quantity and quality of writing by providing an opportunity to communicate with students at other schools. Writing to real people, and using the computer to do so, promoted a greater amount of writing and a greater willingness to put their thoughts in writing. The final objective was to give the students an opportunity to learn more about a very different community, and more about their own too!

The NovaNET notesfile utility was very will suited for our writing project. The teachers would write base notes to start the discussions and students would respond to the base notes and to each other.

The notes contained to writer's sign-on name and date and time written. All students in a group could read any of the notes written by members of their group and easily respond at any point of the discussion.

The project was will received by the teachers and students and the CERL staff has applied for grants to further the project to include more schools. We are also planning to develop relationships with alumni of the participating schools either in post-secondary schools/or in business or industry or faculty people who could discuss their work with the students via the network.

Using ERIC - A Database and More

Jane Janis, ERIC Clearinghouse on Information Resources

When people think of ERIC they think of the ERIC database but the ERIC system provides a lot more. Many users only think or ERIC when they want to get a lot of information for a research project but ERIC is also an important current awareness tool. In addition to the maintenance of the database, each clearinghouse publishes a bi-annual newsletter, a series of digests and mini-bibliographies, information products, and a monograph series. There is also a users services coordinator in each clearinghouse whose primary responsibility is helping users meet their information needs.

The purpose of this presentation is to talk about all these aspects in more detail and help those attending the presentation see what else ERIC can provide for them in an ongoing manner... not just when they need a search done.

The presenter, Jane K. Janis has been with the ERIC Clearinghouse on Information Resources for the last ten years. In that capacity, she has been part of the continuing process of producing, evaluating and improving all the different aspects of the Clearinghouse. She has hands-on understanding of how the system has involved and all the valuable resources available to its users.

Selected Formal Papers from the

Special Interest Group for Distance Learning and Telecommunications (SIGTELE)

Effects of anonymity and group saliency on participation and interaction in a computer-mediated small-group discussion

Terence C. Ahern
Vance Durrington
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Abstract

Research on the use of computer-mediated in learning environments demonstrates that the levels of member participation as well as achievement are consistently high when compared to more traditional learning environments. However, closer scrutiny this medium of exchange can have a negative impact on the ability of groups to structure interaction across time. This paper reports on the amount of individual interaction in a CMC environment in which one condition had a high level of group identification in contrast to a condition which maintained individual anonymity.

Introduction and Rationale

Research (Kraemer & Pinsonneault, 1990) on the use of computer-mediated CMC in learning environments demonstrates that the levels of member participation as well as achievement are consistently high when compared to more traditional learning environments. Hiltz (1988) reports that students who participate in computer-mediated classes participate at levels of interaction which would not be possible in a traditional classroom. Phillips and Santoro (1989) have found that CMC removes time and space as a constraint, so that student-to-student as well as student-to-teacher interaction is not only convenient but also an effective instructional strategy.

However, on closer scrutiny this medium of exchange can affect the ability of groups to structure interaction across time. According to Turner (1988) "sustained structuring is accomplished through 'chains of interaction' where in a literal sense, individuals 'pick up where they left off' from past encounters....Without structuring, every re-encounter of individuals would involve so much interpersonal work that they would exhaust themselves." (p. 121). This is an important issue for learning groups because interaction is usually not confined to a single encounter. Recent research has observed that CMC systems may inherently cause a breakdown in the normative sequence of interaction.

McGrath (1990) observes that because group members in an asynchronous system can choose when to participate an unpredictable lag in feedback is created which dramatically affects the dynamics of the group's interaction structure. According to McGrath current computer-mediated communication systems reduce the "normative force" (1990, p. 52); that is the expectation that communicative events are regulated and follow expected patterns. However, because of an unrestricted ability to participate within a computer-mediated system, any member may interject a comment completely out of rhythm with the rest of the group. This breakdown in the anticipated connectedness between messages (Rogers & Kincaid, 1981) creates "anomalies in the transition of floor turns, and the smooth succession of 'speakers'" (McGrath, 1990, p. 47) and may restrict the amount of reciprocal interaction between members.

Kiesler (1986) theorizes that computer-mediated systems breakdown standard interaction because CMC attenuates the normative social context clues by restricting the ability of senders "to link the content or tone of messages to the receiver's responses so they can evaluate how their messages are being received." (p. 48). Consequently, without the implicit social information such status or gender, participants in CMC feel a greater sense of personal anonymity and less responsibility to the group. This results in group members who are unconcerned with meeting normative requirements for maintaining interactional structure over time.

Lea (1991) on the other hand speculates that the breakdown in reciprocal interaction is due to a lack of group salience and not the attenuation of social context cues. According to Lea, participants identify strongly with the group are more likely to strive to create norms for group interaction. In contrast a higher level of anonymity reduces group salience and forces the individual to invoke the social norms from the larger social context in which the group is embedded. Consequently, current CMC systems reduce group salience by hampering the development of consistent exchange patterns. Because it is more difficult in CMC environments to determine "who said what to whom when" participants are reluctant to risk involvement which results in more conservative interaction sequences.

Problem Statement

Many researchers (Kiesler, 1986; Kraemer & Pinsonneault, 1990; McGrath, 1990; Murray, 1985) have noticed that a breakdown in normative function reduces members effectiveness in using computer-mediated interaction systems. They suggest that a simple solution to the problem would be to, as McGrath points out, explicitly create "the very kinds of social norms that apparently arise spontaneously in natural face-to-face groups" (McGrath. 1990, p. 55).

On the other hand, Hesse, Werner, & Altman (1988) speculates that this breakdown in normative function is a technological problem which could be resolved by designing new software that could provide better temporal sequencing of comments. Recent research (Ahern, 1991a) has demonstrated that the breakdown in normative interaction sequence can be alleviated through a careful design of the user interface.

Consequently, we propose to study the effects of providing members who are interacting through a CMC environment with external, face-to-face group identification in contrast to a group which maintains individual anonymity. Additionally, we will study whether there is an effect on the amount of group interaction by design of the CMC interface.

Method

It is expected that increasing group salience through participant identification in a traditional text-based CMC environment will produce an equal level of student interaction in a non-traditional CMC environment which provides a graphic representation as well as the dynamic linking of participant responses. It is expected that maintaining participant anonymity in a traditional text-based CMC environment will produce an equal level of student interaction in a non-traditional CMC environment which provides a graphic representation as well as the dynamic linking of participant responses. It is expected that increasing group salience in a graphic-based CMC environment through participant identification will produce an equal level of student interaction in a graphic–based CMC environment where the anonymity of participants is maintained. Further it is expected that increasing group salience in a traditional text-based CMC environment through participant identification will produce an equal level of student interaction in a traditional text-based CMC environment where the anonymity of participants is maintained.

Subjects

The subjects in the study were 15 undergraduate students from an introductory course in Office systems technology in a southwestern public university.

Materials

The IdeaWeb© (Ahern, 1991b) is software designed and developed by the author using HyperCard to mediate group discussion. The software has three levels, Topic, Discourse and Comment . There are two versions of the software which differ at the discourse level. For each version, in order to respond to a subtopic a user will click the button labeled Discussion .

Version one employs a graphic-based interface at the discourse level which requires group members to visually map their interactions. In this version when a student adds a statement to the discussion, the computer system automatically creates a Comment Icon and labels it with the respondents name and the day's date. Once the student has made their comment and returned to the graphic map, the new Comment Icon must be moved into the map area where it can be linked to previous responses. Linking comments creates not only a visual representation but also a dynamic response cluster. Therefore in browsing previous responses, a selected a node within an interaction sequence would be displayed first and subsequently any other response in the order in which it was linked with to the primary node.

Version two of the IdeaWeb employs a more traditional textual interface in which the participants see a sequential list of member comments. To add a comment in version two the system requests the name of the addressee and automatically concatenates it with the name of the current user. The computer appends this information to the end of a chronological list of previous respondents. To read comments in this version, the student would select the comment by clicking on the appropriate line. The computer displays the selected comment. The computer system provides users with an opportunity to review other comments in in chronological order starting from the selected response. Within version two, discussion respondents do not have any method of altering the order in which responses are displayed.

Treatments

The subjects were randomly divided into 4 four conditions: group salience with graphic-based interface, group salience with text-based interface, pen-name with graphic-based interface and pen-name with text-based interface of approximately 4 members per group. The group salience conditions met face-to-face for approximately 30 minutes prior to the start of the computer-mediated discussion and will orally exchange information, such as occupation and age. The pen-name conditions did not meet outside of the computer-mediated system which generated aliases for each member of the discussion group.

Over a period of approximately 3 weeks all conditions participated in an open discussion based on the topics of security, privacy, education and regulation in the telecommunications industry.. Due to the nature of this study, data such as the number of messages generated and time will be automatically collected from the actions of the participants in the computer-mediated groups.

Analysis

A significant main effect for identity was found (Wilks l = .299, F (4,8) = 4.686, p = .030). Post hoc univariate F tests revealed that that members in the anonymous condition significantly (F (1,11) = 19.439, p = .001) wrote more words (μ = 64.8) per message than the salient condition (μ = 11.8). Additionally, anonymous groups significantly (F (1,11) = 1601.1, p. .008) spent longer (μ = 22.4 minutes) per message in contrast to the salient group (μ = 1.6 minutes).

Discussion

The typical classroom interaction as characterized by Mehan (Mehan, 1979) is a discourse sequence of initation-reply-evaluation. This type of discourse, more traditionally referred to as recitation (Cazden, 1988; Dillon, 1984) has the teacher controlling who talks about what to whom, which results in the teacher talking three times more often than students. The typical way for a student to have an opportunity to interact is usually in response to a direct question posed by a teacher who then evaluates its correctness. Finally, the recitation model of classroom interaction also limits the opportunity for students to interact with their peers.

Dillon (1988) reports, however, that the traditional classroom interaction is contrary to the more natural situation. He observed students on the playground where the number of questions and general interaction with peers was governed by the age of the interactants. The older they were, the more complex and extensive the interaction, coupled with a more sophisticated world view. Dillon was surprised to find that in the classroom, this situation was reversed. Instead of the older students interacting more often with their peers they made fewer and fewer comments and asked fewer and fewer questions as they moved through school. Dillon suggests that the interaction sequence of initiation-reply-evaluation trains students to respond with only enough information necessary to appropriately answer the question. Students learn very early that it does not benefit them at all to volunteer or elaborate an answer to a question unless they know exactly what the teacher expects. They realize that the content of the response is valued and not the exploration of ideas. The findings in this study support this ob. . rvation. The students in the salient condition were not willing to risk longer or .nore complex interaction. However, under the protection of anonymity the comments became longer and the students spent longer time engaged with the material. This has important consequences for instruction. It is simply not enough to provide students with the opportunity for peer-interaction by employing computer technology, but the traditional role of the teacher as judge must also be altered in meaningful ways if students will risk further interaction.

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Enhancing Context and Continuity in Computer-mediated Conferencing: Developing the IdeaWeb©

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Abstract

Research on the use of computer-mediated communication (CMC) in instruction has demonstrated that user participation as well as achievement are consistently high when compared to more traditional learning environments. Previous investigation, however, has revealed that computer-mediated communication systems can reduce the "normative force" that exists in face-to-face discourse for structuring a group's interaction. This results in higher user disorientation and a breakdown in the sequence of interaction in CMC. Attempts, at reducing this effect have concentrated on developing text-based systems, which seek to constrain user responses. However, this article reports on the development and implementation of a graphic-based user interface that reduced the breakdown in the interaction sequence in a computer-mediated small-group discussion.

Introduction

For a long time, computer technology has been viewed as playing a "critical role in the transformation of the existing educational systems" (Hannafin & Peck, 1989, p. v). Even though the computer has not resulted in a radical revision of the school, Hannafin and Peck report that "progress *is* being made" (p. vi). One area in which innovation is evident is telecommunication.

Watson (1990) reports that "through the commitment of individual teachers, the American classroom is going on-line" (p. 110). Both teachers and students are tapping into a vast array of people and information. Electronic bulletin boards, the modern equivalent of a town meeting, are springing up on almost any topic or subject. Schools in one state can interact with schools in other states and in some cases other countries. In addition, the use of electronic telecommunication is not limited to chit-chat among pen-pals, but whole courses are being delivered on-line (Harasim, 1990).

Research on the use of computer-mediated communication (CMC) in learning environments (Ahern, Peck, & Laycock, 1992; Hiltz, 1988; Kraemer &

Pinsonneault, 1990; Phillips & Santoro, 1989; Quinn, Mehan, Levin, & Black, 1983) has demonstrated that the levels of member participation as well as achievement are consistently high when compared to more traditional learning environments. Phillips and Santoro (1989) found that CMC removes time and space as a constraint, so that student-to-student as well as student-to-teacher interaction is not only convenient but an effective instructional strategy. Hiltz (1986) also reported that students who participate in computer-mediated classes participate at levels of interaction that would not be possible in a traditional classroom.

Nonetheless, the bulk of this research has been limited to task-oriented groups normally found in an office environment (Greif, 1988). Greif cautions us that "specific classes seen in the office may not exhaust all the kinds of differences and interactions that can be found among classes of people working together in other settings" (1988, p. 11). Consequently, even though CMC has been shown to have important effects on the level of user participation within groups, few studies have looked at how a computer-mediated environment affects group dynamics (Ahern, et al., 1992; Kraemer & Pinsonneault, 1990).

Small groups create an environment that encourages a fluid interchange among its members where "each person influences and is influenced by each other person" (Shaw, 1976, p. 11). Even though most groups exhibit a high amount of interchange, there is an orderly pattern or structure which regulates the interactions among members and provides rules for "what behaviors a group considers appropriate or inappropriate" (Shimanoff, 1988, p. 50).

Structure provides the necessary "stability, regularity, and predictability to the system" (Rogers & Kincaid, 1981, p 146) without which "every reencounter of individuals would involve so much interpersonal work that they would exhaust themselves" (Turner, 1988, p. 121). Consequently, group members are able to form context by creating "'chains of interaction' where in a literal sense, individuals 'pick up where they left off' from past encounters" (Turner, 1988, p. 121). Therefore, "as the discourse proceeds, it carries and builds with it a basis of shared understandings in terms of which the participants are able to make joint sense of what they are saying and doing" (Edwards & Mercer, 1989, p. 93).

Typically CMC is an asynchronous form of discourse which introduces a temporal lag between the transmission and the reception of a message. This temporal lag can have a dramatic impact on the ability of groups to structure interaction across time (Ahern, 1991; McGrath, 1990). Current CMC designs are not suited for the multi-channel interaction common of small group interaction.

The standard user interface design duplicates the office memo (Comer & Pederson, 1985) which identifies to whom a message was addressed, from whom it originated, the date it was sent, as well as simple topic information. Outside of displaying a chronological list of messages to a reader, there are no visual or semantic cues which might illustrate a fundamental relationship among the messages. This lack of orienting cues can make it difficult for a user to arrange messages in the proper order necessary to reconstruct an interaction sequence, especially when the "messages arise from more than one source" (McGrath, 1990, p. 52). Consequently, a group member can become easily disoriented because a relevant comment was missed or read out of the proper sequence. In other words, according to McGrath, current computer-mediated communication systems reduce the "normative force" which is the expectation of an orderly pattern for the group's interaction (McGrath, 1990, p. 52). Therefore, a reduction in the "normative force" among group members causes a breakdown in the expected relationship between messages (McGrath, 1990; Rogers & Kincaid, 1981) which may restrict the amount of reciprocal interaction between members. Consequently, the ability of CMC to provide groups with an unrestricted flexibility to communicate may in fact, be its greatest weakness for efficient group interaction.

One solution to the problem of structural breakdown would be, as McGrath points out, to create externally "the very kinds of social norms that apparently arise spontaneously in natural face-to-face groups" (Ahern, et al., 1992; McGrath, 1990, p. 55). On the other hand, Hesse,Werner and Altman (1988) suggest that this breakdown in standard interaction is a technical problem which could be solved by developing new software that could provide better temporal sequencing of comments.

Previous attempts by researchers to solve the technical problems in the seemingly disorderly world of asynchronous computer-mediated communication have concentrated on developing software routines that structure a group's interaction. Comer and Pederson (1985) designed and implemented a software package for asynchronous CMC based on the assumption that the content of a specific message is better understood within a context of messages that are grouped by topic. Winograd (1988) also has developed a system based on the notion that interaction is a "coordinated sequence of acts" (p. 628). Winograd assumed, as did Comer and Pederson, that a message could be understood only in relationship to other messages. Consequently, the system designed by Winograd, provided users with a variety of underlying constraints designed to structure interaction.

These earlier attempts to improve the user's response behavior in computer-mediated systems have concentrated on a text-based environment. Cognitive psychology, however, has learned that providing a visible framework or structure improves the integration of the conceptual relationships among the ideas presented. One such approach has been to map the relationships among ideas visually through the use of a class of cognitive strategies called graphic organizers. Consequently, with the current graphic abilities of modern microcomputing systems, incorporating a more visually informative interface may reduce disorientation in a computer-mediated discussion by providing the group members with a contextualizing structure of the current interaction.

Therefore, the primary purpose of this paper is to report on the effect a redesign of the user interface design had on the amount of reciprocal interaction between group members. It is anticipated that the breakdown in normative interaction structure encouraged by the asynchronous nature of computer-mediated systems can be obviated through a graphic design of the user interface.

Designing the IdeaWeb©

The IdeaWeb software was designed and developed using Apple Computer's HyperCard™ to mediate small group discussion. The software has three levels: a topic map, a discussion map, and individual comment cards. The topic map (see Figure 1) is the first level that a user encounters after logging onto the software. This design approach was suggested by Comer and Pederson (1985), who argued that grouping messages according to topic would orient users thereby improving member response patterns.

At the topic map level, a user selects a subtopic by highlighting a Topic Icon which in turn displays a short descriptive blurb of the subtopic in the area to the right of the map.

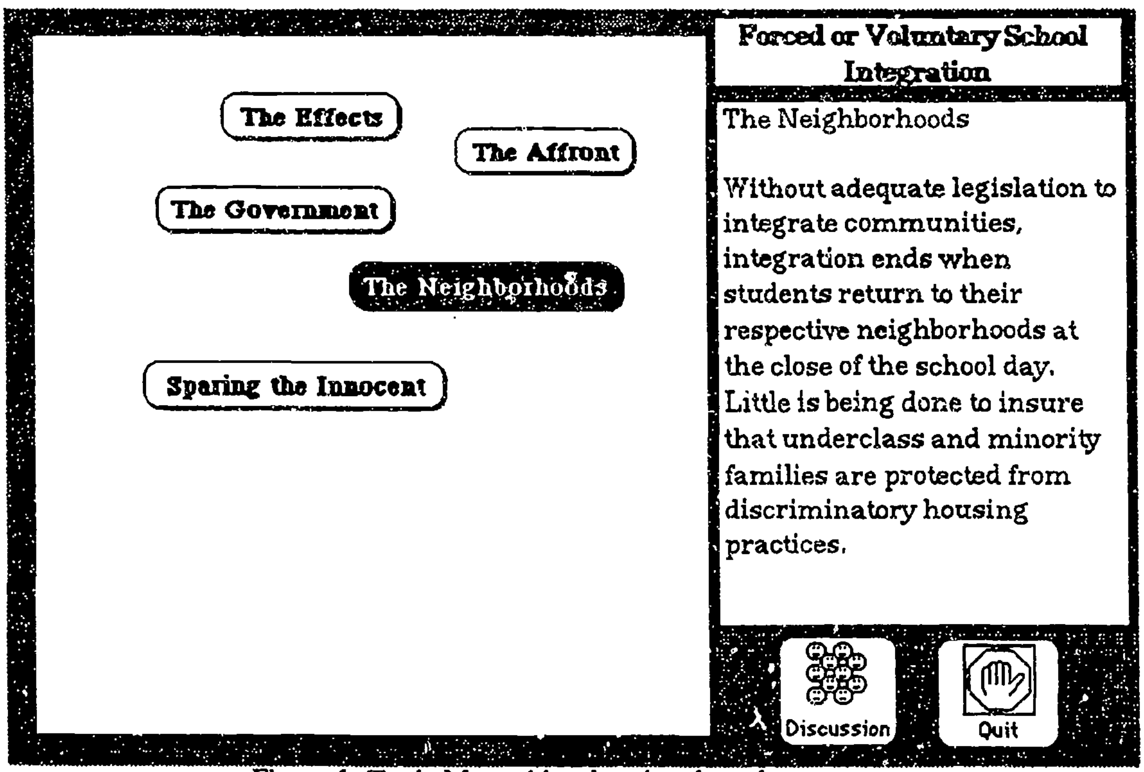

Figure 1: Topic Map with subtopic selected

In the current implementation, subtopic descriptions were entered prior to the discussion. Once a student has selected a subtopic to explore, moving to the appropriate Discussion Map is accomplished by a simple clicking of the "Discussion" button located in the lower right part of the screen.

Each subtopic has a Discussion Map which moderates the creating, browsing or linking of individual comments. In addition the Discussion Map requires each user to chart their interactions visually (see Figure 2).

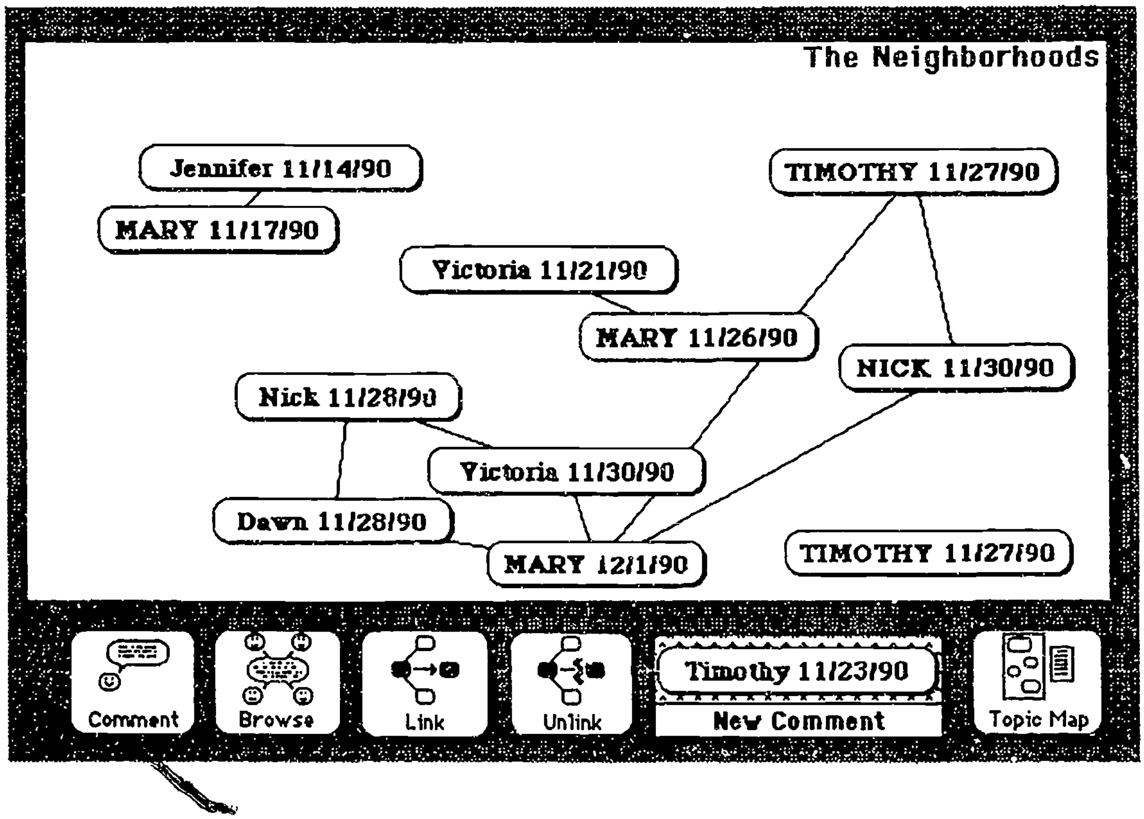

Figure 2: Graphic-based discussion screen with new Comment Icon

To add a comment to a particular discussion, a user would click the Comment button located in the lower left corner of the Discussion Map screen. The computer software automatically creates a new Comment Icon in the "New Comment" box and labels it with the user's name and the current date. The IdeaWeb then immediately displays a blank comment card (see Figure 3) ready to accept the user's note.

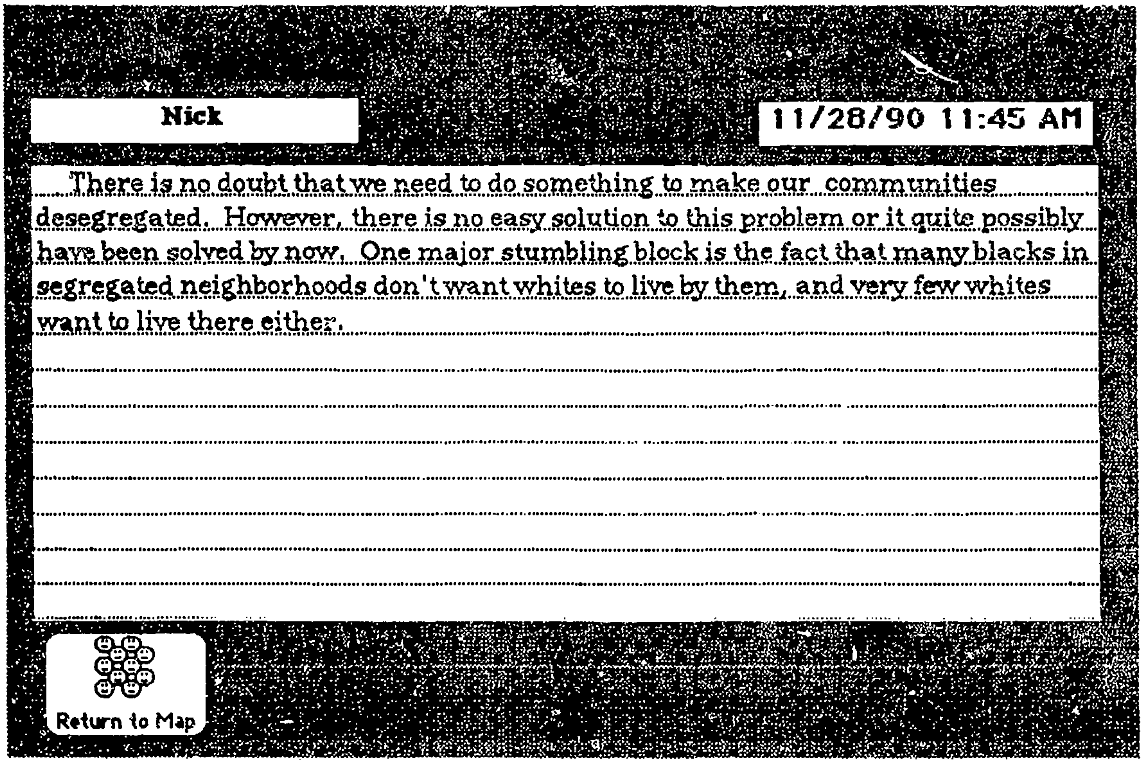

Figure 3: Typical comment card with response

Once a user has finished the current comment and returned to the Discussion Map, the new Comment Icon must be repositioned in the map area. The user places the cursor on the new Comment Icon and while holding down the mouse button moves the cursor somewhere on the discussion map. Once the user releases the mouse button, the software positions the Comment Icon at the last location of the cursor.

Comment Icons also form the nodes in an interaction sequence through the process of linking. To link a comment to another comment, the user selects both a source icon and a target icon as illustrated in figure 4.

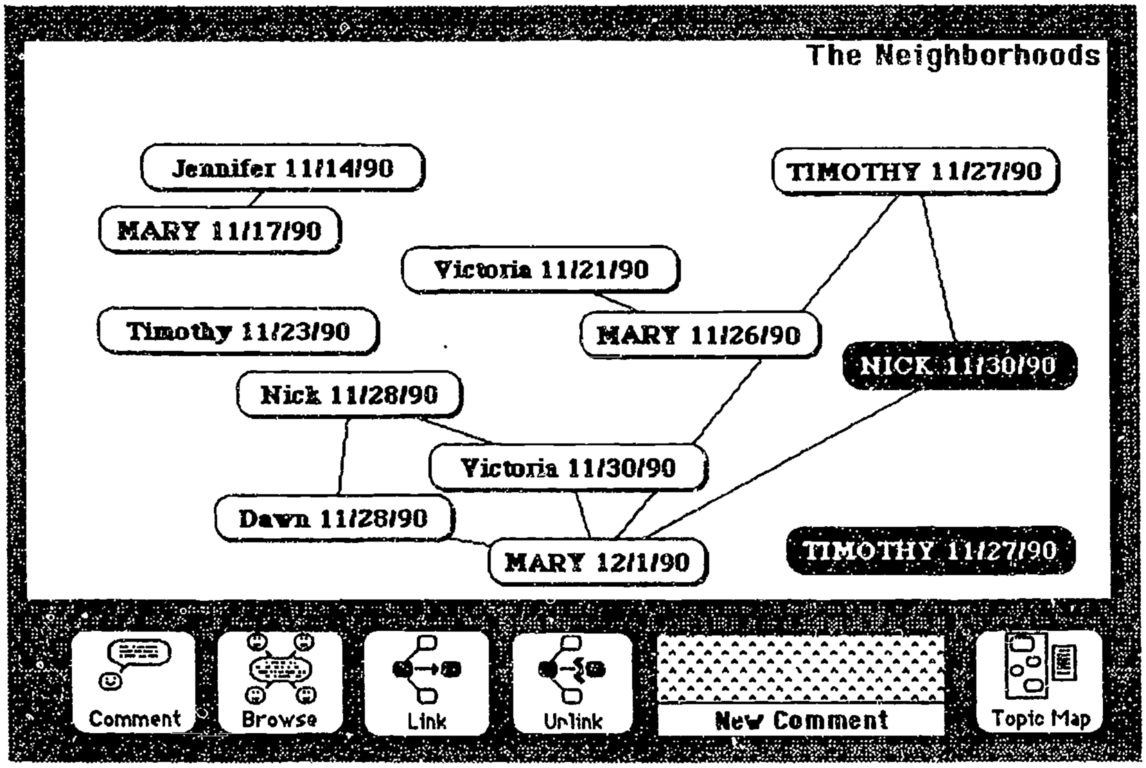

Figure 4: Selecting a source icon and target icon for linking

Once each node has been selected the user clicks the Link button which causes the system to draw a line that visually links the two nodes together. Simultaneously the software identifies the identification number of each icon and stores this information as a double-linked array which the system uses during browsing.

In order to read previous responses, a group member would select a source node by highlighting a particular Comment Icon. By clicking the Browse button located at the bottom of the Discussion Map, the IdeaWeb displays the selected source node first and then, with a simple click of the mouse button, any additional nodes in the order in which they were linked. The user is returned to the Discussion Map once the sequence of links has been exhausted. However, the software allows the user to interrupt a display sequence by issuing a key/mouse-click command string which immediately returns the user to the Discussion Map at any time during browsing.

Once the user has finished with a particular subtopic, the user would return to the Topic Map by clicking the Topic button. The user could now select a different subtopic or exit the program by clicking the Quit button.

Implementation

More often than not, the instructional tactics of the modern classroom follow the traditional patterns of lecture/recitation (Cazden, 1988; Mehan, 1979) which Dillon characterizes as "the familiar form, ...(among other aspects) of recurring sequences of teacher questions, plus student answers, where students 'recite' what they already know or are coming to know through the questioning" (Dillon, 1984, p. 50). Recitation is teacher directed and teacher controlled with few opportunities for students to initiate an interaction and even fewer chances to interact with peers.

Many researchers (Cazden, 1988; Johnson & Johnson, 1990; Sharan & Sharan, 1976) agree that there is a need to shift classroom interaction away from the current paradigm of recitation, where only the teacher controls the interaction. In contrast to the lecture/recitation, the classic small-group discussion seeks a "fuller understanding, a wider grasp of information pertinent to a topic, or consideration of a problem from as many points of view as possible" (Brilhart, 1986, p. 323). The classroom discussion group is a collection of individuals who are jointly seeking a deeper understanding of a work of art, an historical event, or a political policy from as many different perspectives as possible.

Nonetheless the standard interaction pattern has persisted in the modern school because it can be very efficient in dispensing large amounts of information in the least amount of time. Small-group discussion on the other hand, takes a great deal of time to execute -- much more than traditional recitation -- because it involves a many-to-many interaction sequence instead of the more direct one-to-many typical of today's classroom. Computer-mediated communication, however, as Phillips and Santoro (Phillips & Santoro, 1989) have demonstrated, can provide a convenient and effective system for both student-teacher and student-student interaction by removing the constraints of time and space. This has important implications for designing instruction.

The IdeaWeb was tested (for a complete report see Ahern, 1991) against the more familiar text-based conferencing system within a small-group discussion. Sixty-five students in a large undergraduate introductory educational theory and policy course at a large public university volunteered to participate in the study. Each condition was randomly assigned to a particular interface, so that each small group would be contain approximately 5 members. This resulted in the text-based condition having 6 discussion groups while the graphic based condition having 7 groups. The course instructor selected a topic of general discussion which was related to a particular unit the class as a whole was currently investigating.

Students in each of the groups had only two possible audiences to whom a message could be addressed: either to the group as a whole or to a specific individual. There was a statistically significant effect (X^2 (1, $\underline{N}$=441) = 5.30, $\underline{p}$ =.021) on the audience selection by type of interface. The audience of choice in the graphic-based interface was a more often peer in contrast to the text-based condition. One student offered the following assessment of the graphic interface.

> [The graphic-based interface] made it [the interaction] into a conversation, like we were reading a dialogue between people.

This observation is supported by the following student comment, which seems to indicate that the linking of messages within the IdeaWeb helped users to contextualize previous messages into an active interaction sequence prior to responding with a comment of their own .

> S: I liked it because you got to find out what other people thought and it stimulated something that I was thinking [about] and I could relate what I was thinking to what everyone else was thinking before I put [in] my comment. I would read one comment and it would [be] a long-winded paragraph. Then somebody else would say I really agree with that person. Then I could either disagree or agree. Finally it was like an on going debate.

Martson and Hecht (Martson & Hecht, 1988) suggest that group members will participate more often if they perceive their comments have value, which they define as attending to what someone else is saying in an interaction. In a computer-mediated system, the notion of value would be demonstrated by directing a response to another member's previous comment. For example, the following message was left by a student using the graphic-based interface.

> Eric
> 11/30/90 1:20 PM
> Total words = 22
> Yes, pluralism is needed!!!!
> By the way, my last comment is lonely over there, it hasn't been linked to anyone!!

Students in the graphic interface on average produced more messages (μ=5.088) than students in the textual interface (μ= 3.677), as seen in Table 2 which was statistically significant (F, (1,63) = 4.564, p = .02935). The graphical charting of remarks in the IdeaWeb provided users with immediate visual feedback concerning any particular response to an individual comment and seems to have encouraged members to interact more frequently in contrast to the more traditional text-based interface.

Future Design Improvements

The IdeaWeb software as tested initially by having the participants check out a single diskette, which could be used at any campus location. According to the study, this style of implementation did not cause any access problems for the students. However, the next step in development would be to test its effect in a distributed local area network, such as AppleTalk.

Further, an instructor/gatekeeper controls the creation of subtopics in the current implementation of the IdeaWeb. One refinement would be to allow for the dynamic creation of topics and subtopics by users in an interactive fashion.

Summary

The question that this software design investigated was whether the usual interaction structure in CMC systems could be improved by employing a graphic-based design of the user interface. The development and implementation of the IdeaWeb demonstrates that it is possible to design a system that encourages exchanges customary to small-group discussions without hampering the group's interaction. Such a system has important implications for instruction.

Through a simple, standalone microcomputer system, instructors can provide opportunities for learners to interact not only with the teacher but with their peers much more frequently. Students will have the opportunity to challenge their understanding of course material to a greater depth or to explore issues tangential to the main instructional objective. Further a CMC system provides participants with the immediacy of a real-time interaction unrestricted by time and space, which is not possible using the more traditional classroom media of paper and pencil. Teachers and students have access to more people over a larger distance in a shorter amount of time. Finally, CMC technology provides a powerful but flexible tool for organizing and retrieving information that provides students with the ability to explore not only who said what and when, but also the context in which the interaction was embedded.

Computer mediated communication has the potential to revolutionize instruction for many students. However, achieving more effective student engagement in CMC is essentially a problem of design, either redesign the user interface or provide clear external guidelines for student discourse in order to encourage more group interaction.

Therefore it is essential that researchers not only investigate the effects of CMC in a variety of instructional settings but also the impact that CMC systems have on the dynamics of group interaction. For example, what is the effect of a graphic-based interface on the patterns of interaction in which the course instructor takes more active leadership role such as gatekeeper/moderator see (Ahern, et al., 1992). Further what is the effect of the interface design if the group's goal is more directed, such as in a problem-solving group. Therefore, investigating the effects of CMC on group dynamics can provide important information to instructional designers, software engineers and educators in order to develop appropriate strategies for the implementation of CMC systems in a myriad of learning environments.

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NETWORKS AND MULTIMEDIA SYSTEMS

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ABSTRACT

The first part of the paper deals with the nature of multimedia systems and how networks can be used to link individual multimedia workstations. The major problem is full motion video which is described in the second part of the paper. Alternative solutions are discussed with emphasis on compression/decompression algorithms. Finally, the digital video interactive (DVI) and Quick Time software solutions are examined.

INTRODUCTION

During the past several years, educators and trainers have found that the use of multimedia has a tremendous impact on the learner when used in an interactive environment. The notion of multimedia is not a new one; motion pictures have been used by teachers for years. Requiring learners to use multiple senses has always been appropriate.

Historically, however, the learning environment has been a passive one; that is, the learner would watch and listen as instructional materials were presented. The exception to this environment was, of course, the laboratory where the learner could experiment and be more actively involved in the learning experience. The use of the laboratory environment was basically confined to studies in the sciences and so many learners had little or no exposure to it. The lecture method of presenting instruction was the major technique used and for some learners, this was acceptable. But for many learners, the lecture was less than satisfactory.

Successful teachers and trainers were those who actively involved their learners in the learning experience. Learner motivation was higher and the learners usually achieved at a higher level than under the lecture method.

During the 1980's, the development of the microcomputer made computer-assisted instruction (CAI), among other names, a feasible method for delivering instruction to learners. There was some interaction between the learner and the computer but the general quality of the instructional materials was limited because of the technical limitations of the computer.

Instructional materials delivered by the computer were textual and/or animated in nature. Audio and video were not viable options.

The primary reason that audio and video were not available was because they were both analog media and could not be displayed on the same screen at the same time with computer-generated material. This problem was partially solved with the development of the Level III videodisk system and the accompanying graphics overlay adapter card which permitted video from the videodisk and graphics from the computer to be displayed on the screen simultaneously. This was accomplished usually by a hardware/software combination that converted the computer graphics into analog data. Audio, however, was still not feasible in digital format in its natural form such as the human voice.

A second limitation to having audio and video on the computer was the lack of available immediate memory. A single picture or a few seconds of human voice required a great deal of memory in the digital form. This limitation has been partially overcome by the development of relatively inexpensive immediate memory (RAM) in the area of four to eight megabytes and the hard disk in the area of twenty to several hundred megabytes. Still frame video and audio were now feasible and could be used in CAI applications.

There remained (and still remains) the problem of full motion video. As was pointed out previously, digitized video requires a great deal of memory, for each frame (screen). Motion video, to be acceptable, requires that frames be played back at a rate of thirty frames per second and is marginally acceptable at twenty frames per second. Today's technology simply does not permit that kind of transfer rate from hard disk (RAM is too small) to a full screen. Somehow, the amount of storage needed for video must be reduced.

Since several learners may wish to use the same instructional materials simultaneously, it is natural to think of using a local area network (LAN) to link several workstations to a file server. There is an additional reason to think about the use of networks. If instructional material is available on a videodisk or a CD-ROM, then each workstation must have its own videodisk player and CD-ROM drive, thus increasing the cost of equipment. By networking the workstations, the contents of the videodisk and/or the CD-ROM become a shared resource. However, the shared resource solution creates new problems. Solving these problems is the focus of this paper.

The first part of the paper will describe how networks can be used in the development of a multiple workstation instructional delivery systems. Advantages and limitations of networks in this environment will be presented. It will also describe how voice and video data are passed by a network.

In the second pard of the paper, the problem of transferring full motion video across a network will be discussed. Alterative solutions to the problem will be presented.

The third part of the paper will give an overview of two promising solutions to the full motion video problem. The digital video interactive (DVI) technology and its use of video compression will be discussed. The Quick Time software will also be discussed.

NETWORKING AND MULTIMEDIA

Multimedia systems in education and training are designed to be used by either a single learner or multiple users simultaneously. The single user model is good when there are either a small number of users or the cost of a single workstation plus any peripherals makes having multiple workstations impractical. On the other hand, if there are numerous users then the availability of multiple workstations is desirable for maximum benefit to the greatest number of users at one time. Ideally, there would be one workstations for each learner at all times but this situation is seldom possible when costs are a prime consideration, as is usually the case.

So where possible, multiple workstations are desirable. In order to be able to share the instructional materials among several learners, the use of a network and a control file server is desirable. Learners would download portions of the instructional materials to their workstations and work on the assigned tasks. A group of learners could work at the same workstation or at different workstations in a small, proxsimitous area. Since the instructional materials would be self-contained on the file server, no additional peripherals would be needed at each workstation.

A primary advantage of this type of networked system is its cost. Good, reliable LANS are relatively inexpensive, especially when the cost of duplicating peripherals is considered.

Networking does require that all aspects of the instructional materials be in digital form. Audio and video in the digital form takes up far more memory than when in analog form. This means that the file server must be large enough to store the set of instructional materials. Each workstation must have enough memory to store whatever chunk of material is down loaded by the user. The problem of full motion video is still there and may be more acute than before because there is a greater distance between the file server and the hard disk in the workstation than between the hard disk and the RAM in the workstation.

Putting the audio and video data into digital form is a fairly easy procedure with the right hardware and software tools. Still pictures can be scanned into the computer and audio recorded with an audio editor and recording device onto a hard disk.

Networking does create some problems for the developer of the instructional materials. The set of instructional materials must be developed in pieces that will fit into memory on the workstation. Extensive use of video and audio must be carefully considered because of memory size. If a peripheral such as a Level III videodisk player were attached directly to the workstation, for example, it would require no computer memory whatsoever. Hence, an instructional designer must think differently when a networked system is involved as opposed to a single user system.

THE FULL MOTION VIDEO PROBLEM

With an understanding of how networks can be used with multimedia systems, it is appropriate to examine, in greater detail, the problem of full motion video mentioned previously in the paper. Full motion video is taken for granted by learners. They have been exposed to television, movies, and video tape for mush of their life. Thus, they expect to see it in their learning experiences. Full motion video keeps their attention most of the time.

The amount of memory required to store a full screen digital video image is extremely large. For example, a modestly detailed color image with resolution of 512 by 480 pixels with a 16 bit color designation for each pixel requires over 491,000 bytes of storage. Even at today's transfer rates, it still would take sometime to move this image from one place to another.

Now, suppose that this image was one in a motion sequence of video images. A person viewing the playback of the motion sequence will not see flicker at a playback rate of 30 frames per second. In some cases, a playback rate of 20 frames per second will produce the flicker. In either case, the transfer rate technology today cannot support this heavy demand and so some alternatives must be used.

One technique that could be used is to store only the part of each image that differs from the previous image. This technique is commonly used in computer graphics animation. Since the animation is generated by a program, it is relatively easy to create the succeeding image by producing only the part of the image that changed. However, a video image that is scanned or recorded either off-line or in real time is not produced by a program. Consequently, the image must be changed by software and the process can become tedious and time consuming.

A second alternative is to reduce the amount of screen area used to display the motion sequence. This reduces the number of bytes to be transferred. At least one vendor is currently using this alternative utilizing one quarter of the display screen.

Perhaps the most promising alternative is to use compression algorithms to reduce the amount of storage required to store an image. This process can be tricky because too much compression may destroy desired picture detail. When the image is to be displayed, it must then be decompressed. As long as the image is a single frame and not part of a motion sequence, the algorithm can be implemented without worrying too much about speed. However, speed is a main consideration when compressing and decompressing a motion sequence of images. Algorithms that have compression ratios of at least 200 to 1 are considered to be minimum.

Two adjacent pixels that have the same color need store the color information only once. It is not difficult to realize the simple (less detail) video images are more easily compressed than complex video images.

The human vision system also plays a role in compression algorithm development. For example, there are a number of colors that are nearly indistinguishable to the human eye; color data for pixels that use these colors can be eliminated, thus aiding the compression problem and improving the compression ratio.

As yet, there have been no standards developed for video compression technology. Progress is being made to this end by the Instructional Organization for Standards (ISO). A subgroup, the Joint Photographic Experts Group (JPEG) is responsible for developing a standard for still image compression while another subgroup, the Moving Picture Coding Experts Group (MPEG) is responsible for developing the standard for motion image compression. The JPEG standard has had initial approval but the MPEG standard is far from completion because of the complexity of motion image compression. The DVI technology is as well developed as any other set of compression algorithms but it is proprietary and hence, details of their structure are not available.

There is still a great deal of work to be done on the full motion video problem. In the next section, two solutions, both using compression algorithms will be discussed. While these solutions are a first step, the advent of digital television with screen resolution of 1024 by 1024 will continue to make the motion sequence problem a sticky one for many years to come.

DVI AND QUICK TIME

The most promising solutions to the full screen, full motion video problem appears to be the digital video interactive (DVI) technology under development by Intel and IBM and the Quick Time software by Apple. A brief overview of each solution will be given in this section.

Development of DVI began in 1987 with the first demonstration of the technology developed at the Sarnoff Research Center. Its demonstration, using special boards in an IBM PC and a CD-ROM disk, showed that 72 minutes of full motion video could be stored on the 12 cm disk. The increased capability for storage of full motion video was made possible through the use of video compression and decompression techniques.

In 1989, the DVI technology was sold to Intel, who is well known for its development of the 80 series (8088, 80286, 80386, etc.) CPU chips. Intel is vigorously working to make the DVI technology commercially feasible and is making good progress to that end. Initially, the DVI technology was being developed for the IBM PS/2 and PC XT/AT compatibles but will likely be extended to other vendors' products.

The DVI technology has four unique components:

- a custom VLSI chip set
- a specification for a custom software interface
- video/audio data file formats
- compression and decompression algorithms

Hence, it is clearly a combination of hardware and software components.

The VLSI chip set the heart of DVI technology. It consists of two VLSI chips and acts as a compressor. The speed of this chip set is what permits DVI to be able to accomplish its mission.

The functions of DVI are performed in application programs written in the C language. In some cases, assembly language is used. For users who are not C programmers, authoring systems are available. Specifications are given to the authoring system which generates the necessary DVI code.

The development of digitized audio and video has had and will continue to have a significant impact on LANs. It means that full multimedia capabilities can be shared by multiple workstations on a LAN and with TCP/IP, with multiple LANs.

There are a number of applications where the DVI and LAN technologies can work together. One is video conferencing. In this case, a meeting can be held with group members at remote sites. Participants can view and hear each other in real time and materials can be shared with other participants in real time. Time wasted in moving from an office to a control meeting site is eliminated.

A second set of applications for DVI and LANs is the area of education and training. Currently, to achieve full multimedia capability, a workstation for each individual must be equipped with additional peripherals such as a CD-ROM drive. Such workstations have become known as

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A second set of applications for DVI and LANs is the area of education and training. Currently, to achieve full multimedia capability, a workstation for each individual must be equipped with additional peripherals such as a CD-ROM drive. Such workstations have become known as multimedia personal computers (MPC). With DVI, one MPC can be designated as a server to a LAN with other workstations that do not have the peripherals. These remote workstations can share the content of one or more CD-ROM using the LAN, thus reducing the cost of each workstation.

Unlike the DVI technology which uses both hardware and software, Quick Time, developed by Apple, uses software exclusively to do its compression/decompression work. Both audio and video can be compressed and put directly into an applications program (stack) developed by the use of Hypercard, Super Card, or Authorware among others.

Full motion video can be put into the application either off-line (such as a movie or videotape) or in real time using a video camera. The video and accompanying audio can then be edited, if necessary, to fit the needs of the application. Currently, Quick Time will permit only a one eighth screen size window on the display but this capability is scheduled to expand to one quarter screen in October of 1992. No prediction is yet made by Apple relative to full screen, full motion video.

Introduced in January 1992, Quick Time has the advantage that it needs no additional hardware, except memory like DVI, it will operate with a local area network.

SUMMARY

Multimedia systems will play an integral role in education and training, both in the present and in the future. The major abstract to a complete multimedia system that is completely digital is full motion video on a full screen display. Solutions to this problem have been developed by the use of video compression/decompression algorithms that have produced less than full screen, full motion video. It is anticipated that with JPEG and MPEG standards, that full screen, full motion video is close at hand.

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Computer Mediated Communication: How Does It Change the Social-Psychological Aspects of Teaching and Instruction?

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Abstract

This paper examines educational applications of computer-based communications to identify unique tools for learning provided by this medium and to identify key features of successful computer mediated communications (CMC) projects. A review of CMC programs provides guidelines for designing effective teacher training programs in CMC. Since institutions of higher learning are significant sponsors of technology training programs for teachers, an additional section addresses the role of higher education in supporting improvements in teacher training programs.

Introduction

In 1984 Kiesler, Siegel, and McGuire observed that "... no one can predict in any detail the nature of the transformations that computers will bring, but one aspect of life that will certainly be affected is communication" (p. 1123). Today thousands of school children, adult professionals and hobbyists use computers to send millions of electronic messages, files, and data to colleagues on a daily basis. In fact, computer-based network communication is increasing at the astonishing rate of twenty-five percent per month--an increase which would put every single human being online within a few decades (Barlow, 1992, p. 25). Nonetheless relatively little is known about the social and psychological impact of computer-mediated communications on those who communicate.

The technical aspects of computer-mediated communication (CMC) have made this medium an attractive choice for widely varying purposes including instructional programs and courses (Kaye, 1989). CMC can provide interactive capabilities which are not bound by time and geographic distance, and, compared to the telephone and mail service, electronic communications offer increased flexibility and speed at a significantly reduced cost. Proponents of computer communications claim that the greatest merits of well structured network projects in education are that they help students learn specific content knowledge as well as certain academic skills--especially language skills (Riel, 1991-1992, p. 5). However, such relatively uncritical praise may not recognize the actual impact of CMC - both positive and negative.

In this article we review CMC from the perspective of Richard Clark's premise (1983) that media in and of themselves do not affect learning. Instead we assume that particular unique qualities of any medium including CMC interact with learners' aptitudes and preferences. Our goal is to identify the intrinsic characteristics of CMC and analyze how these media traits tend to interact with the learner, situation of learning, and mode of instruction. This may provide a framework to determine educational contexts and objectives for which computer-based interaction may be particularly well suited.

Background

Clark and Sugrue (1991) suggest four key dependent variables as being most frequently studied by media researchers: (1)performance outcomes; (2)cognitive processing (type of learning being measured); (3)efficiency/costs; and (4) equity of access to instruction. While acknowledging that their list of independent variables may be expanded by others, Clark and Sugrue's three main variables are: (1)media characteristics (including type of medium, specific attributes of medium, symbol systems within medium); (2)student characteristics such as general ability, attributions, preferences and prior knowledge; and (3)instructional method such as on-the-job training, lecture, individualized/group instruction, and programmed instruction (Goldstein, 1985).

We believe that CMC research requires some additional conditions for analysis because of the relation between communication context and meaning, an issue not accounted for in Clark and Sugrue's variables. While the technical capabilities of CMC are well documented the social psychological aspects of computer-based communication are not yet clearly understood (Feenberg, 1987; Kiesler et al., 1984; McGuire, Kiesler, & Siegel, 1987; Siegel, Dubrovsky, Kiesler, & McGuire, 1986). Much of the enthusiasm stimulating instructional use of CMC is based on "a shift away from stand-alone computer and individual software packages to technology that is more focused on connecting students and teachers to each other and to the world outside the school walls" (November, 1992, p. 50). In a commentary discussing computer-to-computer conversations, Janet Perrolle (1991) suggests that CMC should be viewed as a social rather than a psychological or cognitive phenomenon and, as such, use of CMC should be carefully planned to establish "nondistorted communication" (p. 23). Therefore, we have added to the Clark and Sugrue framework for media research two variables which address the complexity of the social situation in which the learning occurs. The social context of learning and instruction will be considered an independent variable and the nature of social interaction (descriptive information regarding the kinds, distribution, frequency, and content analysis of social interactions) will be considered a dependent measure used for analysis (See Table 1).

As an initiating statement, we have found that the literature on CMC ranges from enthusiastic testimonials to quasi-experimental studies to a few controlled experiments. The testimonials by classroom teachers and education researchers are helpful in motivating others to consider potential uses for this new instructional medium. However, it is possible that CMC enthusiasts who have not considered each of the media research variables listed in Table 1 may unknowingly be basing their claims of success with CMC on uncontrolled and novelty effects. Quasi-experimental comparisons of CMC with existing instruction also base some of their successful outcomes on uncontrolled factors such as instructional method and student/teacher attitudes. Nonetheless these "real-world," situationally-based application studies (e.g., Beals, 1991; Feenberg, 1987; Kaye, 1989; Quinn, Mehan, Levin, and Black, 1983; Romiszowski, 1990) provide valuable information about CMC technology, its uses, and its potential strengths and weaknesses.

Scientific experiments (e.g., Kiesler et al., 1984; Siegel et al., 1986; McGuire et al., 1987) provide a more solid foundation of knowledge upon which educators can begin to construct an understanding of how CMC can be effectively used as a medium for instruction. However, it is clear that educational application of computer mediated interaction is not easily reduced to scientifically controlled conditions. The primary challenge with social context variables such as those associated with computer-based interactions, is to establish control in order to make comparison with similarly organized face-to-face situations. Because electronic dialogue, at this time, is primarily text-based interchange, it is an ideal medium for conducting social interaction research of this type as the context and structure can be controlled by the discussion moderator and all interactions are archived in electronic text form.

Table 1

Dependent/Independent Variables Associated with Media Research

Dependent Variables	Independent Variables
1) Performance outcomes	1) Media characteristics - type of medium, specific attributes of medium, and symbol systems within medium
2) Cognitive processing - type of learning being measured	2) Student characteristics - including general ability, attributions, preferences, and prior knowledge
3) Efficiency/costs	3) Instructional method such as on-the-job training, lecture, individualized or group instruction, programmed instruction
4) Equity of access to instruction	4) Social context of learning and instruction
5) Nature of social interaction - kind, distribution, frequency, and content analyses.	

Independent Variables

Unique characteristics of this medium. The term computer-mediated communication refers to electronic mail and messages, electronic bulletin board systems, computer conferencing systems, and other forms of computer-based network communications. Here we address only text-based CMC, but state-of-the-art CMC technology can include interactive audio, video, and graphics communications Because CMC is an emerging technology, research regarding the influence of the characteristics of this medium and their impact will change as new features and capabilities are incorporated into standard CMC technology.

CMC offers previously unimaginable communications access and capabilities. Computer communications technology enables student and teachers to exchange, store, edit, broadcast, copy, and send written documents instantly, conveniently, and relatively cheaply over short or long distances (Kiesler et al., 1984). Interactions via computer exchanges may be immediate or delayed regardless of the geographic distance between participants. For example, with the use of network technology two or more individuals can view the same document and make simultaneous revisions without meeting face-to-face or using a telephone. Anthony Kaye suggests that CMC "...is essentially a medium of written discourse, which shares some of the spontaneity and flexibility of spoken conversation..." (1990, p. 10). Others (Davie & Wells, 1991; Harasim, 1990) point out that CMC is capable of the speed and interactivity of telephone and face-to-face communication, but lacks the aural and visual cues associated with telephone and person-to-person exchange.

From a physical perspective, computer-to-computer exchanges are based on activities which are very familiar such as keyboarding and printing messages, using standard syntax. We have been "speaking" to others via text messages in traditional print media using such technologies for centuries. It appears that computer-mediation changes the nature of these communications in two ways.

First, the asynchronous nature of computer interactions appears to cause the pattern of discussion in CMC to differ from face-to-face exchanges. CMC responses can be immediate or delayed and may be to one or to many individuals who may be geographically close or on the opposite side of the globe. Face-to-face exchanges tend to be linear so that remarks and replies build from one another. For example, in a class situation matters of procedure tend to be clustered at the beginning and end of classroom lessons (Quinn et al., 1983). In contrast, online discussions are characterized as having "multiple threads" to the discussion and a non-linear pattern. Procedural questions often continue throughout the entire exchange, running parallel to on-going discussion of several other topics (Kaye, 1989; Kiesler et al., 1984; Quinn et al., 1983). This aspect of CMC can be influenced to some extent by the moderator of the discussion who serves a purpose similar to a moderator of face-to-face meetings by keeping the group focussed and on task (Feenberg, 1987). However, CMC clearly makes possible communication patterns not found in face-to-face interactions.

A second unique aspect of CMC is that users of this technology can create their own syntax and lexical symbol system to convey and clarify affective expression; CMC users also can control the timing of communications interactions. Because CMC is primarily limited to text-based interaction and involves a limited social context, users generate electronic analogs of common communication features such as body language and voice inflection. Beals' analysis of first-year teachers' interactions on Harvard's Beginning Teachers Network reports that participants embellished their informal exchanges with "textual displays of what would have been non-verbal cues in face-to-face conversation" (1991, p. 76). Other CMC researchers (Kiesler et al., 1984) also report use of exaggerated punctuation and lexical symbols in electronic mail and computer conference exchanges to convey tone and gesture cues to the reader. It appears that these contextual aspects of communication are sufficiently important to establishing meaning that creative adaptations have generated symbols to reduce the contextual sterility of CMC. As for timing, CMC users can respond on a personal time schedule. As a result, it appears that CMC communications can be subjected to different types of consideration from the sender and can evoke different types of responses than face-to-face.

Student characteristics. Margaret Riel (1991-1992) points out that failures to create effective electronic projects by and large go unreported. It may be that most of the reports on network projects are biased by the self-selection of their creators and participants. The classroom study conducted by Quinn et al. (1983) found that anxiety about using a computer was a significant factor to consider when introducing a new computer-based medium to adults. It appears that those who have some fear or negative feelings towards using computers self-select themselves out of CMC projects whenever possible. The same report by Quinn, et al. (1983) found that computer anxiety was not factor when introducing computer technology to elementary-age children, and computer anxiety may be much less common today than it was ten years ago.

In her report on participants' reactions to the delay in response time to online interactions, Beals (1991) found that some participants felt that the time lag allowed more time to think and to feel safer before responding. Other participants reported that the delay in receiving responses made them feel "less engaged" in the discussion. Investigations of the level of involvement and attentiveness of participants in face-to-face versus electronic message systems verses computer conference system among familiar and anonymous exchanges indicate that individuals are less psychologically aroused when viewing anonymous postings (Kiesler et al., 1984).

Unanswered questions remain regarding how CMC exchanges are influenced by the tendency of the medium to redirect the users attention from their audience and under what circumstances and for what individuals CMC may tend to stimulate feelings of dehumanization and detachment. The documented increase in uninhibited verbal behavior such as "flaming" in computer-based conferences also reflects a decreased awareness of audience in electronic interactions. The above conditions were found in text-only communication. More sophisticated technologies may provide more social cues by creating conditions more similar to face-to-face exchanges. Nonetheless, it appears that CMC does influence the pace, duration, and content of communication as well as the affective quality of messages.

Instructional method. Clark and Sugrue (1991; Clark, 1983) suggest that conclusions from media research are frequently confounded by two factors: (1)uncontrolled effects caused by variations in instructional method or content differences and (2)novelty effects associated with newer media which tend to disappear over time. Particular attention must be given to these factors in any comparison of CMC with traditional instructional media because online learning is a currently popular medium and is receiving a lot of attention at this time.

Whether the instructional method used is situationally-based (such as on-the-job training), individualized or mass produced programmed instruction, CMC is a viable choice for instructional delivery. Pilot research by Britain's Free University indicates that use of CMC provides a means for enriching home-bound students' interaction with their tutor and fellow students. Instructional media selection relies on an accurate assessment of the need for visual, audio, sensory, hands-on practice, demonstration and discussion/interaction. Kaye (1989) suggests that the additional costs associated with establishing and managing CMC versus traditional distant learning media should be compared with the benefits of increased interaction with instructor and fellow students. Frequently educational applications of new technology stimulate creative instructional methods for delivering information. The new instructional methods such as greater student-to-student interaction is not medium-dependent, but may reflect capabilities of a given medium which make alternative teaching styles more apparent and more manageable (Feenberg, 1987).

Definition of social context. Just like the traditional classroom, a particular electronic community has its own social milieu. The goals and objectives which inaugurated a group also play a continuing role in affecting the social structure of the group as does each individual participant's attitudes towards the group.

In Tombaugh's (1984) study of a technical expert discussion group, the more highly regarded scientists enrolled in the conference group reported that they were too busy to participate in the on-going group interactions and were less motivated to respond to the continuing electronic dialogue. Other (less individually prominent) participants tended to direct their questions and comments to the more prestigious participants. The failure of this social interaction has many possible explanations; but, it is obvious that the prominent scientists did not share a common purpose with their lesser known colleagues. In addition, many of the scientists were reluctant to share unpublished research over the network. This mistrust among group members reported by Tombaugh is not a medium dependent problem; but, it does reflect the social problems resulting from issues not clearly discussed or resolved among members of any group.

Thus, it may be that context in CMC is the product of stated agreements or time-based informal negotiations just as in face-to-face communication. The absence of context cues, however, may increase the importance of context agreements for successful communication that includes considerable interaction and/or revelation of personal or proprietary information.

Other complexities associated with face-to-face group activities that also occur in CMC interactions are evidenced in different ways. Because computer-based interaction is capable of a variety of time and space configurations for interactions, the structure of CMC discussions is more complex than face-to-face exchange. Computer discussions typically exhibit multi-level topical themes being discussed simultaneously at varying rates of response by participants (Romiszowski & de Hass, 1989). This suggests that the social context in which CMC discourse occurs exhibits a unique structure and characteristics of interactions which may be physically impossible to replicate via other communication media.

Dependent variables

Performance outcomes(type of testing/assessment of learning). Several applications of CMC projects measure student performance outcome variables to determine whether students who have learned content material via CMC show similar performance outcomes as their peers who have been through face-to-face interaction. Quinn et al. (1983) found no significant differences in CMC versus student face-to-face scores on tests of course content, but the nature of student-to-student, teacher-to-student, and student-to-student interactions differed. Thus, in this case, different instructional media with different patterns and content of interactions yielded basically similar performance outcomes. In contrast, Kiesler et al. (1984) and Siegel (1986) used previously tested group decision-making tasks to compare CMC versus face-to-face interaction. These studies of CMC showed that the outcome of group decision-making was significantly influenced by the type of media available for group communication. The CMC groups tended to make less predictable decisions than the face-to-face groups.

The results of these studies appear to be inconsistent and suggest that further research is needed to determine more about how learning via CMC affects learning outcomes. However, it may be that differences in outcomes are dependent on the nature of the task; the research above suggests that higher order learning skills such as decision-making and problem solving are more affected by the social context associated with the instructional delivery method.

Cognitive processing (type of learning). Riel (1991-1992), Davie and Wells (1991), and Goldman and Newman (in Roberts,Blakeslee, Brown, & Lenk, 1990, p. 99) described the majority of CMC projects as having markedly different objectives from traditional curriculum programs. They point out that CMC projects typically require cross-curricular skills in problem solving tasks. Goldman and Newman suggest that CMC is most effective as a tool to enrich the classroom learning experience in the following five situations: (1)identified topics and group conferences; (2)non-competitive activities; (3)questions that require more reflection; (4)questions where answers are wanted from several students; and (5)private interactions. In addition, Goldman and Newman propose that electronic communication is not an appropriate tool for teaching new concepts that require intense, fast-paced interactions.

Efficiency/costs. Educational applications of CMC have been found to be fast, relatively inexpensive, and convenient (Beals, 1991). The true test of the cost efficiency of using CMC is addressed in Riel's (1991-1992) question for designers of network projects to answer: Is the time invested in network activities matched by significant return in student learning or teacher development? To some extent individual teachers and school systems will have to answer this question based on their student needs and budgetary restrictions. Attempts to answer this question will be highly speculative until a sufficient database is developed from which careful comparison can be made.

Equality of access to instruction. From a purely technical perspective, CMC is attractive to many because it can be an extremely rapid and efficient way of transmitting information. However, the greater convenience afforded by CMC comes only after all the technical skills needed to use CMC have been mastered. CMC research available at this time rarely considers the current technical requirements to establish an efficient network system described by one network expert as being "not for the technically timid" (W. Sanders, personal communications, September xx, 1991). Frustrations due to technical naivete and the lack of support personnel have resulted in some new users never achieving the necessary level of proficiency in their system or personal skills to surmount technical difficulties.

Some users of CMC are not counted in CMC research because they have been eliminated by self-selective withdrawal (Riel, 1991-1992). For others, the problem is more lack of convenient or any access to the necessary hardware to build a network workstation (Tombaugh, 1984). Thus we find both personal and technical issues that have an impact on access and the influence of both issues is not clear.

Description of social interactions. Several variables that appear consistently throughout the research on social aspects of CMC are: degree of equality of participation, degree of uninhibited verbal behavior, length of response, and pattern of communication among group members. Generally CMC interactions are more equally distributed among group members, but the structure of the group and active presence of a group moderator can affect patterns of communication between group members (Kiesler et al., 1984; Siegel, et al., 1986; Quinn et al., 1983; Tombaugh, 1984). It must also be remembered that CMC typically includes a very select group due to their skill and hardware access. Nonetheless, individuals exhibit more uninhibited verbal behavior in CMC exchanges than in face-to-face interaction (Kiesler et al., 1984; Siegel et al., 1986). And, responses via electronic communication tend to be longer than in face-to-face communication. Quinn et al. (1983) found that the normal pattern of classroom question and response was different in CMC exchanges, in that more student-to-student interaction occurred, as well as less frequent overt evaluation of student comments by the instructor.

In their study of group processes and CMC Siegel, Dubrovsky, Kiesler, and McGuire (1986) reported greater equality of participation and greater shift in choice in the computer-based discussion than in face-to-face interaction. These researchers also found that CMC group decisions deviated more from initial individual preferences than the face-to-face group. This finding lead these investigators to speculate that some people will respond differently in different communication settings. The lack of nonverbal or auditory cues available in current electronic communications systems seem to result in participants feeling more detached from the communications.

Tombaugh's study of an international scientific computer-based conference did not exhibit the equality of participation evidenced in nearly every other CMC study. Participants felt that the lack of structure and need for a group moderator would have corrected this situation. Tombaugh also reported that the CMC conference tended to have many more readers than contributors. This is true of many electronic communications; that is many more messages are sent than are received (Huff, Sproull, and Kiesler, 1989). It does appear that there is sufficient evidence from research and theory to suspect that CMC will indeed influence the nature of social interactions. The degree, direction, and importance of these changes could be a significant factor to consider in assessing uses of CMC.

Future Research Agenda

It is important to note that the current literature on CMC is far from rich. The vast majority of writing is descriptive and testimonial in nature. This is augmented by a group of evaluation studies that primarily report instructor observations and participant reports regarding CMC projects. A very small portion of this literature approaches the standards required for conceptually careful and controlled investigations of CMC variables. Consequently, conclusions about CMC must be weighed carefully in regard to claims advanced and research support.

The current CMC literature points toward the need to investigate additional factors under the broad heading of on-going media research with online learning and electronic communities. A recent electronic report by Cole, Beam, Karn, & Hoad-Reddick (1992) provides a brief summary of current CMC research including: Using a concept mapping tool to assess problem solving strategies among small network groups (Heeren, E.); Identifying relationships between communication media and personality type (Carroll, R., & R. Schipke); Use of CMC to facilitate seminar participation and active thinking (Shedletsky, L.); Exploration of ways to conduct online "focus group" interviews (Robertson, J.); Use of online communication as an enrichment resource for adolescents with disabilities (Lang, S.); and Assessing the effectiveness of CMC to provide scientific role models to under represented groups (Murfin,B.). Each includes the interactive, social aspects of CMC as dependent measures being analyzed in the investigations. Consequently, we should soon begin to amass more data to evaluate critically the most appropriate uses and clientele for CMC.

One of the most exciting outcomes of CMC research is finding that this new medium has provided new insight into the complexity and power of live face-to-face interaction. In addition, research has demonstrated the potential for valuable local and geographically distant interaction via CMC. Obviously, as Christopher O'Malley (1991) prophesies, there will not be a single best instructional use of CMC or any other technology. Existing technologies are not made obsolete by new media, but all modes of instruction should be updated as needs, facilities, and student interests change and new knowledge emerges. However, it is important for research to expand and become more sophisticated. The limited number of studies, restricted as they are to select subjects and settings, provide a relatively modest database from which only the most tentative conclusions may be drawn.

We believe that CMC should be viewed as an opportunity for new development and understanding. As Herbert Simon (1987) so eloquently said, "We have to think about technology in terms of human knowledge...new technology is simply new knowledge; and as such, it resides not in machines but in the human brains that invent them, develop them, and use them." Thus, by putting CMC to use in various ways and carefully considering the characteristics of the medium, the aptitudes and preferences of the students involved, the appropriate instructional method, and the social context in which the instruction and learning are to occur, we shall expand our knowledge about learning and consequently about ourselves as well.

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