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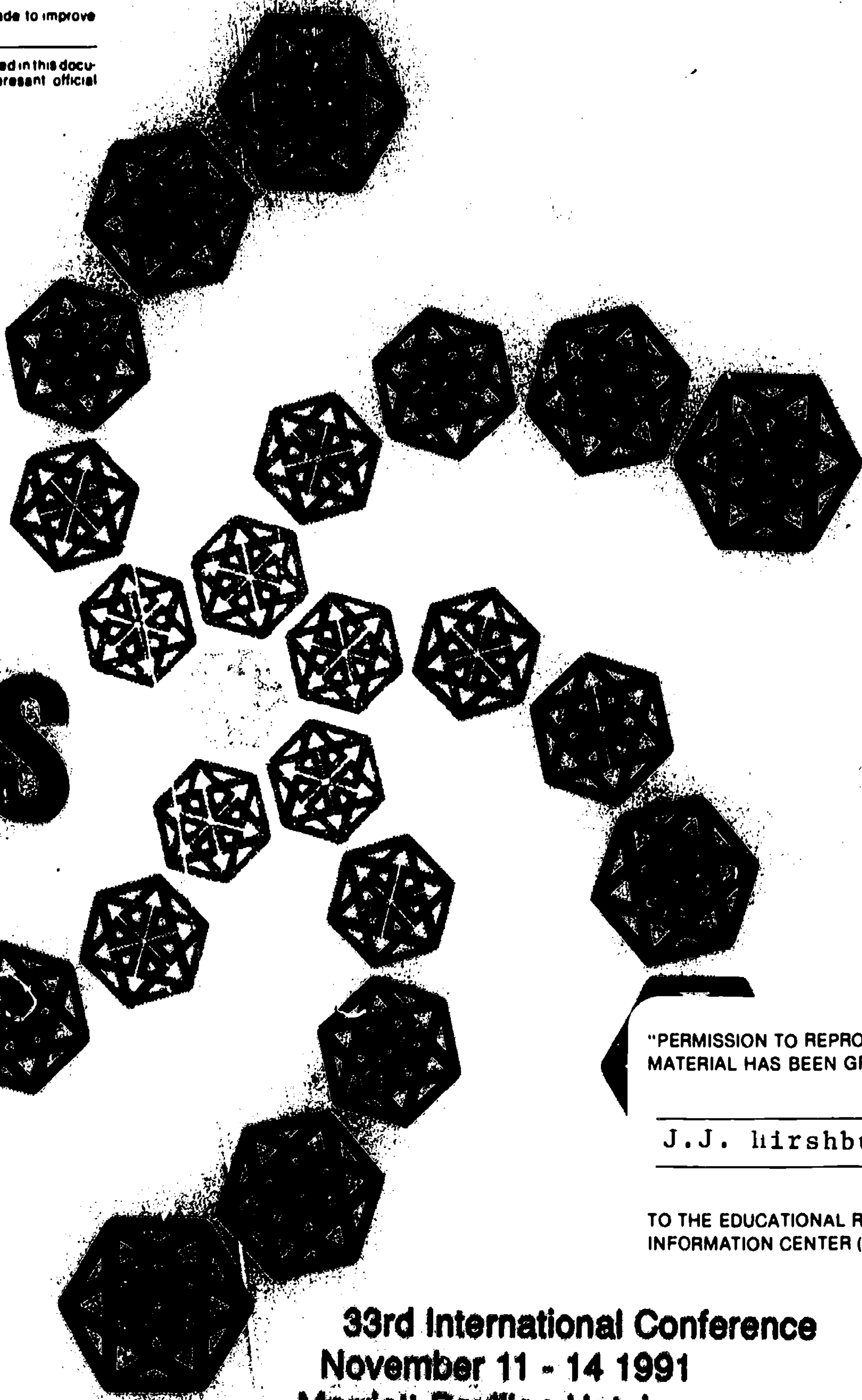
ABSTRACT

This collection of conference presentations contains 48 papers and 122 abstracts (for which there are no formal papers). The papers and abstracts are presented in two separate sections, but both are categorized by special interest groups: (1) Academic Computing (SIGAC, 1 paper, 9 abstracts); (2) Computer-Based Training (SIGCBT, 8 papers, 12 abstracts); (3) Elementary, Secondary, and Junior College (ELSECJC, 6 papers, 14 abstracts); (4) Emerging Technologies (ETSIG, 5 papers, 11 abstracts); (5) Education of the Handicapped (SIGHAN, 2 abstracts); (6) Health Education (HESIG, 3 papers, 12 abstracts); (7) Home Economics (HOMEC, 3 papers, 7 abstracts); (8) HyperMedia Education (HYPERSIG, 3 papers, 10 abstracts); (9) Interactive Video-Audio (SIGIVA, 6 papers, 11 abstracts); (10) Management Issues (MISIG, 4 abstracts); (11) Music Instruction (MUSIC, 3 abstracts); (12) PILOT (SIGPILOT, 2 papers, 1 abstract); (13) Plato Users' Group (PUG, 1 paper, 5 abstracts); (14) Theory and Research (SIGTAR, 8 papers, 18 abstracts); and (15) Telecommunications (TELESIG, 2 papers, 3 abstracts). Many of the formal papers include their own abstracts and/or references, and an author index covering both sections is provided. (DB)



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Selected Abstracts for the

# Special Interest Group for Academic Computing (SIGAC)

## INIGO, A NEW AUTHORING SYSTEM

*Gerdy C. ten Bruggencate, University of Twente*
*Eelco F. Laagland, University of Twente*

The increased acceptance of the Microsoft Windows graphical user interface calls for the development of computer assisted learning (CAL) material that will run in this environment. The Inigo authoring system is developed to facilitate the production of courseware that will run with Windows.

Inigo enables the courseware developer to create CAL material (courseware) that is student controlled. The courseware, as a Windows application, runs in a window that can be arranged on the screen and resized. Within the CAL window the student can handle several windows (including windows containing video images), choose menu options, press command buttons, etc., to create his own learning environment and control the learning process. When another Windows application, for example a spreadsheet or a calculator, runs at the same time, exchange of information between the courseware and the other application is possible. The exchange of information can be student driven by means of the clipboard, or program driven by means of Dynamic Data Exchange (DDE). Inigo contains a DDE protocol enabling other Windows applications to control Inigo and request information (course data) from the currently running course. Furthermore, the data exchange features offer the opportunity to develop in Inigo an educational environment for e.g. a simulation package.

To explore the possibilities of Inigo and in order to improve the system and to adapt it to the needs of courseware developers a first courseware development project has been started in January 1990. The courseware on fundamentals of digital design will be ready in September 1991.

## CONNECTING PEOPLE AND TECHNOLOGY THROUGH OPEN-ACCESS COMPUTING: FACILITY DESIGN FACTORS

*Jeanette S. Cates, Ph.D., Instructional Development*

As resources tighten, open-access computing facilities are often seen as a means to use resources more efficiently. Open-access refers to facilities that are available to all students and faculty, regardless of discipline. Within a single area, open-access users may work on assignments in history or nutrition, review their algebra skills, or prepare a paper for English.

Because of the variety of activities being conducted in a single area, open-access facilities should not be designed or operated in the same manner as traditional "computer labs". For example, desk space may need to be wider and lighting brighter when students are taking notes or working from a hand-written draft, as opposed to composing on the screen. Yet, most designers--be they architects or college administrators--are unaware of the differences in the design considerations that go into an open-access area. At the same time, the literature provides very little guidance, particularly in the level of detail required for actual facility design.

Over the past eight years, the author has designed and opened eight open-access computing facilities. Lessons learned from operating a facility after designing it have been incorporated into the next design. A variety of tools, as well as specifications for the electrical, space, furniture, and environmental concerns have been documented. This presentation will share the knowledge accumulated through this experience.

# CONNECTIONS TO RESOURCES FOR INSTRUCTIONAL COMPUTING IN HIGHER EDUCATION

*Carol A. Dwyer, Penn State University*

Many higher education institutions have a support unit which has as part of its mission to help faculty use interactive computer technologies for teaching and learning. These units often are small but, nevertheless, have more requests for assistance than they can handle.

CBEL—Teaching and Learning Technologies Group at Penn State has been providing support services to faculty for several years. During that time we have become aware of a number of resources which assist in our work in empowering faculty to integrate computer technologies and educational applications into their curriculum.

The database discussed in this presentation is a means by which we can share some of the information we have gathered. The database includes:

1. sources of high-quality and award-winning software,
2. organizations which focus on uses of technology in education,
3. publications focusing on instructional applications in higher education,
4. conferences on the use of technology in education and training,
5. videotapes showcasing software and interactive video applications, and
6. books on instructional design

Database fields include a brief description of the resource, address of the company or organization which will provide further information, phone, electronic address, if available, and cost, if available.

Participants may have a printout of the database during the session. A disk containing the database in Macintosh format may be requested.

# AN OPEN-STRUCTURED INTERACTIVE TEST AND EXERCISE MANAGEMENT SYSTEM

*Pieter Jansen, Delft University of Technology*
*Eugâne v.d. Kamp, Delft University of Technology*
*Roy Natadarma, Delft University of Technology*

One of the educational measures to motivate students or to assess their achievement is to have students solve questions and give feedback on the results. Itembanking may be considered to support structured access to items concerning a particular subject, a specific educational objective or a specific question type.

In this presentation a description is given of an open structured Interactive Test and Exercise Management System, ITEMS-D (-Delft). The tool has been developed to support three types of educational activities:

1. Fully interactive tests, exercises or examinations;
2. Paper and pencil exercises and interactive sessions to enter the answers;
3. Paper and pencil examinations with optical mark forms.

Aspects of ITEMS-D to be described:

- Functions to support user-defined item development and item runtime environments.
- Commercially available wordprocessors or authoring tools may be integrated into the system to develop paper and pencil questions or interactive questions;
- Functions to support the use of variable parameters in questions;
- (replaceable) formula-evaluator;
- The use of profiles to describe student applications based on the itembank;
- Composing the (menu-)interface to direct students to the appropriate application and to run the different item environments using a LAN-network;
- Functions to assess and manage student results and to perform test analysis and item analysis.

Results of pilot projects at the Delft University of Technology will be presented.

# THE GOLDEN ARCHES OF ACADEMIC COMPUTING

*Dr. Kenneth L. Modesitt, Western Kentucky University*

"Press On: Nothing in the world can take the place of
PERSISTENCE.
0 Talent will not -- Nothing is more common than unsuccessful men [sic] with talent.
0 Genius will not -- Unrewarded genius is almost a proverb.
0 Education alone will not -- The world is full of educated derelicts.
Persistence and determination alone are omnipotent."
From a McDonald's Ad, 1989

In a paper presented by the author at ADCIS in 1989 (Modesitt, 1989), he spoke of the many lessons learned about computer based learning, based n spending three decades in the field. In this presentation, an update is given, showing that "persistence" does pay off. This determination has resulted in the campus of a comprehensive university of 15,'000 students having, for the first time, all of the resources necessary to make widespread use of computing in instruction more than just a fantasy.

The recommendations given in the 1989 paper were:
fashion, use software engineering and expert system principles, contribute to new areas, also involving students, and provide organizational-wide resources.

The planning done at that time included several components: hardware, communication, computer-based learning, organizations, and people. This presentation will discuss each of these in turn, indicating past (circa 1987), present (1991), and desired future (circa 19[illegible]) for each. The recommendations for the next period of growth will spread out the esources across the Commonwealth of Kentucky to K-12 schools, government, usiness, and industry.

1. Modesitt, K. "Lessons Learned in Computer-based Learning: A Personal Tale of Three Decades," Association for the Development of Computer-based Instructional Systems (ADCIS) Conference, Washington, D.C., 1989, pp. 174-180.

# A DEPARTMENT GETS A LAN, OR "YOU'RE NOT GOING TO DO THAT TO MY COMPUTER!"

*Donald Scherer, Bowling Green State University*

This paper reports the financial, political and educational complexities of installing an AppleTalk network in an academic department.

The financial problem arises primarily from the conflict between the University's policy of servicing only IBM and Apple machines and the less expensive IBM clones the department can buy.

Political problems attend the contrast between administrative and faculty LAN usefulness, the traditional prerogatives of secretaries, the diversity of faculty uses for a LAN and the security problems of integrating graduate students into the LAN. Problems surrounding the integrating of graduate students arise from both the transience of graduate students and their dual roles as students and instructors.

The department has also needed to educate itself about which of its many computer uses will be networked. In addition to word processing peripherals on the server, communicating registration information and requisitions through the University's mainframe and access to bulletin boards, E-mail, computerized information retrieval, "past master" text accessibility and complete philosophic bibliographic information on CD ROM , different philosophers use computers differently: MIDI for aestheticians, modelling for philosophers of mind and simulations for the environmental ethicist.

## INTEGRATED LEARNING SYSTEMS AND ADULT BASIC SKILLS

*Robin Taylor, PhD, New Century Education Corporation*

Widespread efforts are being undertaken - by public educational institutions, by volunteers, and by business and industry - to remedy the growing problem of illiteracy and innumeracy in the United States. The President's agenda of educational initiatives has heralded the birth of still more projects focused, in part, on this pervasive problem.

A great variety of instructional methods (classroom, tutoring, self-study, CAI) have been employed in our efforts to improve adult basic skills, with varying degrees of effectiveness. One of the more recent approaches to be tried is the integrated learning system (ILS).

Integrated learning systems are proving to be particularly effective in attacking the extensive problem of adult basic skills. An ILS can serve many students simultaneously, is adaptive to individual needs, and provides continuous monitoring and reporting of student progress. ILSs are being implemented successfully in sites as diverse as community colleges, government-funded adult education centers, corporate training facilities, and labor union-sponsored training facilities.

The Hudson Institute, in its report, Workforce 2000, has predicted that the magnitude of the adult-illiteracy problem will increase throughout this decade and into the next century, as workforce skills lag far behind workplace needs. Will ILSs continue to be a viable solution?

## RESEARCH PROJECT "INTERACTIVE TECHNOLOGY IN HIGHER TECHNICAL EDUCATION"

*Jarmo Viteli, University of Tampere, Finland*

There is a growing demand in Finnish Technical education to develop it toward the idea of an open learning environment. One part of this process is to help teachers to utilize interactive technology in their work. The research project "Interactive Technology in Higher Technical Education" is part of developing project "Teacher Education For Higher Technical Education". In Finland there is an obligatory teacher education for those whose aim is to become a teacher to Technical College's.

The research project started in fall 1990. The first question to answer was: How many lecturers in technical education were using interactive technology in their courses? Surprisingly, (or not) the use of interactive technology in technical education showed to be very low. Second question: Why don't you use interactive technology in your courses? The answers varied a lot but one of the main explanation or excuse was the lack of qualitative software.

After that we analyzed existing educational software for technical education in Finland. We found almost one hundred CAI-programs which were evaluated by lectures from technical colleges. The preliminary results will report in this presentation.

We send an open "Call for ICE-BREAKERS" to all technical colleges in Finland to invite lectures who would like put their time to develop instruction by using interactive technology. There were a lot of interest for this and this presentation will report the first steps of this groups ideas, training, results and problems.

# ASSESSMENT OF COMPUTER-BASED INSTRUCTION (CBI) IN CRIMINAL JUSTICE EDUCATION AND TRAINING PROGRAMS

*James B. Wells, North Georgia College*
*Ben Layne, Georgia State University*
*Claudia Flowers, Georgia State University*

Although some published studies have been performed with computer-based instruction (CBI) in criminal justice environments, little knowledge of the extent to which CBI is used in criminal justice education and training exists. The purpose of this study was to investigate the extent to which CBI is being used nationally in criminal justice education and training programs. The target population consisted of all departmental chairmen, training directors, and agency heads in the United States who coordinate or supervise adult criminal justice education or training programs in training centers, technical institutes, academies, community colleges, undergraduate and graduate colleges and universities. The results from a self-administered mail survey (copy provided) utilizing a sampling frame consisting of a directory of criminal justice educators, assessed the extent to which CBI is being used. Key areas of interest included identifying the types of education and training programs that are using CBI, as well as those that are not. Reasons for CBI usage as well as non-usage were also investigated. The results of this survey present concerned criminal justice educators an opportunity to examine computer-based instruction applications in criminal justice education and training settings, as well as indicate a need by some programs to expand their use of computers into a specific teaching area. Applicability of this survey toward assessing CBI usage in other disciplines is also discussed.

Selected Abstracts for the

# Special Interest Group for Computer-Based Training (SIGCBT)

## ERGONOMIC CBT

*Kay Bonham, Goal Systems International*
*Linda Randolph, Goal Systems International*

Ergonomics is a design philosophy that considers various aspects of usability. For example, efficiency, ease of use, and comfort level are central ergonomic principles. This session describes ergonomics and explains how sound ergonomic design principles can be applied specifically to the design and development of quality computer-based training courses.

This session will analyze the usability of everyday objects to illustrate the importance of applying ergonomic principles during the design process. It will describe a systematic ergonomic design procedure and will compare this procedure to the CBT development process.

This session will also discuss the benefits of using ergonomic design principles in CBT development, as well as the problems that arise from not following ergonomic principles. It will encourage participants to apply an ergonomic approach to various phases of the CBT design process, from how to accommodate diverse learning styles to the best way to present information on the screen.

## COMPUTER-BASED TRAINING MODEL FOR A GEOGRAPHIC INFORMATION SYSTEM

*Debra A. Brinegar, U.S. Army Construction Engineering Research Laboratory*

A Geographic Information System (GIS) is a complex computer system used in solving difficult planning and management problems related to land, facilities and the environment. In the last few years, the GIS user community has gone from consisting of only computer programmers and GIS experts to the land manager's assistant and college students. This movement from an expert-to-novice user community has brought with it inherent training problems. The complexity of the system may produce these problems yet, in turn, offers an advanced technological environment in which to train and support users. Most GISs use state-of-the-art workstations which provide access to multi-media (i.e., graphics, text, video) simultaneously.

This session discusses current research being performed in the area of GIS training that looks into how to best design a total performance support system in this type of environment. A training model will be presented which provides instructional designers with an insight into issues that need to be addressed when designing a support environment for users of GISs and other similar systems.

## AUTOMATED INSTRUCTIONAL DESIGN AT MEDIASHARE INC.

*Ann Marie Canfield, Utah State University*

Utah State University and MediaShare, Inc. have teamed up to design and develop a performance support system for salespeople. The project is in its first year of development and prototypes of version 1.0 of the system will be demonstrated at this showcase. The system is designed to deliver product training for salespeople and service departments as well as provide interactive presentations for customers. The system contains a knowledge indexing framework which enables a hypermedia system to contain meaningful links and avoid the problems of losing users in hyperwilderness. The system is based on the Second Generation Instructional Design theories also in development at Utah State University under the direction of M. David Merrill.

## OUTGROWING THE COTTAGE: DEVELOPING COMPUTER-BASED TRAINING ON A LARGE SCALE

*Robert C. Fratini, AT&T National Product Training Center*

Developing, maintaining, and supporting two computer-based training courses is more than twice as difficult as doing the same for a single CBT product. Managing more and more CBT deliverables requires more than simply an increase in the scale of operations. There is a qualitative as well as a quantitative change in the nature of the tasks required.

The Electronic Training Solutions (ETS) department of the AT&T Product Training Center has learned through the experience of such growing pains. By 1991, the department was responsible for the development, maintenance, and support of students using several hundred electronic training deliverables worldwide running on a range of delivery platforms.

The department had recognized beginning in 1989 the fact that its organizational mission and role was changing. Internal processes and software tools were analyzed in terms of their ability to meet the needs of courseware production on the current scale, as well as organizational skills and the corporate product management environment.

This presentation discusses the results of our analysis and provides a status report of our efforts. Software tools, development processes, and the role of CBT specialists have all changed in this new courseware management process. The techniques that we have used are appropriate for any electronic training development group which seeks to tailor their processes and tools to their specific organizational environment.

## COCKPIT RESOURCE MANAGEMENT TRAINING: MULTIMEDIA SITUATED LEARNING

*Hilary McLellan, Kansas State University*

Line-Oriented Flight Training (LOFT) for flight crews, developed to promote effective cockpit resource management, is an example of situated learning in a sophisticated multimedia training environment. All six of the critical situated learning components --- Apprenticeship; Collaboration; Reflection; Coaching; Multiple practice; Articulation --- are present in the LOFT training program. The LOFT program has several important implications for designers seeking to implement training in accordance with the Situated Learning Model: 1) the debriefing or reflection process for a team of learners, rather than an individual learner must be designed to provide feedback for both the team and the individual; 2) it is essential to differentiate between training and testing in the situated learning environment and to make sure that this distinction is clear to both the instructor and the learner; 3) the role of the instructor in a situated learning environment must be carefully designed as part of the overall design of the situated learning training program; 4) the selection and training of the instructor must be explicitly considered and planned for in situated learning, as in other training contexts; 5) the pacing and coordination of complex interrelated events in the situated learning scenario or script must be carefully designed in order to promote both realism and learning; and 6) it is necessary to design customized scenarios to meet the needs of different learners.

## THE REMOTE MECHANICAL "C" LINE COURSE: A DESKTOP SIMULATION SOLUTION

*M.M. Prather, Westinghouse Hanford Company*
*K.R. Nuttall, Boise Cascade Corporation*

Westinghouse Hanford Company has developed a desktop simulation-based training program for the operation of the Remote Mechanical "C" Line process in the Plutonium Finishing Plant at the Hanford Site, Richland, Washington. Simulations display and continually update values of system parameters on computer graphics of Remote Mechanical "C" Line equipment. Students use a variety of controllers to maintain proper system status. Instructors may select faults to be introduced into some simulations to test student responses to off-normal events. Simulations are preceded by computer-based tutorials on the function, processes, operation, and error conditions associated with each part of the line. The tutorials are also interactive; they include opportunities to use each of the controls--valves, heaters, agitators, etc., used to operate the individual processes. Phase I of the course was completed in December 1990, and the complete General Concepts course was delivered in July 1991. Instructors report that student response to the course has been extremely favorable.

From one perspective, the Remote Mechanical "C" Line course represents one step in the diffusion of the well-known and well-documented simulator training activities for nuclear reactor operators to other training programs. Because of the lengthy response times of the actual process, the Remote Mechanical "C" Line course can retain many of the capabilities of practice and testing in a simulated work environment while avoiding the cost of a full scale simulator and the exposure and waste developed by practice runs of the Remote Mechanical "C" Line itself. From another perspective, the Remote Mechanical "C" Line course suggests training advances even beyond the most faithful simulators. For example, by combining computer-based training lessons with simulations, this course permits students to focus on specific processes occurring inside chosen components. In effect, an interactive training manual is available on line with the simulation itself.

## DELIVERING CBT TO YOUR USERS: DESIGN AND IMPLEMENTATION ISSUES FOR SUCCESSFUL LEARNING

*Adele Suchinsky, U.S. General Accounting Office*
*Catherine C. McMahon, WORDPRO, Inc.*

A wealth of excellent off the shelf Computer Based Training (CBT) is available for use by business, government and academia. Top management support, however, is not necessarily the only element required to ensure the successful implementation of a multi-media Learning Center or a distributed training program. A well defined understanding of the job functions performed by the user population, clearly defined training/learning objectives, a well designed and equipped facility, appropriate staffing, marketing the new programs, effective procedures, and, above all, the appropriate up front and on-going selection of courseware (CBT, IVD), etc to address the target population is critical to successful implementation.

The initial challenge is to identify the place of the Learning Center within the context of the training environment. The key issues include methodologies for courseware selection, gaining organizational support for the program, determining the best ways to get the training to the users, determining when/how self-paced training can enhance and/or support the existing instructor-led training program, and determining how to maintain the viability and acceptance of the program in the future.

This presentation will discuss how to's and lessons learned in one successful case study. It is designed for the training professional charged with the responsibility to implement CBT in a Learning Center environment or distributed training program who would like to improve his/her current operation.

## WHAT DO WE REALLY KNOW ABOUT SMALL GROUP CBT

*Theodore M. Shlechter, Army Research Institute*

Foremost among many recent trends in education has been a surge of interest in small group learning. A search of ERIC and DTIC have produced nearly 50 works since 1985 on small group CBT. A number of claims have been made for small group CBT. It has been claimed for example, that small group CBT will help students elaborate upon the instructional materials and thus increase their likelihood of retaining the information. Unfortunately, most of these studies have focused on examining strategies for making small group CBT more instructionally effective while ignoring the more basic issue--the relative instructional value of small group versus individualized CBT. Those few studies, which have actually examined this issue, have provided inconsistent findings. Shlechter (1990), for example, has found that small group CBT led to more lasting retention of procedural instructional materials than did individualized CBT; while this effect was not found by others (e.g., Dalton, 1991: Carrier & Sayles, 1987). A consistent finding in this literature is that students in individualized CBT situations very rarely outperformed those in small group situations. Indeed, small group learning may make CBT more instructionally efficient with more students using fewer computers without harming the instructional process.

## THE MANAGEMENT CHALLENGE-CBT AT THE COMMONWEALTH BANK OF AUSTRALIA

*R J Spence, Commonwealth Bank of Australia*

The Commonwealth Bank of Australia is represented nationally across a network of 1500 branch offices. Training needs, coupled with distance education challenges, has seen the installation of 1200 stand-alone PCs dedicated to CBT. This session outlines the processes that were involved in establishing this large-scale CBT system and then concentrates on system acceptance, maintenance and the management of a courseware development group of 25. Present day challenges include a change in the delivery platform operating system to OS/2.

## USING A WORD PROCESSOR TO DEVELOP COMPUTER-BASED INSTRUCTION

*Kevin Stall, Systems , Requirements , and Services Associates ,Inc.*

Many developers and designers neglect one of the most obvious tools that make a programmers life easier. Using a word processor can increase not only the developers and designers productivity, but also the programmers. By using macros and other techniques the programmer will be able to do all the programming utilizing the word processor. This is particularly true with PLATO.

## OBJECT-ORIENTED PROGRAMMING: A PASSING FAD OR THE COMMING OF A NEW GENERATION

*Jennifer A. Chen-Troester, Utah State University*
*Zhongmin Li University of Utah*

Object-oriented programming (OOP) is becoming the programming methodology of the 1990's. Through the use of an object model, encapsulation, abstraction and inheritance, object-oriented programming enables programmers to easily reuse, extend and modify code. We will discuss the basic elements of OOP, how object-oriented design is different from traditional procedural software design and also look at designing a project using two object-oriented tools, HyperCard and ToolBook.

# COMPUTER-BASED INSTRUCTION (CBI) MODELS

*Peter J. Rizza Jr., Princeton Center for Education Services, Inc.;*
*Volkert Balk, University of Amsterdam; and*
*Franklin C. Roberts, Western Washington Univ.*

Courseware is the term used to refer to the range of possible computer based instructional (CBI) lessons. Courseware is used to deliver instruction on virtually all topics, employing a variety of strategies and approaches. This variety is one of the characteristics of CBI design that makes it an extremely labor intensive task.

While courseware is often varied in both its purpose and format, there is a common set of strategies and procedures that are frequently used in the design of CBI materials. There are literally dozens of approaches that can aid the designer in creating effective lessons.

By systematically applying these basic strategies, it is possible to reduce the amount of time required to create lessons, as well as ensure a level of consistency and instructional integrity in what is produced. At the same time, they help to focus the CBI development process on the more important and creative aspects of instructional design.

This session will outline the rationale for a set of models which can be used in the courseware design process. These models can be used to create a lessons that are complete, thorough, instructionally sound, and have a consistent interface.

This session will present the standard navigation and record keeping architecture for the router which supports the CBI Models and launches other "off-the-shelf" application.

Selected Abstracts for the

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

## LINKING TELECOMMUNICATIONS AND PROBLEM SOLVING

*Dr. Barbara Brehm, Eastern Montana College*

Students in seven middle school classrooms participated in one of three treatment groups to study the connection between telecommunications, problem solving training, and the use of problem solving strategies in the classroom and over a telecommunications network. Data was collected and analyzed using a pre- and posttest and a classroom observation form developed by the researcher.

Students, participated in the Most Liveable Places Telecommunications Project over the FrEdMail Network, by identifying factors which made their city a good place to live, rating their city, and by using "receiver site transfer" to analyze information from other cities . Network and classroom activities incorporated levels of problem solving corresponding to Bloom's Taxonomy.

Findings from the study include significant increases for the CTP (Telecommunications and problem solving) group on posttest scores and on the level of problem solving strategies over the CT (Telecommunications) group and the C (Comparison) group. Both the CTP and the CT group also generated more problem solving strategies than the C group.

Recommendations for future research include involving students more directly in sending and receiving messages, providing more training for teachers, stressing the problem identification stage, and focusing on the "receiver site transfer" stage of the activity.

## ELECTRONICALLY ACCESSING MULTIPLE RESOURCES: NETWORKING ISSUES IN MACINTOSH AND MS-DOS ENVIRONMENTS

*Dr. Mary Ann Hindes, The University of Georgia*

When considering the implementation of an information retrieval network, the first decision must be to select a hardware environment. This presentation will address the benefits and pitfalls of operating in an MS-DOS or Macintosh network environment. Points to be considered will be student access and training, the user/computer interface, and cost. This presentation will highlight two schools which have implemented information retrieval networks including online catalogs and CD-ROM databases.

# COMPUTER-BASED SPACE PROGRAMMING TECHNIQUES TOOLS FOR THE EDUCATOR AND THE PRACTITIONER

*Thomas L. Houser, The University of Tennessee, Knoxville*

Interior space programming comprises the collecting and analyzing of data from myriad sources, synthesizing information, and preparing reports. Although proven to be successful, conventional graphic programming procedures have drawbacks: repetitive, time-consuming techniques; the one-time use of visuals; and the redesign of graphics for program reports. The challenge, therefore, lies in developing computer-based techniques that encourage thorough data collection, compress the timeframe for programming, and reduce redundancy. Procedures must address client-designer interaction dynamics, as well.

The computer-based alternatives presented have been tested in professional practice and the classroom. This has been accomplished on diverse projects, including an industrial research laboratory, a day care center, and an educational facility's masterplan. Potential project types run the gamut of architectural and interior design endeavors. Field settings range from private meetings to sophisticated teleconferences.

The procedures employ basic drawing, spreadsheet, database, desktop publishing and desk accessory programs. The conceptual nature of the drawing programs and the use of macros in the others allow quick mastery of the techniques.

Computer-based programming offers effective tools for producing graphics, analyses and reports. They have proven effective in professional and academic settings. With additional application of the procedures, designers will acquire expanded repertoires of graphics, thus expediting future projects.

## GETTING TEACHERS INVOLVED WITH TECHNOLOGY

*Annette Lamb, University of Toledo*

*My chalkboard works just fine. Why do I need a computer? ...I'm six years from retirement. Why learn something new? ...I've seen most of the educational software. It's junk. Computers can't teach.*

These are familiar comments from educators. Regardless of whether they are professors of chemistry or teachers of first graders, many educators are reluctant to embrace computer technology as a tool for instruction. How can we get educators more involved using emerging technologies (e.g., computers) as instructional tools? This session addresses this growing concern. The early innovators are already on the "technology" band wagon. However, what about all the educators in the shadows that aren't making use of what technology has to offer? Hypermedia applications, desktop publishing, desktop presentations and other "high tech" areas are a great way to get educators involved with technology. With the use of easy-to-learn authoring and production tools, educators can develop professional-quality computer-generated materials.

This presentation provides sneaky and not-so-sneaky ideas for getting teachers involved with technology. Successes and challenges to achieving these goals are also discussed. The session explores ways to encourage reluctant educators to use tools of technology for personal, professional, and instructional applications.

It is our job as technology users to encourage the integration of technology into the curriculum. We often become so entrenched in our daily routines that we forget about the need to reach out to others. The session highlights strategies for conducting effective teacher inservices and workshops including the identification topics for inservice and workshops, potential problems, as well as, selection of formats and activities are discussed. For example, the "one shot" inservice, courses and workshop series, "make-it and take-its," and demonstrations are highlighted. Finally, tips for successful workshops are outlined.

## MAKING GEOGRAPHY FUN WITH HYPERCARD

*Annette Lamb, University of Toledo*

This presentation will describe and highlight the development and use of two HyperCard-based geography activities. First, Banking Bucks in Brazil is a simulation that incorporates technology tools to support student participation in collaborative decision making, information exploration, and practice of higher level thinking skills. Middle school students participate in a collaborate approach to information exploration through accessing, manipulating, and applying regional and investment information about Brazil. Students have access to regional and investment information, compare and contrast regions of Brazil, identify geographical information, evaluate possible investments, and select a successful investment. This project goes far beyond a simple simulation by providing access to a wealth of important information about the country, its regions, and its people through a hypermedia format.

Second the terminology related to geography. Students must create a resort using a random set of geographic components. Information about the components is provided to assist users in identifying and incorporating these elements into their resort. This game stresses the geographic themes of place and location.

## TECHNOLOGY IN THE CURRICULUM: ISSUES AND QUESTIONS FOR THE 90'S

*Dr. Deborah Little, University of Illinois*

This presentation is an interactive exchange of ideas of K-12 classroom teachers, school administrators and others interested in technology integration in K-12 settings. Participants will share experiences, insights and ideas as the presenter leads them in proposing some possible answers to difficult questions.

The following questions will be the focus of the presentation:

1. What are some barriers that have made it difficult to integrate technology in the curriculum?
2. Of the new technologies, which are affordable? Which are not?
3. How can the unaffordable technology be made more affordable for K-12 schools?
4. Should teachers be taught to create their own curricular materials using hypertext or other authoring tools?
5. Who should be teaching the teachers to integrate technology in their various curricula?
6. How do we teach responsible uses of technology? *e.g.*, issues of privacy, copyright laws, equity
7. How *or where* can teachers and administrators new to technology begin?
8. What are some successful methods of technology integration in your school or schools you work with?

If time allows, participants will be encouraged to suggest and discuss other issues and questions in new technologies for educational settings.

## AN INSTRUCTIONAL MERGER: HYPERCARD AND THE INTERGRATIVE TEACHING MODEL

*Carolyn M. Massie, University of Virginia*
*Larry G. Volk, University of Virginia*

This paper will explain how one information processing model of teaching can merge with computer technology to create a more effective data retrieval process. The hypermedia program on the Macintosh computer, HyperCard,will be used to help focus students' attention on the material being presented in the lesson. In addition to the hypermedia program being able to isolate specific data display information, using animation and speech can also increase students' on-task behavior.

The Integrative Teaching Model combines content information with inductive and deductive reasoning to help develop students' thinking skills by having students progress through five instructional phases. This paper will summarize the theory behind the model, give reasons for using an information processing model, and will point out the advantages of using HyperCard for the data display and retrieval. The Integrative Model's five phases are described within a sample lesson plan. References will be included which would enable an educator to design hypermedia stacks on HyperCard.

## COMPUTER-ENHANCED LEARNING EDVIRONMENTS AND THE REINVENTION OF SCHOOL

*Dr. Kyle L. Peck, The Pennsylvania State University*

To drastically improve today's schools in terms of conventional measures and the development of skills and attributes currently overlooked, small-step changes will not do. And, as George Leonard said, "It may be easier to change all of it than to change any part of it."

A paradigm shift is needed in education -- a breakthrough on the scale of the discovery of microorganisms in medicine, leaving the ground in transportation, or the microprocessor in computing. Instructional technology has made almost no difference in the lives of students because our approach has been to squeeze technologies in without changing much else. Only when we redesign the entire process, with no "sacred cows," will we realize the potential of instructional technologies.

"Project Rethink!," set out to "reinvent" education, applying instructional systems design "at the macro level." Following a needs assessment, a philosophy of education was developed, and a minimal but realistic set of constraints was identified. Alternatives were synthesized into a powerful student-centered learning environment in which active students work in cooperative groups on multidisciplinary, topic-oriented investigations, producing multi-media outputs. An integrated learning system develops basic skills in math, reading, and language arts, and exercises in creativity and problem-solving become integral parts of the students' day.

## COMPUTERS AND TEACHER EDUCATION: A GRADUATE CURRICULUM DESIGN

*James P. Randall, Ed. D., Widener University*

A unique masters level program in Computer Science Education provides a curriculum design for integrating teacher education with emerging technologies at Widener University, Chester, Pennsylvania. The goal of this program is to infuse classroom teachers, computer coordinators and school administrators with the necessary competencies, knowledge and value structures to lead the integration of computer-based technologies into curriculum and classroom instruction contexts.

This 30-credit hour graduate program provides students with a comprehensive knowledge of computer applications and utilization in elementary, secondary and post-secondary education settings. In addition, course offerings draw students from a variety of other graduate programs and thereby allow for a continuing dialog between classroom teachers, computer coordinators and school administrators relative to issues of instructional technology integration.

Instruction is delivered in both on-campus and off-campus settings. Instructional resources include three IBM micro computer presentation laboratory classrooms which are configured in a LAN environment and one Apple development laboratory classroom. Each of the IBM laboratory classrooms also interfaces with the campus wide Cyber mainframe WAN environment which allows for EMAIL, programming and data base nformation retrieval access.

Curriculum development is evolutionary in nature addressing emerging technologies and their impact/integration in formal schooling.

# INFORMATICA - A COURSE IN ALGORITHMIC THINKING

*Peter Rizza & Volkert Balk, Princeton Center for Education Services, Inc., Alexei Semenov, Institute for New Technology*

In 1989 ADCIS sponsored a conference on Computers, Education and Children in Moscow, USSR. At that time a small group of participants agreed to create a joint project between the USA/USSR to design and develop courseware based on the Soviet approach to algorithmic thinking and problem solving.

The William C. Norris Institute, MN agreed to fund the Princeton Center for Education Services to work jointly with the Institute for New Technologies in Moscow to produce a new course called INFORMATICA, based on this Soviet approach to learning.

The session will present the instructional designs used in the development of the INFORMATICA lessons and will discuss the Soviet approach to the design and development of MicroWorlds.

The session will present the major advantage of the INFORMATICA course and demonstrate the highly interactive use of CBE lessons to develop concepts critical to problem solving. The course also provides the students with a fully functional MicroWorld. A demonstration will show how students interact with this open-ended software environment to create algorithms to solve new problems.

The INFORMATICA course is available to schools and can be obtained from Norris Education Innovations, Inc. (NEII) upon request. The INFORMATICA course is offered in a floppy disk as well as a networked version. It runs on Macintosh and MS-DOS systems (IBM PS2 & PC-compatibles), and will soon be available for MS-Windows platforms.

# PERSONALIZED EDUCATION MANAGEMENT SYSTEM - PEMS

*Peter J. Rizza Jr., Princeton Center for Education Services, Inc.;*
*Karl G. Kelly, Princeton Center for Education Services, Inc.;*
*Marilyn Martin, Norris Education Innovations, Inc.*

The **Personalized Education Management System™ (PEMS)** is a comprehensive multi-user application designed to help educators organize and track student progress through a predefined curriculum. *PEMS™* contains all of the entities, attributes, relationships, and keys in a well defined database structure with a friendly Macintosh interface. *PEMS™* specifically supports:

- Personalized Plan for Development (PPD) and Learning (PLP),
- Curriculum Goals, Objectives, Learning Resources and Tests,
- Management Plans for Teachers (TMP) and Students (SMP),
- Planning and Scheduling of Instructional Activities.

*PEMS™* allows teachers to prepare student's goals and construct lists of student objectives. *PEMS™* provides a range of potential goals and objectives and allows the teacher, student, and parent to meet to determine the best personalized education plan for the student.

Teachers can manage the student assignments and scheduling, as well as record student progress by clicking on icons in the Teacher's Office. The underlying relational data base allows them to query PEMS on-line, with security supported via password sign-ons and group codes.

*PEMS™* calculates and tracks student progress, including test and learning resource scores. *PEMS™* also allows for manual entry and manipulation of the data by the teacher.

*PEMS™* supports the complete education management cycle, helping professional educators, administrators, teachers, parents, and students to move through all the phases in the cycle:

- **Definition** Phase - In this phase the curriculum goals, objectives, learning resources, and tests are defined,
- **Assignment** Phase - Here the appropriate goals, objectives, learning paths, learning resources and tests are assigned,
- **Performance** Phase - In this phase the students interact with their assigned instructional activities,
- **Progress Tracking** Phase - The students' progress is tracked, updated, posted and reported during this phase,
- **Evaluation** Phase - During this phase the students and teachers can evaluate the system's performance and the effectiveness of activities and programs, and
- **Reassignment** Phase- Periodically the students are assigned new goals, objectives and learning assignments.

In the presentation we will discuss the design of *PEMS™* and the results generated by some of the pilot schools that have implemented *PEMS™* within their districts.

# TRAINING TRACKER

*Peter J. Rizza Jr., Princeton Center for Education Services, Inc.;*
*Karl G. Kelly, Princeton Center for Education Services, Inc.;*

The *Training Tracker™* is a comprehensive multi-user application designed to help the training coordinator organize and track participants progress through a specified training program. The application contains all of the entities, attributes, relationships, and keys in a well defined database structure with a friendly Macintosh interface, and specifically supports:
- Planning - professional development assignments for participants,
- Managing - the participants path through professional development activities, and
- Defining - the structure and professional requirements within the corporate training environment.

*Training Tracker* is a complete data base application that helps training managers document a participant's training plan, schedule required correspondence among individuals involved in the training program, and maintain a complete history of a participant's assignments in the training program. The application also provides for the generation of overdue correspondence notices.

*Training Tracker* provides a list of skills, knowledge, and competencies associated with training assignments, indicates which are required of a given job function and which are appropriate development assignments for the participant's job classification.

*Training Tracker* provides a means of tracking a participant's progress against the skills, knowledge, and competencies for an assignment, and maintains a complete history of the participant's progress through the training program.

*Training Tracker* provides multi-user access to the application and secure access, by individual and group, to features and information.

The session will present the overall structure of the application, give examples of how it can be implemented and demonstrate the functions and features.

## A CONTROLLED STUDY ON DEVELOPMENTAL WRITERS AT THE COMPUTER

*Gary Vaughn, University of Cincinnati*
*Rex Easley, University of Cincinnati*

The 1990-91 academic year marked the fifth and final year of a study at the University College of the University of Cincinnati to measure the effects of classroom computer use on the composing processes of developmental writing students. Five English instructors and a large number of sections of a developmental writing course (a total of over 1,000 students) were involved in the study. The freshman students are placed into this course on the basis of their performance on a holistically-graded essay and on a standard reading test. They have the opportunity to retake the essay test at the end of each quarter; a passing grade is needed before they may enter into the Freshman English sequence. Sections involved in the study used either the Bank Street Writer II word processing program, or Bank Street Writer in combination with William Wresch's Writer's Helper writing-aid program, or no had no computer usage at all. All classes in the study used the same syllabus with the same assignments and the same point-based grading system. Results form the five-year study were subjected to statistical analysis not yet completed at the time of this proposal submission. However, preliminary data indicate that none of the three groups performed at a significantly higher level on the essay test or averaged a significantly higher quarter grade. On the other hand, when the results are examined from a perspective of traditional students versus non-traditional adult learners (about ten years older on the average), the adult learners passed the essay exam at a much higher rate if they belonged to sections which used Writer's Helper . Furthermore, student evaluations indicated a positive response toward using the computers, showing, for example, that students in the computer classes were more likely to judge their writing assignments as "interesting and stimulating." Complete results of the study and its ramifications will be discussed.

## SCIENCE INSTRUCTION ON GLOBAL ELECTRONIC NETWORKS

*Michael L. Waugh, University of Illinois at Urbana-Champaign*
*James A. Levin, University of Illinois at Urbana-Champaign*

Real world science is conducted in global contexts, with collaboration among colleagues around the world a common occurrence. With the spread of microcomputers into science classrooms and the availability of electronic networks, it is now possible to conduct science instruction in such global contexts as well. This presentation will discuss ongoing research and development efforts concerning ways in which electronic networks can be used in science teaching and learning. Electronic networks can allow students to participate in distributed science problem solving activities by providing "dynamic support" so that students can gather and analyze data and jointly create project reports with students from other parts of the world. Several of these "telescience" activities will be described in detail. In one activity, students from across the United States have been engaged in data collection and data analysis activities related to estimating the circumference of the earth. In another activity, students and teachers participated in the collection and analysis of data concerning the cost, nutritional value and appeal of typical school lunches. The session will conclude with a discussion of the potential for electronic networks to improve science teaching and learning.

Selected Abstracts for the

# Special Interest Group for Emerging Technologies (ETSIG)

## REALIZING THE POTENTIAL OF A LEVEL ONE VIDEODISC-BASED SCIENCE PROGRAM FOR ELEMENTARY CLASSROOMS: A REPORT OF AN EVALUATION STUDY

*Gayle V. Davidson, Ph.D., The University of Texas at Austin*
*James L. Barufaldi, Ph.D., The University of Texas at Austin*
*Lowell J. Bethel, Ph.D., The University of Texas at Austin*

The purpose of the evaluation study was to ascertain the effectiveness of the videodisc-based elementary science program in selected fourth grade classrooms as determined by the users of the program involved in the pilot testing. This study is qualitative in nature, supplemented with quantitative information. Student information was collected through the administration of interviews, assessment of science- and technology- related attitudes, skills and content, and classroom observations. Information about the pilot teachers was collected through demographic surveys, interviews, classroom observations and administration of assessments of concerns and anxiety towards science and technology. The selected schools also represented the socioeconomic and ethnic diversity of Texas. the study was conducted to : (1) describe classroom behaviors and perceptions of students and teachers and the ecology of the learning environment, (2) determine teachers' attitudes toward technology and state anxiety toward the teaching of science, (3) identify students' attitudes toward science/technology and interest in science outside the classroom, and (4) to identify students' science content knowledge and skill development based before and after the implementation of the videodisc-based science program. The outcomes of the pilot test show promise that the videodisc-based program is effective in initiating positive changes among teachers and students towards science and technology. Data supported the notion that the program is effective in the fourth grade pilot classrooms. The presentation will report and discuss the findings of this evaluation study.

## OBJECT ORIENTATION AND THE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS

*Eric Hansen, Educational Testing Service*

Object orientation is a software engineering methodology that undergirds many of the recent advances in authoring productivity tools, graphical user interfaces database technology, distributed processing multimedia, and inter-application communications. The key concepts of object orientation - objects classes, and messages - will be introduced. The considerable benefits of object orientation for developing computer-based instructional systems will be discussed, particularly for multimedia applications.

## THE APPLICATION OF HUMAN FACTORS TO THE ID PROCESSES FOR COMPUTER-BASED PROGRAMS

*Hueyching Janice Jih and Michael A. Orey,*
*The University of Georgia*

The field of instructional design (ID) integrates knowledge, ideas, techniques, and technology from a number of areas, for instance cognitive science, learning theory, media technology, and computer science. The advent of computer-based instructional materials as a new kind of instructional vehicle brings a considerable challenge to the education/training field. The appeal of computer-based instructional (CBI) materials, with its myriad opportunities for instructional innovation and creativity, has encouraged ID professionals to push ahead. We suggest here that advances in human factors will provide fruitful ideas for developers of CBI.

For the past two decades, the field of human factors has been contributing greatly to the design and development of computer-based technology. Specific questions that will be addressed in the presentation are: 1) What new directions do we need to pursue to improve current mindsets in instructional design for computer-based materials?; and, 2) What efforts in human factors field might contribute to the modification of a five phase (analysis, design, development, implementation, and evaluation) phase model of ID for computer assisted instructional systems? The purpose of this presentation is to indicate some salient aspects of human factors research which can shed light on instructional design of CBI. The focus of this discussion will be towards designers and developers of CBI.

## HYPERMEDIA IN THE INFORMATION DISSEMINATION PROCESS

*Ellen N. Piety, U. S. Army Construction Engineering Research Laboratory*

How can an Army Research Laboratory disseminate information on all their ongoing research projects, either fielded or still under development, in a convenient and timely manner? This is a period of minimal time for fact absorption, complex innovative technological advances, varying levels of technical expertise, multi sensorial output devices and varying individual human nformation processing skills. Which are the best technologies to transfer critical knowledge optimally, efficiently and yet in as short a time as possible.

Hypermedia seems to offer the optimal solution to this variety of challenges with its unique and enriching experiences, any person can have a significant interaction with a hypermedia information dissemination system. The design, implementation and validity of nformation presented needs to be carefully constructed and flexibly delivered to meet the potential users' needs.

Current research underway at USACERL is investigating the applicability of this emerging technology to the area of nformation dissemination. Major objectives include analysis of the best techniques for different types of presentation, optimal branching capabilities, ease of knowledge acquisition, and permitting the user to easily find his way through the levels of nformation he is interested in, without getting lost in "hyperspace".

## COGNITIVE OUTCOMES OF BUILDING EXPERT SYSTEMS

*David H. Jonassen, University of Colorado*

Researchers and businesses are investigating the effects of having students and employees construct expert system rule bases. What is important are the cognitive effects of the construction process more than the resulting advisors. Expert systems can be thought of as cognitive tools engaging learners in cognitive and metacognitive learning outcomes. This project proposes to investigate the changes in critical thinking skills, cognitive learning strategies, and metacognitive skills that result from employees and students constructing rule bases. Changes in individuals' knowledge structures will also be investigated.

## USER'S PERFORMANCE AND PREFERENCE ON DIFFERENT INPUT DEVICES: TOUCHSCREEN, MOUSE AND KEYBOARD

*Chi-Hui Lin & Gayle V. Davidson, Ph.D.*
*The University of Texas at Austin*

This presentation begins with a discussion for the consideration of human factors on designing computer-assisted instruction with respect to input devices. The three most frequently used input devices (touchscreen, mouse, and keyboard) in educational settings will be discussed. The discussion will include the advantages and disadvantages of using each of theses three devices based on both the user's and the developer's points of view. The presentation will culminate with a reporting of pertinent research on the effects of the use of these input devices on task performance and attitudes. Handouts of summary points of the presentation along with references will be provided.

## INTELLIGENT TUTORING WITH HYPERTALK: WHO NEEDS LISP OR PROLOG

*Wayne A. Nelson, Southern Illinois University at Edwardsville*
*Safiah Md.Yusof, Southern Illinois University at Edwardsville*

Intelligent tutoring systems (ITS) represent a new approach to instructional software design that takes advantage of recent advances in cognitive science research. Rather than making all decisions about instruction before presenting the software to the learner, ITS utilize representations of learner and expert knowledge to diagnose learner errors and select instructional tactics and curriculum sequence in a dynamic process which unfolds as the learner interacts with the system. Such an approach allows the system to adapt to individual performance in ways not possible for software developed using the traditional instructional systems approach to design.

Object-oriented systems such as HyperCard provide a viable alternative for implementing instructional software which utilizes some ITS techniques. The presentation will discuss ways to implement specific techniques for intelligent tutoring in HyperCard related to interface design, data structures for knowledge representation, diagnosis of errors, instructional transactions, and curriculum sequencing. A specific example of a system programmed entirely in HyperCard will be demonstrated.

## WHY AUTHORING TOOLS SHOULD BE OBJECT-ORIENTED

*Joseph Seeley, University of Illinois*

Object-oriented programming (OOP) can increase programmer productivity in several ways. It supports the rapid creation of new software components out of old ones and the relatively easy integration of new and old. It makes possible reliable, reusable components with which the designer can compose new applications. It factors code in ways that can lessen both the impact of changing requirements and the extent of maintenance needed.

Three aspects of OOP lead to the above benefits: data abstraction, inheritance, and polymorphism. Understanding these concepts allows courseware developers to understand how OOP can help them. It also helps them separate object-oriented hype from substance.

Courseware authoring differs from other software engineering tasks in several important ways. Among these are the vital importance of the interface and the inherent difficulty of manipulating mental processes instead of data. These differences suggest that OOP may be an especially appropriate tool for authors.

Examples taken from an object-oriented framework for drill construction illustrate the presentation throughout.

## THE COLORADO LITERACY NETWORK: HOW AN ELECTRONIC COMMUNICATION NETWORK ENHANCES THE ADULT LITERACY PROGRAMS

*Eric E. Smith, University of Northern Colorado*
*Jennifer G. Rudd, EG&G, Rocky Flats*

This paper addresses the communications problems of adult literacy providers dispersed over a large geographical area. The need for increased communication to provide better services and the implementation of an electronic network to facilitate communication are discussed.

## OBJECT-ORIENTED PROGRAMMING: A PASSING FAD OR THE COMMING OF A NEW GENERATION

*Jennifer A. Chen-Troester, Utah State University*
*Zhongmin Li, University of Utah*

Object-oriented programming (OOP) is becoming the programming methodology of the 1990's. Through the use of an object model, encapsulation, abstraction and inheritance, object-oriented programming enables programmers to easily reuse, extend and modify code. We will discuss the basic elements of OOP, how object-oriented design is different from traditional procedural software design and also look at designing a project using two object-oriented tools, HyperCard and ToolBook.

# A CASE STUDY IN DISTANCE DELIVERY

*Michael Yacci, Rochester Institute of Technology*

An introductory graduate college course in Learning Theory was distance delivered to a Fortune 500 company in upstate New York. Prior to distance delivery, the course had contained elements of Personalized System of Instruction (PSI), along with elements of a "traditional" college class, such as student discussion and activities. Although PSI has components that are easily adapted to distance delivery, the adult, professional audience still expected learner-instructor interaction and discussion. Therefore, a hybrid mediated course was designed that could meet the requirements for both student autonomy and interaction among learners.

The course objectives specify that the students will learn a large amount of declarative knowledge coupled with some specific procedural skills. This means that the course primarily teaches verbal information intermixed with some specific concepts and principles. Its intent is to supply the learner with the background knowledge for other courses in the curriculum by creating an interrelated cognitive structure of various learning theories. By the end of the course, students are expected to see similarities and differences between competing theories as well as use and apply these theories to a limited degree.

The instructional events of presentation, elaboration, practice with feedback, and testing were approached by analyzing the cognitive activities necessary in the learners and then by carefully selecting a strategy and a medium that could encourage and support these activities. This translated into each unit of the course being comprised of required reading, audio and video tapes, a work book, handouts, worksheets, experiential activities, and electronic mail.

Selected Abstracts for the

# Special Interest Group for Education of the Handicapped (SIGHAN)

## ADAPTING HYPERCARD STACKS TO PROVIDE SPEECH OUTPUT FOR READERS WITH DISABILITIES

*Wren M. Bump, Texas A&M University*

HyperCard stacks can be enhanced with sound and speech capabilities. Do you want to use "real" speech or "machine" speech? What is your purpose for the sound and how much memory do you have available? How are both types of sound installed into the stack? What does the student with special needs require in order to be successful in the use of the HyperCard stack? These questions will be answered in this presentation.

## ALLOWING STUDENTS WITH PHYSICAL DISABILITIES ACCESS TO COMPUTERS THROUGH ADAPTIVE TECHNOLOGY

*Wren M. Bump, Texas A&M University*

Students who do not have the physical capability or control needed to use computers in the traditional way are many times not given the opportunity to use computers at all. These are the very students who could benefit the most from computer use. Adapted keyboards and switches will be shown that help a range of students.

Selected Abstracts for the

# Special Interest Group for Health Education (HESIG)

## THE IMPACT OF COMPUTER-BASED LEARNING ON EXAMINATION PERFORMANCE IN MEDICAL BIOCHEMISTRY

*James Baggott, Ph.D and Sharon E. Dennis, M.S.,*
*Hahnemann University*

An optional student-controlled computer-based learning (CBL) environment (lecture, review, self-testing and clinical problem modules) covering over 50% of a Medical Biochemistry course was made available to first year students. Users experienced improved performance on multiple choice examination questions. The percentage improvement on questions for which CBL was used is predicted by the intensity of CBL use.

## THE DEVELOPMENT OF A REPURPOSING VIDEODISC WORKSHOP FOR HEALTH PROFESSIONAL FACULTY

Michael Weisberg, Ed.D., National Library of Medicine
Victor Carr, Ed.D, National Library of Medicine

This presentation describes the concepts and developmental process involved in the creation of a two and one-half day "hands on" workshop that enables health professionals to repurpose existing videodiscs. The ideas for the workshop evolved from staff interaction with health professionals at The Learning Center for Interactive Technology and were first tried out in the format of brief ( two and one-half to three hour ) seminars at national health professional meetings held throughout the country. These seminars provided an introduction and overview of the concept "repurposing", and were elucidated with several concrete examples. As staff gained knowledge and experience working with videodiscs, the seminars evolved into a plan for developing a "hands on" workshop where faculty would design and create repurposed videodiscs. This plan involved the systematic development of a full-scale workshop. Forty- eight health professionals participated in four developmental workshops conducted by the staff of The Learning Center for Interactive Technology. ( In addition to the presenters of this session, major contributions to the workshop were made by Richard Banvard, M.A. , Craig Locatis, Ph.D , and Mr. Quang Le).

## HEALTHY PEOPLE 2000: OPPORTUNITIES FOR COMMUNICATION TECHNOLOGY IN DISEASE PREVENTION AND HEALTH PROMOTION

Mary Jo Deering, Ph.D., Office of Disease Prevention and Health Promotion

The biomedical science base supports health promotion and disease prevention efforts to reduce disease, disability, and premature death. Escalating medical costs encourage informed decisions about the appropriate use of preventive and other health care services. Healthy People 2000: National Health Promotion and Disease Prevention Objectives was developed as a national consensus document under the leadership of the U.S. Public Health Service. The 300 objectives target improvements in health status, reductions in risk, and expansion of services. They are grouped in 22 priority areas ranging from specific chronic diseases such as cancer to nutrition and physical activity.

Information and education activities developed by or for health care professionals, health officials, schools, worksites, national and community based organizations, and the individual consumer will be important tools for achieving these objectives. Technological applications about preventable health problems can facilitate long-term behavior change through participatory learning. Interactive video, utilizing scenes from real or staged patient counseling sessions, can help teach medical students--or doctors--how to counsel their patients about behavioral risks such as smoking, poor diet, or exercise. Decision-support mechanisms can help professionals, patients, and consumers sift through an ever-increasing prevention knowledge base.

This presentation, with a video and slides, will outline the opportunities for computer-based educational products and services within the framework of Healthy People 2000.

## DEVLOPMENT OF COMPUTER EDUCATION IN HEALTH SCIENCE (NURSING): SOME ALSTRALIAN EXPERIENCES

*Dr. Nitya Karmakar, University of Western Sydney (Hawkesbury)*

University based nursing education is new in Australia. In New South Wales, diplomas in nursing started in 1985 and universities are now offering bachelor degrees. Computing has not been significant in these rapidly developed curricula. This paper looks at important issues in introducing computers in nursing education, because the nursing profession in Australia is challenged by changes in information technology.

## THE NEGLECTED ROLE OF EVALUATION: INSTRUCTIONAL PRODUCT SELECTION

*Marjorie A. Kuenz, Ph.D., National Library of Medicine*

Evaluation--its definition, approaches, purposes--has received a lot of consideration in professional literature in the last 2 decades (See, e.g., Scriven [1967, 1972, 1974], Stufflebeam [1971, 1974], Airasian [1974]). Two purposes of evaluation that appear most frequently in its definitions are (1) to render judgment on the worth of a program; and (2) to assist decision makers.

Assessing the worth of a program is a concept basic to evaluation. However, early in the history of modern evaluation theory, evaluation was distinguished from actually rendering judgments (See Alkin [1969], Patton [1978], Stufflebeam and Webster [1980], and Weiss [1972]); that was the role of the decision maker. In this age when instructional materials are developed by commercial firms, other educational institutions, or enterprising individuals, often the roles of evaluator and decision maker belong to the same person, whose responsibility it is to determine the value of instructional products and to decide whether to incorporate them into curricula.

Frequently, evaluative information is found in descriptions of educational products provided by developers or disseminators; and evaluation is included as a sub-topic in presentations regarding such programs and products, specifically to sway decision makers who consider adopting the products. Curriculum decision makers can approach their product selection tasks more confidently if they have compiled basic data about the course or program for which they are seeking a computer or other technology-based product. These data serve the critical role of guiding their product review and selection activities.

The presenter will provide guidance for what course/program and technology data are most relevant and how to navigate through and evaluate the information provided about a product.

## INTERACTIVE VIDEODISC FOR NURSING EDUCATION: VITAL SIGNS

*Donna Larson, Grand Valley State University*
*Barbara Breedon, Fuld Institute for Technology in Nursing Education*

Design, content, and production issues will be discussed during the demonstration of this interactive videodisc series currently under development at the Fuld Institute for Technology in Nursing Education. The content (the measurements and interpretation of temperature, pulse, respiration, and blood pressure) reflects development of both psychomotor and cognitive skills in beginning level nursing students.

## A DATABASE AND STUDY OF AUTHORING SYSTEM TECHNOLOGY

*Craig Locatis, National Library of Medicine*

A review of authoring systems was undertaken to update an earlier study of the software conducted by the National Library of Medicine in 1985. A literature review was made and an entirely new review of available products was conducted because the technology and marketplace had changed significantly. Over 170 potential products were identified, but only 82 of these were actually reviewed because many are 1) not being marketed, 2) not truly creating computer-based instruction, or 3) running on mainframe or older microcomputers (e.g., Apple II's) not common in medical schools. A number of trends, like more graphical interfaces and multimedia capability, were identified. Reviewers were also able to detect varied vendor approaches to the market. Of particular interest are new "intelligent" authoring tools and more objective selection methods. The study explores potential problems in using the new tools and evaluation techniques. AuthorBase was developed in support of the study in anticipation that future reviews will be likely. Since the database contains source, hardware, cost, and other information about specific products, it may be useful to others.

## AN INTERACTIVE TECHNOLOGY SAMPLER VIDEODISC IN THE HEALTH SCIENCES

*Craig Locatis, National Library of Medicine*

The Interactive Technology Sampler portrays twenty interactive technology applications in the health sciences that can be viewed at the National Library of Medicine's Learning Center for Interactive Technology. The disc is intended to make information about the technology available outside the center and is designed for individual use in kiosks and exhibitions and in formal presentations conducted by center staff. In addition to the portrayals, there are operating instructions, an attract loop, and "tours" providing supplemental information about some programs on the second soundtrack. An index allows accessing programs by subject, title, and application.

The disc is designed for multiple levels of use: level 1 (player keypad), level 2 (on board program), and level 3 (computer control). The current level three programs allow interaction with a single touchscreen on IBM InfoWindow or mouse using M-Motion or dual screen display with IBM PCs or Apple Macintosh computers. Barcodes also can be used for access. The design maximizes the disc's functionality, both with or without external computer control, and uses video production techniques that shorten presentation length and increase presentation rate.

## A COMPUTER-BASED APPROACH TO REINFORCING COMMON PRINCIPLES IN BIOLOGY

*Harold Modell, National Resource for Computers in Life Science Education*

Students often approach each course in a curriculum as a body of completely new information that has little in common with previous or future courses. In doing so, they fail to realize that our understanding of biological phenomena is based on a set of basic principles that are applied in a variety of ways. To help introduce students to underlying principles and make them aware that these principles can be applied in a variety of ways, we have begun to develop a series of computer exercises focusing on common themes in mammalian physiology and designed for use in an independent study setting. The first program in the series deals with the principle of conservation of mass applied to indicator dilution determinations and mass balance analyses in cardiovascular, respiratory, and renal physiology. The program contains aspects of the three approaches to computer-based education: tutorial, drill and practice, and simulation. The overall context of the exercises is that of a series of simulated experiments, all requiring some aspect of a conservation of mass analysis for determining the value of a specific parameter. In defining the specific experiment, the student provides descriptive data about the subject or conditions of the experiment. From this description, the program calculates values for the physiological parameters ("unknown") within the system being tested. Thus, the simulated experiment leads to a drill and practice problem in which the student must calculate the value of the "unknown". Each drill and practice problem contains appropriate tutorial feedback for reinforcing how conservation of mass is applied to the problem, should that be necessary.

## AN OSMOTIC PRESSURE TUTORIAL THAT REINFORCES REASONING SKILLS

*Harold Modell, National Resource for Computers in Life Science Education*

We have developed a computer based tutorial to help students review the basic principles underlying osmotic pressure and osmotic relationships within physiological systems. However, unlike the tradional question/answer tutorial format, the design of this program is intended to reinforce scientific reasoning skills by having the student pose and test hypotheses. The program begins with a demonstration of water movement in an osmometer after a 1% sucrose solution is added to one side of the semipermeable membrane. The next several screens ask the student what took place, explain the phenomenon, and define osmotic pressure. The student is then asked whether particle size, particle number, or both determine the osmotic pressure. No information regarding the answer to this question is presented in previous screens. Thus, the student must form an hypothesis. The program then allows her to test this hypothesis using a simulated osmometer with either several choices for the test molecules or the concentration of the test solution placed on one side of the osmometer membrane. Upon completing the experiment, the student may choose to run another experiment or choose to stop gathering data. If at least two experiments have not been run, the program reminds the student that not enough data has been gathered to test the hypothesis. When sufficient data have been obtained, the program asks if the data support the proposed hypothesis. The program response provided following the correct choice reinforces the observed results rather than merely restating the correct answer. The tutorial covers basic principles of osmosis, tonicity, and the interaction of hydrostatic and oncotic pressures determining fluid exchange in the capillary.

## CAI: A LEARNER VIEWPOINT

*L. Q. Thede, Kent State University*

In many settings, getting college nursing students to use CAI is a challenge. This despite studies in all fields which indicate that students learn as much with computer instruction as with so called "traditional methods," and often in less time. Given these facts and today's time conscious student, it would seem logical for students to be calling for more CAI, not resisting its use.

Insight into this situation was gained through voluntary interviews with nursing students who used one of four computer programs, tutorials about blood gases or dosage calculation, a simulation, or a nutrition analyzer. The results indicated that interactivity, or the ability to respond to learners, which many see as the key to CAI effectiveness, goes beyond the expected software learner combination to the learner's feelings about computers and beliefs about learning.

Three overall categories of interaction influence were found: 1) factors based on individual beliefs about learning, 2) factors derived from learner interactions with the computer and computer environment, 3) interactions with the software. This presentation will describe each of these categories and illustrate them with quotes from the interviews. Besides pinpointing problem areas, much of the data suggests positive actions that can increase CAI use.

## PANTHERS AND LIONS: TRANSFORMING COMPETITION TO COLLABORATION

*Karen S. Wedge, University of Pittsburgh*
*Dee McGonigle, Pennsylvania State University*

Two faculty researchers at traditional football rival universities present the trials, tribulations, and ultimate successes of collaborating on a joint developmental research project. Collaborative projects present challenges in searching for a collaborative partner, melding research protocols, and logistics of project development.

The presentation includes a description of the collaborative project - an interactive video program entitled "Perinatal Data Base and Tutorials: An Elaborated Resources Approach to an Interactive Video Hypermedia Application." This project encompasses the three functions of computer based learning as suggested by Taylor (1980): tutor, tool and tutee. As a tutor, the multiple microtutorials related to perinatal data provide access to the body of knowledge contained in the program. As a tool, the project produces an extended visual resource for learners that interconnect in an elaborated resources program including access to an on-screen glossary from any point in the program. As a tutee, the project provides a lesson shell that enables learners to design units of self study or visual presentations from the videodisc and actually extend the program. The project's flexibility supports use by undergraduate students initiating inquiry into perinatal information as well as by graduate students synthesizing theoretical concepts or by others needing to review or present this material.

Selected Abstracts for the

# Special Interest Group for Home Economics (HOMEC)

## BUYING CLOTHING SERVICES, SUPPLIES, NOTIONS, EQUIPMENT AND PATTERNS BY MAIL

*Bette Jo Dedic, University of Kentucky*

The MoreMail computer program is designed to be used as a resource for home-based sewing entrepreneurs, educators, home sewers and other consumers in locating mail order items needed for the design, construction, care, and maintenance of clothing, textiles and related articles. These items include sewing notions, supplies and equipment, patterns, and related services. Over 200 businesses are represented in the data base.

## HOME ECONOMICS, SOCIAL STUDIES, AND HEALTH TEACHERS' ATTITUDES TOWARD AND USE OF COMPUTERS FOR INSTRUCTION

*Chryssoula Drizou, Iowa State University*
*Cheryl Hausafus, Iowa State University*

The purpose for this study was to investigate the differences between secondary teachers teaching in the social sciences on availability, use, and attitudes towards computers. In particular, this study focused on three areas of the social sciences where similarities on the implementation of computers were anticipated: home economics, social studies, and health studies.

A stratified random sampling method was used to identify the invited sample of 201 teachers with 67 teachers selected from each group. Data for this study was obtained by a questionnaire mailed during winter 1989-1990. The instrument consisted of three parts: demographic information, attitudinal scale, and open-ended questions. The attitudinal scale was designed to describe three types of attitudes: a) anxiety of using computers b) like working with computers, and c) confidence in ability to use computers.

Data analysis showed that the majority of teachers (61%) reported using the computers in their work but only 41% of them use computers for instructional purposes. A greater proportion of home economics teachers (62%) report using computers with their students than social studies (22%) and health teachers (47%). Teachers indicated that they do not feel anxious or fear computers; rather, they like using computers but they do not show significant confidence in using computers in their classrooms.

## COMPUTER-BASED SPACE PROGRAMMING TECHNIQUES: TOOLS FOR THE EDUCATOR AND THE PRACTITIONER

*Thomas L. Houser, The University of Tennessee*

Interior space programming comprises the collecting and analyzing of data from myriad sources, synthesizing information, and preparing reports. Although proven to be successful, conventional graphic programming procedures have drawbacks: repetitive, time-consuming techniques; the one-time use of visuals; and the redesign of graphics for program reports. The challenge, therefore, lies in developing computer-based techniques that encourage thorough data collection, compress the timeframe for programming, and reduce redundancy. Procedures must address client-designer interaction dynamics, as well.

The computer-based alternatives presented have been tested in professional practice and the classroom. This has been accomplished on diverse projects, including an industrial research laboratory, a day care center, and an educational facility's masterplan. Potential project types run the gamut of architectural and interior design endeavors. Field settings range from private meetings to sophisticated teleconferences.

The procedures employ basic drawing, spreadsheet, database, desktop publishing and desk accessory programs. The conceptual nature of the drawing programs and the use of macros in the others allow quick mastery of the techniques.

Computer-based programming offers effective tools for producing graphics, analyses and reports. They have proven effective in professional and academic settings. With additional application of the procedures, designers will acquire expanded repertoires of graphics, thus expediting future projects.

## ELUCIDATING TIME MANAGEMENT ACCOUNTABILITY THROUGH SPREADSHEET ANALYSES

*Thomas L. Houser, The University of Tennessee*

In service professions such as architecture, engineering and interior design, fees are determined on an hourly or project basis. Either base challenges the professional's time management accountability. Firms maintain detailed records to vouch for efficiency and effectiveness and to predict requisite staff commitments for future projects. Accountability is critical to the individual and the firm's success.

The challenge for the educator lies in cultivating the student's sensitivity to time management principles. To address this challenge, computer-based spreadsheet exercises have been developed to record and analyze time usage. These timesheet projects have been used in microcomputer applications and business procedures classes. Students delineate coursework and employment activities for a minimum of three months, entering this information into spreadsheets beginning midway through the study. They then extract and make analyses of pertinent data. Students also prepare tables and graphs by using the application's chart commands or by running macros developed for the project. Representative analyses include comparisons of time spent on academic and non-academic endeavors; distribution of efforts among tasks associated with specific courses; patterns of effective time management displayed throughout each week and over the term; and percentages of effort relegated to individual commitments.

Through course evaluations, students have indicated these exercises to be beneficial. Findings reflect enhanced sensitivities to accountability and improved effectiveness in time management.

## REPACKAGING: ONE KEY TO COST-EFFECTIVE TRAINNING

*Elizabeth Miller, Control Data Corporation,*
*Cheryl Shankman, Hughes Training Systems*

Frequently companies reject "canned" training materials with the cry, "That's nice, but that's not what we do!" Upon closer inspection many of these programs contain 80 - 90 percent of the necessary training, but are missing the 10 - 20 percent that customizes it for a company or department's specific needs. Using real-life examples from DoD, industry, and manufacturing, the presenters will discuss their experience with "repackaging" existing materials and/or developing new materials to provide cost-effective training solutions.

Repackaging provides companies with a series of advantages. including:

* the ability to customize and reorganize pre-existing courseware to make a new curriculum to meet your organization's specific needs.
* the ability to integrate non-CYBIS courseware into curricula.
* the ability to add placement tests, increase question test banks, change testing strategies and scoring procedures, add feedback, etc. for existing courseware.

The presenters will also discuss repackaging techniques utilizing the ISD method to insure instructional effectiveness and systematic methodology in the design and development of new training materials and the integration of existing materials including print, CBT, audio, video, reference, and lab materials into the new curriculum.

## A QUALITATIVE ANALYSIS OF STUDENT TEACHERS' CLASSROOM MANAGEMENT TECHNIQUES

*Cecelia Thompson and Dale E. Thompson*
*The University of Arkansas*

Student teachers' in home economics, business, and industrial education kept diarys chronicling their positive and negative experiences with classroom management over a twelve week period. Students were asked to write a weekly entry in response to each of these two open ended statements. This week, I handled this discipline problem most successfully by reacting in this way. I handled this discipline problem least successfully by reacting in this way. They described both the discipline problem and their methods of management.

*HyperQual*, Macintosh software designed to facilitate qualitative data analysis, was used to analyze diary entries. HyperQual is an application of HyperCard that allows researchers to search text for materials relevant to a study. The researcher can code chunks of data and sort them into categories.

Using HyperQual, meaningful topic categories were isolated to identify similar problems faced by student teachers and successful and unsuccessful strategies employed by student teachers. Problem solving techniques were identified and classified.

Padilla, R.V. (1990) *HyperQual Version 3.0* (Computer Program). Chandler, AZ: Author. (Address: 3327 N. Dakota, Chandler, AZ 85224 U.S.A.)

## CADD IN THREE DIMENSIONS: EXAMINATION AS DESIGN TOOLS FOR INTERIOR DESIGN PROGRAMS

*Susan Winchip, Illinois State University*

Computer-aided design and drafting (CADD) has penetrated all phases of the interior design industry. Now the field has expanded to a score of programs with 3-D graphics software. Some of these 3-D graphic programs are aimed at very specific markets, while others have wide applicability. If a designer needs to create realistic images in three dimensions, it becomes essential to understand how 3-D programs work generally, and the strengths and weaknesses of the currently available software. The objectives for the presentation and the participants are to 1) Explore the variations of 3-D images, including wire frame, hidden line, shaded, ray traces, and antialiasing, 2) Examine the methods for cre ting 3-D models, including coordinate input, 3-D primitives, curved 3-D surfaces, and multiview ir t, and 3) examine the series of operations whicn basic image-creating methods require including, revolving, extruding, surface sweeping, connecting of cross sections, reshaping, rotating, translating, and zooming. This presentation focuses on what 3-D in perspective is and how it can create effective realistic images for interior designers. In addition, two architectural programs will be compared and contrasted. One program is architectural rendering which is a visualization tool that allows a designer to create three-dimensional views of projects, but not working drawings. The second program is an integrated architectural design system which allows a designer to produce fully-dimensioned working drawings, elevations, cross sections and bills of material. The interaction between a three dimensional program and its users can be influenced by both the system itself and the participation of the users., Thus, in order to increase the user's satisfaction, performance, effectiveness, and to create high-quality drawings it is critical to build a good understanding of the variations in a 3-D images, the methods for creating 3-D models, and the basic operating methods. This presentation serves to enhance the interaction between three-dimensional programs and the interior design process.

Selected Abstracts for the

# Special Interest Group for HyperMedia Education (HYPERSIG)

## TOOLBOOK—SPEAKING FROM EXPERIENCE

*Lorinda Brader, Penn State University*

CBEL—Teaching and Learning Technologies Group of Penn State supports faculty in the use of interactive technologies in teaching and learning. While assisting faculty in finding, evaluating, using, and developing instructional software, our unit has worked in depth with several programming systems including HyperCard and, most recently, ToolBook. This presentation will highlight advantages, disadvantages, problems, and solutions that we have encountered in our experiences with ToolBook.

As with any new product, people are interested in learning how ToolBook can be used to solve instructional problems. They are interested in knowing how easy ToolBook is to learn and what problems they may expect to encounter while developing a product. This presentation will focus on the use of ToolBook in an instructional environment. A description of the problems that were encountered while learning and developing in ToolBook and how these problems impacted instructional design issues will be discussed. Solutions to difficult ToolBook issues will also be mentioned.

Additionally, many individuals are familiar with HyperCard and the role it has played in providing the capability of combining text and graphics to create powerful applications without mastering a difficult programming language. There are numerous questions about the similarities of ToolBook and concerns about the transition from the HyperCard environment to the ToolBook environment. Questions about the similarities and differences of HyperCard and ToolBook and the move between these two environments will be addressed.

## IMPLEMENTING HYPERMEDIA CONCEPTS WITH HYPERTALK

*R. Scott Grabinger, University of Colorado at Denver*

HyperCard® and HyperTalk® from Apple Computer are used frequently for the development of small scale hypermedia/hypertext systems. Hypermedia systems require complex development of links, nodes, maps, and networks of information from a variety of sources. The purpose of this session is to define some of the basic hypermedia concepts and illustrate how those concepts can be implemented with the HyperTalk language.

## HYPERTEXT LEARNING ENVIRONMENTS AND COMPUTER-BASED DRILLS: A COMPARISON OF CONTRASTING DESIGNS FOR THE ACQUISITION OF COMPLEX KNOWLEDGE

*Michael J. Jacobson, University of Illinois*

Although the application of hypertext systems to educational situations has been attracting considerable attention recently, there has been little empirical validation as to the instructional effectiveness of such systems. A study was reported which employed two contrasting designs for structuring hypertext learning environments that were used to provide instruction in a complex and ill-structured content area, the social impact of technology. The experimental treatment incorporated several design features derived from recent cognitive instructional theory, in particular a procedure that used multiple presentations of case-based examples that highlighted different abstract facets of the domain knowledge. The comparison treatment consisted of a hybrid hypertext/computer-based drill design that recycled missed items using an increasing ratio review algorithm.

The results of the study revealed that while the computer-based drill design led to higher performance on the measures of memory for factual knowledge, the more hypertext-like design promoted superior transfer to new situations. These findings suggest that hypertext learning environments which present the instructed knowledge by explicitly demonstrating critical interrelationships between case-specific and abstract knowledge components in multiple contexts would promote superior knowledge transfer. Some implications of these findings for cognitive instructional theory and for the design and use of hypertext learning environments and computer-based drills were also discussed.

## MEDICAL HYPERTEXT BASED UPON COGNITIVE FLEXIBILITY THEORY

*David H. Jonassen, University of Colorado at Denver*

**Advanced Knowledge Acquisition**

In order to solve complex, domain- or context-dependent problems, learners must acquire advanced knowledge, which occurs after the introduction of knowledge and prior to the development of expertise (Spiro et al, 1988). Since introductory learning stresses simple reproduction of rigid examples based upon limited cases, learners often fail to achieve advanced knowledge. Without being able to reason with or apply the information that they acquire, learners will not be able to transfer the knowledge to novel situations. Since nearly every cases in medicine is unique, transfer skills are essential. Learners need instructional conditions that stress multiple interconnectedness and different perspectives on the same cases. Learners need flexible representations of domain knowledge. Hence, we recommend cognitive flexibility theory.

## BRIDGING THE GAP BETWEEN INSTRUCTIONAL STRATEGIES AND COMPUTER COURSEWARE

*Annette Lamb, University of Toledo*

The development of effective, efficient, and appealing materials should be the goal of computer courseware designers. However with all the "bells and whistles" available in newer authoring tools, designers sometimes forget about basic design principles. Currently, much of the commercial software being developed is ineffective. While some of the problems lie with incomplete or ineffective front-end analyses, interactivity that is non-existent ("Press spacebar to continue") or at too low a level of processing are prevalent in other courseware materials. The nature of the information processing generated by courseware will determine what is learned by the students. For novice designers one of the biggest obstacles to the design of effective educational software is the translation of precise instructional strategies into computer courseware. This transfer from paper and pencil ideas to HyperCard cards and stacks can be mediated with some practical guidelines that relate directly to the events of instruction.

The purpose of this presentation is to describe strategies for transforming instructional strategies into computer courseware materials. The session focuses on individual events of instruction and provides practical approaches for designing lesson elements. These Events of Instruction are: gaining and maintaining attention, informing the learner of the objective, recalling prerequisite skills, presenting the stimulus material, providing learning guidance, eliciting the response, providing feedback, assessing performance, and enhancing retention and transfer. Examples from HyperCard stacks will be provided for each of these events.

## MAKING GEOGRAPHY FUN WITH HYPERCARD

*Annette Lamb, University of Toledo*

This presentation will describe and highlight the development and use of two HyperCard-based geography activities. First, Banking Bucks in Brazil is a simulation that incorporates technology tools to support student participation in collaborative decision making, information exploration, and practice of higher level thinking skills. Middle school students participate in a collaborate approach to information exploration through accessing, manipulating, and applying regional and investment information about Brazil. Students have access to regional and investment information, compare and contrast regions of Brazil, identify geographical information, evaluate possible investments, and select a successful investment. This project goes far beyond a simple simulation by providing access to a wealth of important information about the country, its regions, and its people through a hypermedia format.

Second, Ralph's Retreats and Resorts is a HyperCard-based instructional game that helps students learn the terminology related to geography. Students must create a resort using a random set of geographic components. Information about the components is provided to assist users in identifying and incorporating these elements into their resort. This game stresses the geographic themes of place and location.

The presentation will describe the integration of these activities and other simulations in a middle school social studies classroom. Finally, the presentation will highlight lesson extensions and other ideas for HyperCard-based activities.

## HYPERTEXT DELIVERY SYSTEMS

*Carol B. MacKnight, University of Massachusetts*
*Santosh Balagopalan, Mentor Graphics*

Hypertext and Hypermedia have captured our imagination with their capabilities to support instruction, learning, and collaborative research. For IBM users taking the first step often means selecting a hypertext system that will provide the links between text, graphics, audio, and video. In this paper, emphasis is on a comparison of two hypertext systems based on the object-oriented paradigm.

## INSTRUCTIONAL APPLICATIONS OF HYPERMEDIA: FUNCTIONAL REQUIREMENTS AND RESEARCH ISSUES

*Ok-choon Park, U.S. Army Research Institute*

The purposes of this presentation are: (a) to examine the functional features hypermedia systems need for instructional applications; (b) to describe important uses and limitations of hypermedia; and (c) to discuss research issues and technical improvements for hypermedia's instructional applications.

Functional requirements of hypermedia depend on its use. First, this presentation will discuss the features and needs of the following functions: (a) guiding node selection; (b) opening multi windows; (c) changing window locations and sizes; (d) changing data base structure; (e) having browsers; (f) selecting nodes by key words; (g) having independent storage files; (h) generating newly edited versions of the program; (i) interfacing with hardware peripherals; (j) interfacing with programming languages.

Second, values and limitations of hypermedia will be discussed for the following uses: (a) as an instructional delivery system; (b) as an idea generation and organization tool; (c) as a relational information management system; and (d) as a CBI authoring system.

Third, the following research issues will be discussed to clarify the instructional applications of hypermedia: (a) use of learner-control principles and strategies, (b) selection of information-representation forms, (c) use of a hypermedia-based knowledge base in CBI, and (d) development of intelligent hypermedia.

## DESIGN, DEVELOPMENT AND TESTING OF A CONTEXTUALIZED COMPUTER ENVIRONMENT FOR SPANISH LANGUAGE ACQUISITION

*Wayne A. Nelson, Southern Illinois University at Edwardsville*
*Kathleen A. Bueno, St. Louis University*
*Safiah Md. Yusof, Southern Illinois University at Edwardsville*

Issues related to the design, development, and testing of a contextualized computer environment for Spanish language acquisition are discussed in relation to the role of computer in school settings and the need to embody cognitive learning theories in computer-based instructional systems.

## INTELIGENT TUTORING WITH HYPERTALK: WHO NEEDS LISP OR PROLOG?

*Wayne A. Nelson,and Safiah Md.Yusof,*
*Southern Illinois University at Edwardsville*

Intelligent tutoring systems (ITS) represent a new approach to instructional software design that takes advantage of recent advances in cognitive science research. Rather than making all decisions about instruction before presenting the software to the learner, ITS utilize representations of learner and expert knowledge to diagnose learner errors and select instructional tactics and curriculum sequence in a dynamic process which unfolds as the learner interacts with the system. Such an approach allows the system to adapt to individual performance in ways not possible for software developed using the traditional instructional systems approach to design.

Object-oriented systems such as HyperCard provide a viable alternative for implementing instructional software which utilizes some ITS techniques. The presentation will discuss ways to implement specific techniques for intelligent tutoring in HyperCard related to interface design, data structures for knowledge representation, diagnosis of errors, instructional transactions, and curriculum sequencing. A specific example of a system programmed entirely in HyperCard will be demonstrated.

## THE INSTRUCTIONAL DESIGN PROCESS: A HYPERCARD MODEL

*Lawrence C. Ragan, Penn State University*

Faculty and staff interested in developing instructional courseware are faced with many challenges due to time constraints, job requirements, and lack of direction or procedures to follow. Although motivation is initially high, interest soon lags as the "small" project dredges on for months or years. Most faculty or staff do not have formal training in the instructional systems approach and therefore work unfocused and misguided often without the program ever being completed. The Instructional Design Process (IDP) provides the developer with a model that illustrates the four major phases and accompanying steps in the development process.

The *IDP* HyperCard stack was created as one method of guiding the potential developer through the relevant phases and steps in the instructional design model. This software was generated to provide a focus on such important details as learner characteristics, and task requirements. The developer can select and choose the appropriate steps for their development project and more realistically set goals and measure their completion. This stack has been used in Instructional Design Seminars with success at Penn State and in faculty-training programs in Costa Rica.

The stack was not designed for advanced courseware developers and is not an instructional design management tool.

Selected Abstracts for the

# Special Interest Group for Interactive Video-Audio (SIGIVA)

# FULD INSTITUTE FOR TECHNOLOGY IN NURSING EDUCATION: "THERAPEUTIC COMMUNICATION"

*Barbara Breedon, Fuld Institute for Technology in Nursing Education*

The Fuld Institute for Technology in Nursing Education (FITNE) is a non-profit corporation established by the Helene Fuld Health Trust to encourage and support the use of educational technology in nursing education Our second interactive videodisc production, "Therapeutic Communication", is a multi-purpose educational tool for the analysis and synthesis of communication strategies for nursing education. In the design of this interactive videodisc program, there were some unique considerations made that may be of interest to other developers.

As a project team, we endeavored to make the program friendly and accommodating to our target audience. Several factors were important:

- the program should accomodate use by learners working in pairs, etc.
- the program should easily adapt to group use
- the program should support instructors in integrating it into their curriculum

In teaching therapeutic communication, instructors have traditionally relied on role playing situations in the classroom. Recognizing this, we included Partner Exercises throughout the program that set up situations for the learners to role play with each other. This also accommodates the reality that quite often students will work in pairs at the systems and these exercises give them the opportunity to share, compare and discuss what they are learning.

The disc was organized to facilitate the viewing of the character vignettes without the computer. In this mode, the videodisc is used like a videotape with more precise control. We provide, on the disc and in the teacher's guide, an index of frame numbers for the vignettes. The instructor can show the vignettes in the classroom on a large monitor or projection system and control the presentation with the remote.

Along with the program package, we include a VHS Demonstration Tape that can be kept in the LRC for students and faculty. It illustrates how to load the disc, bootup the system, enter the program and continue to move through the menus and chapters. The videotape format is more familiar to most learners and instructors and helps to introduce them to the interactive disc format.

We also provide a very thorough Teacher's Guide with the program. Besides describing the content and many features of the program, it also includes a chapter called "Suggestions for Integration" and an appendix with class materials to photocopy.

This presentation will demonstrate "Therapeutic Communication" and how we accommodated our audience's needs within the program's design and the materials that accompany it.

# A COMPUTER MANAGEMENT SYSTEM FOR PATIENT SIMULATIONS

*Lynn Johnson, The University of Iowa*

We are teaching clinical problem-solving skills, including diagnosis and management, to dental students using a series of interactive videodisc patient simulations. We call this series Oral Disease Simulations for Diagnosis and Management (ODSDM). (Finkelstein, et al., 1988) ODSDM presents an oral pathology diagnostic schema and thirty patient simulations. ODSDM is a prototype for a comprehensive dental simulation project. This paper describes a computer management system which assigns students patient simulations, tracks their progress, and generates reports.

Our computer management system was designed in response to the following needs. First, the sequence that students perform simulations is critical. Each student should be presented with the individualized sequence of simulations they require to master clinical decision-making skills. Second, maintaining records of completed simulations and student performance on each simulation is a time-consuming task for faculty. Third, the simulations and the simulation models require ongoing evaluation to ensure high quality instruction.

The objective of the management system is to ensure that each student masters diagnosis. Mastery must be obtained at a specified level before advancing to the next level. The management system does this by individualizing the sequence of the simulations to adapt to the needs of each student. Students who learn diagnosis quickly need to complete fewer simulations than those students who learn diagnosis less quickly.

The management system generates 200 demographic, progress, and system reports.

## USE OF INTERACTIVE VIDEO IN PERFORMANCE APPRAISAL RATER TRAINING

*William A. Kealy, Texas A&M University*

A recent approach to the longstanding problem of how to improve rating accuracy of performance appraisals has been to show idiosyncratic raters videotaped examples of specific levels of job performance. This "frame-of-reference" approach was carried one step further, in this case, by developing an interactive video program that lets users view a scene, rate the performance shown, and receive corrective feedback on their judgements.

The Food Service profession served as the rated activity for the current project. Experts in the field identified seven discrete categories of work performance, such as Menu Familiarity, while another group of experts generated, for each category, twelve written descriptions that represented the entire range of potential job-related behaviors. These served as the "rough scripts" for producing 84 video segments, half depicting the job performance of a waitress with the remainder showing the same behavior by a waiter. Each video scene was then rated by 24 former waiters and waitresses to determine its "true" score and confirm its equivalence to the original performance description.

These video scenes formed the basis for an interactive video rating exercise that was part of a comprehensive CBT lesson. This instruction, created through the SUPERPILOT authoring language, provided instruction on the importance of accurate performance appraisal, typical rater errors (such as Halo Effect), types of job categories in the food service profession, and how to use the Behaviorally-Anchored Rating Scales (BARS) contained in an accompanying workbook. After this instruction, a job category title appeared followed by a related video scene of a waiter's or waitress' performance. At the end of the scene, the viewer was asked to rate the behavior shown using the keyboard. For responses other than a true score, viewers received directional feedback for first attempts and motivational feedback when an error was made more than once for a given video segment. By contrast, accurate ratings yielded a statement on the favorable progress of the user who was then presented with another video scene to rate.

This project is discussed in terms of development practices for interactive video with similar, attitudinally-based outcomes as well as its potential application in research.

## INTERACTIVE VIDEODISC FOR NURSING EDUCATION: VITAL SIGNS

*Donna Larson, Grand Valley State University*
*Barbara Breedon, Fuld Institute for Technology in Nursing Education*

Design, content, and production issues will be discussed during the demonstration of this interactive videodisc series currently under development at the Fuld Institute for Technology in Nursing Education. The content (the measurements and interpretation of temperature, pulse, respiration, and blood pressure) reflects development of both psychomotor and cognitive skills in beginning level nursing students.

## AN INTERACTIVE VIDEODISC APPLICATION ON SKILL ANALYSIS OF THE FREESTYLE AND BUTTERFLY IN SWIMMING

*Kirk E. Mathias, Arkansas State University*
*Eric E. Smith, University of Northern Colorado*

A call for interactive videodisc development by researchers in educational technology resulted in the production of this application. Discipline specific videodiscs have been needed in order to move away from the adaptation of interactive videodiscs for research. Having a greater quantity of topic specific videodiscs, according to educational technology researchers, would provide a larger arena of instructional topics to study. The purpose of this interactive videodisc application is to teach future teachers to analyze the freestyle and butterfly skills in swimming. Film segments which were combined with other video segments were borrowed from the American Swimming Coaches Association. The interactive application is designed to present correct and incorrect freestyle and butterfly techniques. Questions are incorporated throughout the instruction. The final two modules present a random generation of video segments and questions which allow for analysis practice. The specific objective of this presentation is to introduce a new direction of interactive videodisc technology through the presentation of the application.

## AN INTERACTIVE VIDEODISC INSTRUCTIONAL DESIGN STUDY IN TEACHING SKILL ANALYSIS

*Kirk E. Mathias, Arkansas State University*
*Eric E. Smith, University of Northern Colorado*
*Thomas M. Adams II, Arkansas State University*

Researchers within the field of educational technology have called for discipline specific applications. Such applications would allow for improved research in that they would increase control and allow for better identification of factors that influence the effectiveness of interactive video instructional applications. Specific applications which best meet the capabilities present in interactive video still need to be studied. Therefore, the purpose of this study was to analyze interactive video instructional design features relative to analyzing skills in swimming. Specific objectives of this presentation are to introduce multiple regression results on six subjects who experienced an interactive video treatment in learning analysis of swimming techniques. Instructional design features to be presented include time of instruction, competency levels on specific modules, and repetition of modules relative to final gain scores.

## INTERACTIVE VIDEO AS A RESEARCH TOOL IN EDUCATION

*Kirk E. Mathias, Arkansas State University*
*Eric E. Smith, University of Northern Colorado*

Slee (1989) explained that media comparisons (i.e. interactive video vs. traditional teaching) with interactive video have been studied beyond the necessary limits and that an effort should be made to use IVD as a research tool. The purpose of this presentation is to present a position on specific models and learning strategies of research which can best be studied through the use of interactive video. This will include the following: recent evolution of technology specific to education, recent research relative to the sports arena, specific positions and ideas of use in the areas of research feedback on performance, teaching methods for preservice teachers, Gordon's cognitive model, interactive video instruction effects on sport skill performance and identification of cognitive processes in sport skill analysis. Research ideas for establishing identification of cognitive processes in pre-service teacher preparation will also be presented.

## AN INTERACTIVE VIDEO LESSON PLANNING PROJECTFOR TEACHER EDUCATION

*Dr. Charlotte Scherer, Bowling Green State University*

This teacher education project involves the development of a HyperCard stack to assist education students in planning for instruction. The stack is designed to control the MECC *Improving Teacher Effectiveness* laser disc, which calls up appropriate visual segments illustrating many of the effective teaching strategies. Although effective teaching strategies are stressed, the lesson plan process in this program does not adhere to a single approach to planning. Rather, the HyperCard stack is designed to facilitate general lesson planning while allowing for incorporation of effective teaching strategies.

The materials were pilot tested in the spring semester of 1991 with elementary education students enrolled in Computer Utilization in the Classroom courses who needed to write lesson plans incorporating the computer as assignments for that class. In this project they used the IVD resource to analyze and apply principles that promote student learning. Research was completed to test for the effectiveness of this lesson plan writing strategy by comparing the quality of lesson plans written using this media with plans written in other ways. A questionnaire was also given regarding the use of the IVD media itself.

Preliminary results indicate these materials are effective; however, the HyperCard stack alone may also be adequate.

## BEHIND THE SCENES: THE MAKING OF A GENERIC RESEARCH VIDEODISC

*Eileen Schroeder, Marilyn Arnone, Richard Kenny, and Thomas Moats, Syracuse University*

Interactive video has been described as a tool for examining general questions on instructional strategies, message design, media/learner interactivity, and learner characteristics. It is also seen as a medium with unique attributes worthy of examination. With the high cost and time required to produce a videodisc, the concept of a generic disc which provides a database of still and moving images and audio has arisen. A generic disc could be used to study a variety of different research questions and also be useful for developing a number of different lessons in real life settings. Its use in a variety of classes at different institutions could provide a large pool of research subjects.

To develop such a generic research disc one must consider a number of questions dealing with the overall instructional design process, content/task analysis, selection and collection of images, on-disc versus off-disc variables, putting the images on a disc, budget, and a realistic timeline. Decisions at each step of the way affect the utility of the disc for research and lesson development. Further, experience in the process of developing a generic videodisc has yielded lessons transferrable across other new technologies such as DVI and CD-I.

This presentation will examine the rationale for a generic research disc, advantages and disadvantages, development factors, and the tradeoffs of recent technological developments that can duplicate many of the features formerly available solely on videodiscs.

## NEW INTERACTIVE VIDEO DISPLAY CAPAIBILITIES: BASING DECISIONS ON DESIGN GOALS

*Dr. David Taylor, Virginia Tech*

The technical sophistication of new interactive technologies for displaying and merging video and computer graphics is increasing rapidly, and these capabilities can easily lead clients and developers astray when selecting a display system for their courseware. The basic choice is between a system that integrates computer graphics and text with video on one screen, versus simpler systems that place computer output (digital) and video (analog) on separate screens. The tendency is to choose the system that offers the most in terms of "bells and whistles", without adequately considering the implications for instructional design, project objectives, or the delivery environment.

Two recent projects with different hardware and software platforms—a computer-based sophomore-level plant biology laboratory, and a tutorial/simulation for veterinary students—serve as examples of how decisions can be made in considering display needs and capabilities.

This presentation includes:

- An overview of available interactive hardware and software systems from the standpoint of their display capabilities;
- Theoretical factors (from research in perception and learning) related to instructional design and development for one or two-screen systems;
- Practical reasons (e.g., cost and space) for deciding between the two systems:
- Guidelines for choosing a system, based upon project goals, instructional objectives and the user environment.

# INTERACTIVE VIDEO AT THE MOTOROLA MUSEUM OF ELECTRONIVS

*Paul Wangemann, Motorola Inc.*

The Motorola Museum of Electronics offers a structured learning environment for corporate visitors and public school groups that emphasizes everyday cognition, authentic tasks, and real world problem solving. The museum combines the dynamic world of working professionals engaged in problem solving with the specific needs and challenges of the world in which we live in.

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.

The purpose of this presentation will be to showcase examples from the museum of multimedia interactives delivered via the computer. The interactives are integrated into a larger educational system or program. The purpose of the interactives is to provide motivating real world problem solving experiences in which visitors utilize electronics.

Selected Abstracts for the

# Special Interest Group for Management Issues (MISIG)

## COST-OF-QUALITY PRINCIPLES RELATED TO COMPUTER-BASED TRAINING

*Robert Callan, AT&T Corporate Education and Training*

This presentation will address the use of Cost-of-Quality (COQ) principles to identify areas for improvement in the development and delivery of CBT. The basic COQ categories will be described and illustrated with CBT examples. The COQ Identification Process will be explained and applied to the work done in a CBT delivery group.

## PLANNING FORMATIVE EVALUATION IN DESIGNING COMPUTER ASSISTED INSTRUCTION

*Lih-Juan ChanLin, The University of Georgia*
*James R. Okey, The University of Georgia*

A formative evaluation plan for computer-assisted instruction should plan for different assessments and use the acquired information to revise the product and processes to achieve the purposes of making learners learn better and the processes be conducted more effectively. Conducting the formative evaluation can be considered from three perspectives: assessing the achievement of the outcomes or objectives, assessing the effectiveness of the development process, and assessing the nature of the product.

Traditional formative evaluation of CAI products has focused on assessing learner achievement of objectives and the inferential use of this information to make revisions. A more comprehensive approach to formative evaluation includes traditional learner achievement assessment but adds assessments made during the development process and of the product itself. Formative evaluation should begin well in advance of a trial product being ready for learner tryout. As soon as goals are set, instructional analyses carried out, or learner characteristics considered, formative evaluation of the decisions made and processes followed should be done by a development team throughout the development process. Additionally, the product should be examined to assure that it includes the characteristics and features consistent with learning theory and appropriate to the content being taught.

The three pronged approach to evaluation proposed here uses learners as a source of evaluation information but relies as well on content and instructional development experts. Together, the three perspectives provide a comprehensive approach to the development of effective and efficient CAI materials.

## OUTGROWING THE COTTAGE: DEVELOPING COMPUTER-BASED TRAINING ON A LARGE SCALE

*Robert C. Fratini, AT&T National Product Training Center*

Developing, maintaining, and supporting two computer-based training courses is more than twice as difficult as doing the same for a single CBT product. Managing more and more CBT deliverables requires more than simply an increase in the scale of operations. There is a qualitative as well as a quantitative change in the nature of the tasks required.

The Electronic Training Solutions (ETS) department of the AT&T Product Training Center has learned through the experience of such growing pains. By 1991, the department was responsible for the development, maintenance, and support of students using several hundred electronic training deliverables worldwide running on a range of delivery platforms.

The department had recognized beginning in 1989 the fact that its organizational mission and role was changing. Internal processes and software tools were analyzed in terms of their ability to meet the needs of courseware production on the current scale, as well as organizational skills and the corporate product management environment.

This presentation discusses the results of our analysis and provides a status report of our efforts. Software tools, development processes, and the role of CBT specialists have all changed in this new courseware management process. The techniques that we have used are appropriate for any electronic training development group which seeks to tailor their processes and tools to their specific organizational environment.

## THE MANAGEMENT CHALLENGE - CBT AT THE COMMONWEALTH BANK OF AUSTRALIA

*R J Spence*

The Commonwealth Bank of Australia is represented nationally across a network of 1500 branch offices. Training needs, coupled with distance education challenges, has seen the installation of 1200 stand-alone PCs dedicated to CBT. This session outlines the processes that were involved in establishing this large-scale CBT system and then concentrates on system acceptance, maintenance and the management of a courseware development group of 25. Present day challenges include a change in the delivery platform operating system to OS/2.

Selected Abstracts for the

# Special Interest Group for Music Instriction (MUSIC)

## THE USE OF INTERACTIVE VIDEODISC IN ACQUIRING LESSON PLANNING COMPETENCIES FOR MUSIC TEACHING

*Mary Leglar, University of Georgia*

The objective of the program is to introduce preservice music teachers to techniques of instructional planning. The program addresses all aspects of planning for all types and levels of music classes, including performance-oriented classes, general music classes, and specialized classes such as theory and history.

The first phase provides instruction in selecting and formulating objectives. In step 1 short video segments are used to illustrate computer-provided instruction. In step 2 the student practices identifying correctly stated objectives by viewing video segments and choosing behavioral statements that most accurately describe the lesson. In step 3, the student views a video segment and formulates an appropriate objective for that lesson.

The second phase focuses on selecting and sequencing activities appropriate to a given objective. First the student watches a lesson segment and identifies and sequences the activities demonstrated. The student then views several classes using different strategies to teach the same objective, and selects the sequence of activities that most effectively accomplishes the objective.

In the third phase, the student is introduced to various methods of evaluation. He then views selected lessons and chooses the best means of evaluation.

The program is written for the Macintosh using HyperCard.

## ASSESSING MUSICAL ABILITY WITH COMPUTERIZED ADAPTIVE TESTS

*Walter P. Vispoel, The University of Iowa*

One of the most significant recent advances in educational and psychological measurement is the development of computerized adaptive tests. Research has shown that adaptive tests require from 50 to 80% fewer items to yield reliabilities and validities comparable or superior to those of conventional tests (McBride & Martin, 1983; Moreno, Wetzel, McBride, & Weiss, 1984; Urry, 1977; Weiss, 1982). These promising results have led to the development of the first operational computerized adaptive tests, which presently include adaptive versions of (a) standardized aptitude tests, such as the Armed Services Vocational Aptitude Battery (Sympson, Weiss, & Ree, 1982), and The Differential Aptitude Tests (McBride, 1986), (b) college placement tests (Stocking, 1987), and (c) achievement tests for elementary and high school students developed by the Portland Public Schools, the Montgomery County (MD) Public Schools, and the WICAT Systems Corporation (cf. Rudner, 1989).

In prior ADCIS conferences (Vispoel, 1987; Vispoel & Twing, 1990; Vispoel, Coffman, & Scriven, 1990), the present investigator has described research about the first applications of computerized adaptive tests designed to assess music listening skills. Results from two recent computer simulation studies (Vispoel, 1990; Vispoel and Twing, 1990) have indicated that adaptive music tests require up to 67% fewer items to yield reliabilities and validities comparable or superior to those of conventional music tests. This research culminated in the development of MusiCAT, the first operational adaptive test of musical ability (Vispoel, Coffman, & Scriven, 1990). The purpose of this session is to describe results from a "real data" study evaluating MusiCAT. Results from this study, consistent with prior simulation studies indicated that MusiCAT required substantially fewer items to yield levels of reliability and validity comparable or superior to, those of commercially available music tests assessing the same skills.

## SELF-ADAPTED TESTING: A NEW METHOD FOR ASSESSING MUSICAL ABILITY

*Walter P. Vispoel, The University of Iowa*

One of the most important recent milestones in educational and psychological measurement is the development of item response theory. Item response theory enables one to estimate examinees' ability levels and their corresponding reliabilities even when examinees respond to completely different items. This feature of item response theory makes " Computerized Self-Adapted Testing"--a new and innovative assessment method--possible. In a self-adapted test, items are grouped into different difficulty categories, and examinees choose the difficulty level they desire before responding to each item. After answering each item, examinees are told whether they answered the item correctly or incorrectly. The test ends when an examinee's estimated ability level is measured at a pre-specified level of reliability (.80, .85, .90, etc.) or when a pre-specified number of items have been administered (15, 20, 25, etc.). Self-adapted testing appears to be particularly advantageous for test anxious individuals. In two recent studies (Rocklin & O' Donnell, 1987;1991), test anxious individuals achieved significantly higher vocabulary scores when taking self-adapted tests than when taking conventional fixed-item tests (i.e., the same set of items is administered to all examinees) or adaptive tests (i.e., the computer administers items to examinees based on their responses to previous items). In this session, results from a study comparing self-adapted, adaptive, and fixed-item tests of musical ability will be described.

Selected Abstracts for the

# Special Interest Group for PILOT (SIGPILOT)

# SHORTCUTS TO CREATING LEARNING MODULES

Marianne Yoder, Northern Arizona University

The purpose of this presentation is to demonstrate various ways to shorten the length of time necessary to write the PILOT code when developing learning modules. Templates can be created of design elements used often in each module. Assembling the templates when creating a new module can cut down on the amount of programming time. Considerations in designing the templates will be discussed, and demonstrated. Among the templates demonstrated will be: random selection of questions, learner calculator, return to previous screen, global window setting, and teacher's summary (a template for viewing and printing out how the learner did). A handout of the code necessary for these templates will be provided.

Selected Abstracts for the

# Special Interest Group for PLATO Users' Group (PUG)

# NEW FEATURES OF THE CYBIS SYSTEM

*Dean Christensen, Control Data Corporation*

Control Data is making significant changes to the CYBIS (formerly PLATO) system to enhance communications, support additional hardware devices, improved the user interface and take advantage of increasingly powerful workstations. An overview of the new CYBIS system will be presented and new features will be previewed. These features will include:

An Enhanced notes system, featuring
- Full color
- Graphical notesfiles
- 80 column text mode option
- Notesfile compatibility with E-mail systems

CYBIS Workstation Software, featuring
- Interactive Videodisc (IVD) support
- CD-ROM (Compact Disc-Read Only Memory)
- Windowing
- Pull-down menus
- Fine touch grid
- Screen captures and restores
- Image imports

The new CYBIS (formerly PLATO) system will be presented along with the following new features:

An Enhanced notes system, featuring
- Full color
- Graphical notesfiles
- 80 column text mode option
- Notesfile compatibility with E-mail systems

CYBIS Workstation Software, featuring
- Interactive Videodisc (IVD) support
- CD-ROM (Compact Disc-Read Only Memory)
- Windowing
- Pull-down menus
- Fine touch grid
- Screen captures and restores
- Image imports

## COURSEWARE EVALUATION

*C. B. Dunnagan, Control Data Corporation*

This presentation addresses one way that developers of computer-based instruction may have their courses evaluated and recommended for college credit. In 1979 Control Data had several of its courses evaluated and recommended by the American Council on Education (ACE). The number of courses has expanded and now numbers more than 50. The ACE evaluators are subject-matter specialists in the field under consideration. Evaluators are solicited from postsecondary educational institutions, professional and educational associations, and accrediting agencies recognized by the Council on Postsecondary Education. The review team may include one practitioner from a noncollegiate organization.

The presentation further discusses the benefits such a course evaluation has for potential students, present and future employees in the knowledge-based/information age, and colleges entering the distance learning field.

## AUTHORING UTILITIES THE HIDDEN POTENTIAL OF PLATO

*Robert Elmore, Control Data Corp.*

For more than two decades PLATO (now reborn as CYBIS) has been known as a comprehensive instructional system, combining quality interaction and graphics, a huge library of courseware and possibly the best user communications system available anywhere. What it has lacked is an easy way to author courseware.

As part of the new suite of features being made available on CYBIS Control Data is including several authoring utilities. This presentation will outline this "toolbox" concept of an authoring environment, where a variety of authoring tools, from models to authoring systems to authoring languages, is made available to fit the needs of different authors and different applications. It will also briefly introduce each authoring tool with some examples of courseware developed using these tools.

The authoring tools will consist of the following:

Authoring models

The authoring models will include tutorial, simulation, case study, drill/practice and testing models.

Authoring Systems

Two or more CYBIS-based authoring systems will also be presented. These authoring systems will allow authors more flexibility than the authoring models, but will not require programming skills.

## REPACKAGING: ONE KEY TO COST-EFFECTIVE TRAINING

*Elizabeth Miller, Control Data Corporation*
*Cheryl Shankman, Hughes Training Systems*

Frequently companies reject "canned" training materials with the cry, "That's nice, but that's not what we do!" Upon closer inspection many of these programs contain 80 - 90 percent of the necessary training, but are missing the 10 - 20 percent that customizes it for a company or department's specific needs. Using real-life examples from DoD, industry, and manufacturing, the presenters will discuss their experience with "repackaging" existing materials and/or developing new materials to provide cost-effective training solutions.

## USING A WORD PROCESSOR TO DEVELOP COMPUTER-BASED INSTRUCTION

*Kevin Stall*

Many developers and designers neglect one of the most obvious tools that make a programmers life easier. Using a word processor can increase not only the developers and designers productivity, but also the programmers. By using macros and other techniques the programmer will be able to do all the programming utilizing the word processor. This is particularly true with Plato.

Selected Abstracts for the

# Special Interest Group for Theory and Research (SIGTAR)

# THE EFFECTS OF VARIED LEVELS OF INTERACTIVITY IN IV ON LEARNING AND SOCIAL PROCESSES

*Margaret L. Bailey, Arthur Anderson & Company*
*Dr. Jack Byars, Kansas State University*

Much of the research to date in interactive video has focused on comparing IV to CAI or stand-alone video. Few studies have attempted to define and vary the unique attributes of interactive video and systematically compare the effects on learning and the social environment. This presentation will discuss a research project which investigated the effects of varied levels of interactivity (defined as the number of opportunities for computer-user interaction) in an interactive video physics lesson on learning and social processes.

Students enrolled in a college-level physics course were paired and assigned to one of three interactivity levels (No, Low, High) of an interactive video lesson. Data was gathered and comparisons made on students' ability to retain and transfer lesson concepts, as well as attitudes toward the learning environment. In addition, a detailed analysis of the peer interaction patterns, as obtained through audio-tape recordings, was completed.

Preliminary results indicate that while High levels of interactivity may result in significantly more positive attitudes, Low levels of interactivity result in greater retention of lesson concepts. Transfer effects, in this study, while somewhat greater for the High interactivity treatment, were not significantly greater than No or Low interactivity levels.

In addition, it was found that social interaction was progressively more frequent as interactivity levels increased. However, detailed analyses reveals that a greater percentage of the interaction among peers in the High interactivity treatment can be classified as procedure-related (reading aloud, asking for suggestions as to what to do next) rather than task-related (asking/answering content questions, giving explanations).

This presentation will conclude with a discussion of the implications of this research and suggest future areas of study in interactive video software design.

# COMMUNICATION STRUCTURE ON AN ELECTRONIC TEACHERS' NETWORK

*John R. Broholm, University of Kansas*

This study examined the communication patterns and relationships among teachers using an electronic mail (E-mail) and shared database system. The system of interest, UNITE, was designed and implemented specifically for primary and secondary schools, including users and resources in all teaching content areas. The effects of teaching content area, school level, and participation in a collaborative teaching project were studied as communication constraints on UNITE.

Schools have been characterized as work environments where teachers w rk in isolation from each other. Yet teachers maintain a norm of interactive behavior that puts some emphasis on collegiality -- their willingness to be helpful and cordial to one another balanced against autonomy in determining exactly how they will teach. A new medium, computer-mediated communication (CMC), is being introduced into schools, and may have profound effects on how teachers communicate with each other.

A network analysis revealed that users of the UNITE electronic mail system seemed to overcome the constraint of spatial distance between communicators quite effectively. However, being in the same teaching content area was a significant structural parameter of communication -- possibly the most powerful parameter extant. School level was also a significant constaint, but participation in a collaborative teaching effort did not prove significant.

A clique-detection program, NEGOPY, found two clusters of communicators on UNITE, one larger and relatively heterogeneous, the other smaller and largely made up of librarians. Science teachers were the largest group using the system, but librarians used it more heavily than other teachers, mostly to communicate with librarians in other schools, which was an extension of their communication routines when not using CMC. As with most new technological systems, a few individuals accounted for a disproportionate amount of use.

# THE EFFECTS OF COMPUTER SELF-EFFICACY ON DIRECTION-FOLLOWING BEHAVIOR IN COMPUTER ASSISTED INSTRUCTION

*Randal D. Carlson, The Pennsylvania State University*
*Barbara L. Grabowski, The Pennsylvania State University*

In many cases, instruction requires that students precisely follow directions provided to them. This may be especially important in the case of computer-aided instruction (CAI) where the individual navigates through the instruction independently. In this case, cavalier attitudes toward following directions may result in the learner becoming "stuck" or confused. In spite of the importance of this instructional design issue, there has been little prior research which examines various patterns of direction-following behavior. One important aspect of this issue is understanding what types of individuals attend to and follow directions.

In this study, a CAI lesson provided the framework to study the relationship between direction-following behavior and computer self-efficacy, participation in military training programs, and gender. A sample of 57 undergraduate students completed a module designed to provide them with the computing skills necessary to perform elementary operations on the mainframe operating system, VM/CMS. Students' direction-following behavior was measured by counting the number of directions in the CAI program that were properly followed. Their confidence in their ability to use a computer was measured by a Computer Self-Efficacy scale developed by Murphy, Coover, and Owen (1988). Analysis of the results using ANCOVA to control for time indicated a main effect for ROTC membership and a disordinal interaction between gender and self-efficacy in relation to direction following behavior. In addition, the covariate, time to complete the instructional module, was found to be significantly related to direction-following behavior. Reasons for the discovered relationships, implications for instructional design, and suggestions for future research are presented.

## CENTER FOR INNOVATIVE INSTRUCTIONAL TECHNOLOGY

*Sine Farrell, PhD, U. S. Army Construction Engineering Research Laboratory*

1. How do a University and a Department of Defense Research Laboratory collaborate to serve each population in attaining objectives of a "Center for Innovative Instructional Technology"?

2. Can criteria be developed by which problems can be classified to ease the task of matching situation/technology and anticipated audience?

3. Can the Center's area of expertise be usefully expanded with the Army problems and the Research Laboratory open this unique service to other DoD problems. These are a few of the probing questions that are the basis of a research project currently underway at U. S. Army Construction Engineering Research Laboratory (USACERL) and the University of Illinois. The University provides a rich and deeply committed foundation in Instructional Technology. USACERL is replete with examples of unsolved or poorly solved problems that can best be addressed by Instructional Technology. Interagency cooperation and the fostering of "mentoring" or leadership roles in any pursuit of learning are encouraging the mutual relationship put forth in this research.

Discussion will focus on the process of establishing and nurturing a center. It will present results and recommendations from other related research, current objectives and measures, as well as future goals and applications. Implications and recommendations for future research will also be presented.

## VIEWER PERCEPTIONS: MODEL SCREENS VS. ACTUAL SCREENS

*R. Scott Grabinger, University of Colorado at Denver*

This session reports results from a study which examined viewer perceptions of a variety of display screens to identify constructs to guide the design of those screens. Specifically, the study examined the effects of CRT screen models vs. actual screens from CAI programs on viewer preference and the relationships among viewer preference and viewer field articulation (field dependence/independence) and conceptual style (relational/analytical).

## A PROPOSED TAXONOMY FOR THE DESIGN, STUDY, AND EVALUATION OF INSTRUCTIONAL SYSTEMS

*Dale Y. Hoskisson, Valley City State University*

Researchers are constantly comparing one instructional system with another. Computer-based systems are being compared with "traditional systems." But these studies often provide no help in improving instruction because they do not tell us much about the system itself. We need to have a way to describe an instructional system independent of the medium used or the theory espoused. This presentation explains a proposed taxonomy for instructional systems that would allow the researcher and the consumer to evaluate a system independent of medium or theory. This approach describes the ability of a system to manipulate information to facilitate learning. Such a taxonomy will make comparing systems a more useful and viable activity for research. The language consists of:

- an objective classification and presentation description element based on Merrill's Component Display Theory
- a measurement of interactivity from static to dynamic
- terminology to describe interactivity addressing such items as number of facts (facts is used in a very general way here) presented, method of connecting facts, time allowed to connect facts, pacing, and information for problem solution
- a presentation mode component—discovery, expository, or combination
- a complexity component—simple to complex.

The presentation will include the results of applying the language to four representative instructional systems which will include print-based and level three interactive videodisc systems.

## THE FORMATION AND IMPACT OF USERS' MENTAL MODELS IN HUMAN-COMPUTER INTERACTION

*Hueyching Janice Jih and Thomas C. Reeves*
*The University of Georgia*

Computer users struggle to understand the structure and functions provided by various programs and to learn the correct procedures of operation for programs that are supposed to help them accomplish tasks. Often a program is designed form the designer's points of view and not from the perspectives of users. As a result, users end up lacking the clear conceptual understanding about the software's structure and functions that the designers have. This problem can be especially acute when users are given the freedom to explore hypertext materials in which the possibility of user disorientation is a major concern. Currently, there is a growing concern about exactly what users know about computer programs in terms of users' mental models.

Mental model theory is an attempt to model and explain human understanding of objects and phenomenon during learning, in problem solving, and when we are reflecting on or attempting to rationalize or explain the system's behavior. 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.

What is a user's mental model of a computer program? What is the distinction between a computer program, the designer's conceptual model of the program, and the user's mental model of the program? How does a user develop his/her mental model of a specific program? What is the role of users' mental models in human-computer interaction? How could the mental model aspect influence the design consideration of computer programs? These are the central issues that this article will discuss.

## COGNITIVE OUTCOMES OF BUILDING EXPERT SYSTEMS

*David H. Jonassen*
*University of Colorado*

Researchers and businesses are investigating the effects of having students and employees construct expert system rule bases. What is important are the cognitive effects of the construction process more than the resulting advisors. Expert systems can be thought of as cognitive tools engaging learners in cognitive and metacognitive learning outcomes. This project proposes to investigate the changes in critical thinking skills, cognitive learning strategies, and metacognitive skills that result from employees and students constructing rule bases. Changes in individuals' knowledge structures will also be investigated.

## SECOND GENERATION INSTRUCTIONAL DESIGN

*Mark Jones and Dave Merrill*
*Utah State University*

The overall goal of the Second Generation Instructional Design ($ID_2$) Research Program is to develop a comprehensive new generation of instructional design theory and methodology, and to build a set of intelligent tools that aid the designer in applying the theory. There are a total of six funded research projects currently active in the program.

Dave Merrill will summarize the latest theoretical advances that have resulted from the research, and Mark Jones will demonstrate the most recent software developments.

## THE GENERATIVE EFFECTS OF GRAPHIC ORGANIZERS WITH COMPUTER-BASED INTERACTIVE VIDEO

*Richard F. Kenny, Syracuse University*
*Barbara L. Grabowski, Pennsylvania State University*

This presentation reports on the results of a study of the use of graphic organizers in conjunction with an interactive video on Nursing practice. Twenty nine university Nursing juniors were asked to complete three of four modules of a CBIV program entitled Nursing an Elderly Patient with Chronic Obstructive Pulmonary Disease. With each module, participants were presented one of two forms of pictorial graphic organizer: Final Form Graphic Organizer (filled in) or Participatory Graphic Organizer (with various blanks to be filled in). Participants completed two posttests: immediately after the third module and one week later.

The purpose was to investigate the differential effect of the organizers on immediate and delayed learning according to Wittrock's Generative Learning Hypothesis; that is, comparing the amount of learning from the final form graphic organizer to that from the more generative participatory graphic organizer. Further, the investigation examined the interaction between the graphic organizer treatments and the cognitive processing style of students who are analytic (those who have the ability to abstract a common dimension across stimuli) or holistic (those who have the ability to construct a whole from information about its parts).

It was hypothesized that the more generative (Participatory Graphic Organizer) treatment group would achieve a significantly higher mean score on both Posttest 1 and Posttest 2. As well, it was postulated that the less generative (Final Form Graphic Organizer) treatment group would display a significantly greater mean loss score (from Posttest 1 to Posttest 2). Results did not support these hypotheses but provided some evidence in favor of advance organizer theory. Note-taking behavior on the part of most participants may have provided a substantial confounding factor. Neither analytic nor holistic ability appeared to interact with the treatments. These results will be discussed as well as implications for instructional design and further research.

## AN INTERACTIVE VIDEODISC INSTRUCTIONAL DESIGN STUDY IN TEACHING SKILL ANALYSIS

*Kirk E. Mathias, Arkansas State University*
*Eric E. Smith, University of Northern Colorado*
*Thomas M. Adams II, Arkansas State University*

Researchers within the field of educational technology have called for discipline specific applications. Such applications would allow for improved research in that they would increase control and allow for better identification of factors that influence the effectiveness of interactive video instructional applications. Specific applications which best meet the capabilities present in interactive video still need to be studied. Therefore, the purpose of this study was to analyze interactive video instructional design features relative to analyzing skills in swimming. Specific objectives of this presentation are to introduce multiple regression results on six subjects who experienced an interactive video treatment in learning analysis of swimming techniques. Instructional design features to be presented include time of instruction, competency levels on specific modules, and repetition of modules relative to final gain scores.

## THE EFFECTS OF STRUCTURE AIDS ON LEVEL OF LEARNING AND EFFICIENCY IN AN INSTRUCTIONAL HYPERMEDIA ENVIRONMENT

*Timothy L. Phillips, The University of Iowa*
*Ginger Watson, The University of Iowa*
*Jay Cook, The University of Iowa*

Hypermedia allows learners to customize the instruction to meet their needs. However, in implementing hypermedia-based instruction the effects of the following factors should be considered: learner disorientation, cognitive load, and learner control. Hypermedia-based instructional environments require learners to make numerous branching decisions. Research has indicated that learners are not always capable of assessing their instructional needs. Secondly, learners must keep track of their current location and the information path taken, in order to not become disoriented. Many learners find the demands too great and become disoriented. The combined cognitive load of learner control and learner orientation may result in reduced comprehension.

One possible way of reducing the cognitive load of a hypermedia environment is the use of structural aids. Structural aids (outlines, indexes) have been found to aid learners in organizing and comprehending information. Different types of structural aids have been found to effect both the quantity and level of learning. It has been suggested that providing learners with a structural aid would reduce the cognitive load on the learner resulting in increased comprehension. Therefore, the purpose of this study is to evaluate the effectiveness of Structural Aids (hierarchical index, alphabetical index) on Level of Learning (Fact, Inference) in a hypermedia lesson.

## THE EFFECTS OF GENERATIVE CONCEPT-MAP STRATEGY IN CBI

*Lawrence C. Ragan, Penn State University*

The generative learning theory proposed by Wittrock and others describes meaningful learning occurring when the learner generates, or constructs new meaning from presented stimuli, and existing knowledge and experiences. Incorporating generative learning strategies into CBI presents a unique set of challenges to todays courseware developers. Generative strategies embedded in the software may elicit specific learning outcomes. This presentation will present the results of research on the effects of one generative learning strategy, the concept map technique, on comprehension scores measured an instrument designed after Royer's Sentence Verification Test. The research hypothesis is directed at examining the effects of generating concept-nodes and relationship-links on comprehension of textual passages about a fictitious country in Africa.

Based on schemata network theory and spatial learning strategies by Holly and Dansereau, a HyperCard-based technique was developed that enables the learner to generate concepts-nodes and the relationships-links between those concepts after the presentation of information. The two treatments in this study consisted of one group that constructed a concept map representation of the the textual passage, and one group receiving system supplied concept map representations of the textual passage. This seminar will demonstrate the generative concept-map HyperCard stack as well as discuss results from the pilot study conducted in the spring of 1991. Plans for future research based on the pilot study will be explained as well.

## DEVELOPMENT OF AN INTELLIGENT TUTORING SYSTEM IN ACCOUNTING

*Thomas H . Rowley, Georgia State University*
*Michael A. Orey, The University of Georgia*

It is difficult to develop interesting and highly interactive computer-based instruction (CBI) in accounting. The reason for this difficulty include the fact that accounting is a rule-based discipline, and accounting learning is perceived to be linear. That is, the conventional teaching model is to build a student's knowledge base incrementally along a carefully developed path. Conventional teaching strategies require a structure (syllabus) that outlines the expected procedural growth of a student's knowledge-base. Use of conventional teaching models to develop CBI often result in 'page turning' tutorials.

Faculty who are seeking technologically sound, interactive vehicles for accounting education will be interested in the recent developments fo educational technology. Intelligent Tutoring Systems (ITS) may be one such development that may impact on accounting education. This type of technology permits learners to work on problems while a "smart" tutor monitors their progress. In this way, fundamental misconceptions can be eliminated before they become so entrenched that it would be difficult to correct that misconception.

This presentation describes the conceptual development of an ITS to provide accounting students with assistance in learning the concepts and principles of preparing a statement of cash flows. The presentation will first summarize the background literature from the perspective of prior CBI efforts and identifies the success factors for development of ITS. The second section describes the design process for an ITS application in accounting.

## EXAMINING EDUCATIONAL SOFTWARE FROM A CULTURAL PERSPECTIVE

*Penelope Semrau, Ph.D., California State University, Los Angeles*

Research has demonstrated that different cultural groups perceive and decode visual materials in different ways (Heinich et al, 1982, p. 67). Yet, Digranes and Digranes' research (1989) found that instructional materials specific for various cultural groups was virtually non-existent.

How are women portrayed in the images seen in educational software products? Are women shown in successful careers? How about men? Are men shown as nurturing, caring beings? Are there just as many images of women as men; or, is there a greater volume of male images? Are the elderly and the physically impaired represented equally with images of the young and physically able? What cultural values are being projected through the software regarding Latinos, Asians, and Afro-Americans?

How does one analyze the visual images in educational software from a cultural perspective? In this presentation guidelines for examining images from software products such as Reader Rabbit and Carmen San Diego will be discussed. The speaker concludes that certain values and attitudes are being projected and learnt by children while using the software. When educators evaluate software, they need to be concerned with the underlying cultural values being taught.

## ADAPTIVE ON-LINE HELP FOR CONCEPT DEVELOPMENT

*Doris S. Shaw, L. Michael Golish,*
*Julie L. Webster, and Der-Shung Yang,*
*U.S. Army Construction Engineering Research Lab*

Our previous research found that embedded instructional systems were effective for teaching computer-aided design (CAD) to architects, engineers, and technicians. Also, understanding CAD concepts, how the system functioned, was instrumental in increasing the design effectiveness of users, and experience in similar systems was a significant factor in learning those concepts (Shaw, 1988).

Recent research examined the effectiveness of a different approach to teaching CAD concepts. On-line help aimed at presenting conceptual information was designed to supplement the procedural help that had been available in our previous instruction. The program was set to direct users with some experience to the conceptual help screens when they requested "help". Asking for "more help" showed them the procedural help. When the learner indicated that he/she was not experienced, the procedural screen appeared first, but the conceptual help could be seen by requesting "more help." The system was implemented with an adaptive feature that would exchange the initial help screen setting if the user continuously requested "more help."

Fifty-four adult professionals responded to a survey that indicated the learner's satisfaction with the help system. Novice users who consulted the help screens profited greatly from the help and felt confident that they could use the system. Learning style and previous conceptual understanding influenced the other three groups. Some learners experienced in other systems reported a high level of understanding without the use of help, but those who requested help did not always profit from it. Novices who did not select help often found the lessons difficult.

## DESIGNING MICROCOMPUTER-BASED INSTRUCTIONAL SIMULATIONS: IMPLICATIONS FROM COGNITIVE PSYCHOLOGY

*Richard A. Thurman and Joseph S. Mattoon,*
*Air Force, Armstrong Laboratory*

The entrance of the microcomputer into the educational system resulted in an increased interest in the design and use of computer-based instructional simulations. This type of simulation has the potential to enhance the transfer of learning by teaching complex mental and procedural tasks in environments that approximate fairly realistic settings. However, many of the microcomputer-based instructional simulations produced today are poorly designed from a psychological standpoint and therefore do not provide an effective learning environment. This presentation represents our attempt at identifying areas in the psychological literature which have important implications for the design and use of instructional simulations. In this presentation we focus on five major issues: (a) cognitive structure, (b) cognitive strategies, (c) metacognition, (d) automaticity, and (e) affect. Each issue will be explored by summarizing representative research and findings, and by presenting implications for the design and use of instructional simulators.

# CBT APPLICATIONS OF KOLB'S EXPERIEMENTIAL LEARNING THEORY

*Michael Yacci, Rochester Institute of Technology*

Kolb's Experiential Learning theory is a descriptive theory about how people learn. Briefly, it suggests that learners can be divided into four quadrants based upon the way they process information. However, it can be used as the basis for a prescriptive model of instructional design, by creating instruction that sequentially moves through each quadrant, therefore appealing to a learner's strengths while simultaneously challenging the learner to process information in new ways.

This theory can be used in the design of CBT and Interactive Video as a guideline for engaging the learner and taking him or her through the four learning quadrants. This presentation suggests that there are techniques and methods of CBT design that correlate with the cognitive processes that occur in each quadrant, and that a CBT lesson based on Experiential Learning can use these methods in a deliberate manner. Experiential Learning suggests a prescriptive sequence for common CBT strategies and techniques, such as online notepads, hypertext, tutorials, and simulations.

Selected Abstracts for the

# Special Interest Group for Telecommunications (TELESIG)

## THE UTRECHT TELECAI-PROJECT

*Drs. J.P. Bakker, Hogeschool Utrecht (Utrecht Polytechnic)*

In the Utrecht TeleCAI-project 20 students from Utrecht Polytechnic study at home using courseware and a telelink with the teacher. The telelink is used for transfer of logged data from the CAI-lessons and for electronic mail between students and teacher.

Main objectives of the project are to decrease time and place constraints for the students (flexibile learning), to increase personal teacher support and to decrease traffic at rush-hour.

Results of the project after one year are that the e-mailsystem served well for exchange of questions, for delivery of extra exercises and for exchange of information about study-progress. The use of e-mail for personal messages was less than expected. Direct interpersonal contacts were preferred. The logged data was a good predictor of study-success. Students appreciated very much the flexibility of the learning process, but found the (standard) e-mail service still too cumbersome to use.

The end-conclusion was that the introduction of telematics as a learning tool shifts the roles of teacher and students. It takes time to find new ways for both. The e-mail system must be more user-friendly and specifically dedicated to the learning task.

The project is a unique experiment in the Netherlands and will continue on a larger scale in 1991/92.

## COMPUTER COMMUNICATION-FOUR INNOVATICE PROJECTS AT PENN STATE UNIVERSITY

*Barbara Grabowski, Penn State University*

The purpose of this symposium is to describe four projects being implemented at Penn State University. The symposium will begin with an overview of innovative instructional uses of electronic communication as demonstrated by an advisory tool developed using HyperCard. The presentations will consist of :

INSTRUCTIONAL USES FOR ELECTRONIC COMMUNICATION: AN ADVISORY TOOL FOR NOVICE FACULTY USERS

PROBLEM SOLVING AND LOGICAL THINKING with
--CLASSNEWS-- AN ON-LINE COMPUTER DIALOGING FACILITY FOR THE CLASS,

ENHANCING COMMUNICATION WITH A COMPUTER CONFERENCING SYSTEM AND DEOS - THE DISTANCE EDUCATION ON-LINE SYMPOSIUM

TEACHER COLLABORATION THROUGH REGIONAL AND STATEWIDE BULLETIN BOARD SYSTEM

ELECTRONIC COMMUNICATION: A SYNTHESIS AND CRITIQUE.

The presentations will describe three different uses of the medium and present implementation results. Finally, all of the presentations will be synthesized and critiqued by the discussant.

# SCIENCE INSTRUCTION ON GLOBAL ELECTRONIC NETWORKS

*Michael L. Waugh, University of Illinois at Urbana-Champaign*
*James A. Levin, University of Illinois at Urbana-Champaign*

Real world science is conducted in global contexts, with collaboration among colleagues around the world a common occurrence. With the spread of microcomputers into science classrooms and the availability of electronic networks, it is now possible to conduct science instruction in such global contexts as well. This presentation will discuss ongoing research and development efforts concerning ways in which electronic networks can be used in science teaching and learning. Electronic networks can allow students to participate in distributed science problem solving activities by providing "dynamic support" so that students can gather and analyze data and jointly create project reports with students from other parts of the world. Several of these "telescience" activities will be described in detail. In one activity, students from across the United States have been engaged in data collection and data analysis activities related to estimating the circumference of the earth. In another activity, students and teachers participated in the collection and analysis of data concerning the cost, nutritional value and appeal of typical school lunches. The session will conclude with a discussion of the potential for electronic networks to improve science teaching and learning.

Selected Formal Papers From the

# Special Interest Group for Academic Computing (SIGAC)

# COMPUTER AIDED TESTING MAKES STUDENTS WORK REGULARLY (AND INCREASES TRANSFER RATES DRASTICALLY)

*M.W.J.W. Dijkman, Delft University of Technology*
*R.H.A. Staal, Delft University of Technology*

**Abstract**
First year university science courses often have an hierarchical content. Hence it is very important that students work regularly. Weekly computer aided testing stimulates students to follow a regular pattern of studying. This gives them a great help and shows clear increases in the transfer rates of 3 mechanics courses in the first and second year.

**Introduction / educational context.**
In the last 25 years the developments within many Dutch universities were strongly determined by a large increase in student population and at the same time a constant or decreasing number of lecturers available, especially in the first 2 years of the study.

At the Technical University of Delft the student population in several faculties was roughly doubled from about 150 to over 300 per year. Because of the lack of good trained teaching staff many small classroom lectures for about 30 students (tutorials) were stopped and the only way to give the student oral instruction was to give lectures in the large auditorium with one lecturer for 300-400 students.

This was especially the case for the courses in mechanics in the first and second year. The idea was that by means of good books for selfstudy and other written teaching facilities students hopefully would have the same results as in the former situation with more teaching and exercise facilities in small classrooms. Moreover in that time many people inside and outside the universities clung to the theory (or belief) that the students had to be treated as complete independent creatures who could pave their own way through the jungle of the university courses and exams.

So the tendency was that teachers were not for teaching, but for producing textbooks, other written materials and exams. Besides that the system of examination changed also in those years. It became a very free system; every exam could be done as many times as the student wished.

This however turned out not to be a good approach to education at a technical university, at least not for the courses like mechanics. Although in many occasions the results of the exams were not that bad (around 50 %), the transfer rate of the students through the curriculum decreased dramatically. Many students postponed the exams untill the next year(s), because they started too late doing exercises by themselves.

In 1988 the faculty of Civil Engineering switched from a system of many parallel courses, in which each course is taking several months to over half a year, to a modular system of short courses, which each take 4 or 8 weeks, with only 2 courses running at the same time.

So the lecturers of mechanics in the faculty of Civil Engineering were placed for the serious problem: "How to get students working immediately, without seeing or knowing them personally".

In that situation the call for Computer Aided Instruction was obvious. From the beginning the starting principle of the task of the computer was not to teach or instruct the student difficult parts of the courses, but it had to serve as a kind of testing machine for the student to see for himself whether he is studying in the right way and to give him a bonus for the coming exam. It must motivate the student to start working in time at home. For that purpose in the years '89-'90 an interactive testing system has been developed, which is used for several courses in mechanics in the first and second year of the faculty of Civil Engineering. These are Mechanics I (MI), Fluid Mechanics (FM) and Mechanics II (M I). MI is taught in the first year and FM and MII in the second year.

The description of the system and the effect on the transfer rate of the students through the courses are described below.

**Organization of the courses**
We will describe the organization of the MI

course in more detail. The organization of the other courses is equivalent.

Mechanics I is a basic subject which is taught in many technical and science curricula. In our university the average student spends 80 hours on the subject. Lectures are given in the very first block of 4 weeks of the first year for Civil Engineering students. At the same time only one other course is taught in that block.

The learning material consists of a book and an additional study guide, indicating the topics which are dealt with in the lectures and the exercises which the students have to do at home.

Out of the 80 hours which are available for this subject, 20 are devoted to lectures for a group of approximately 300 students. In the remaining 60 hours students are supposed to study by themselves. To stimulate this self activity five computer tests have been implemented which were originally obligatory for all students. Each test concludes a chapter and has to be done approx. 2 days after the chapter has been dealt with in the lecture. The first test has to be taken in the very first week of the first year.

Four groups of approx. 75 students are formed. Each group has one and a half hours to accomplish the test and as a result in 2 afternoons the testing of 1 chapter for a total of 300 students is complete. A written examination concludes the subject. The final mark for the subject is obtained for 70 % by the written examination and for 30 % by the tests. The written examination must have a minimum of 4.5 out of 10, otherwise the test result doesn't count. The tests can only be done once and the test result is only valid for the subsequent written exam. When the students are working on the tests they are allowed to use their book and all the other study materials; when they do the written examination they are only allowed to carry a pen, a pencil and a pocket calculator.

The only difference with the courses M and MII is that FM is taught in 2 blocks (8 weeks, 120 hours) and that both are taught at the end of the second year(not parallel).

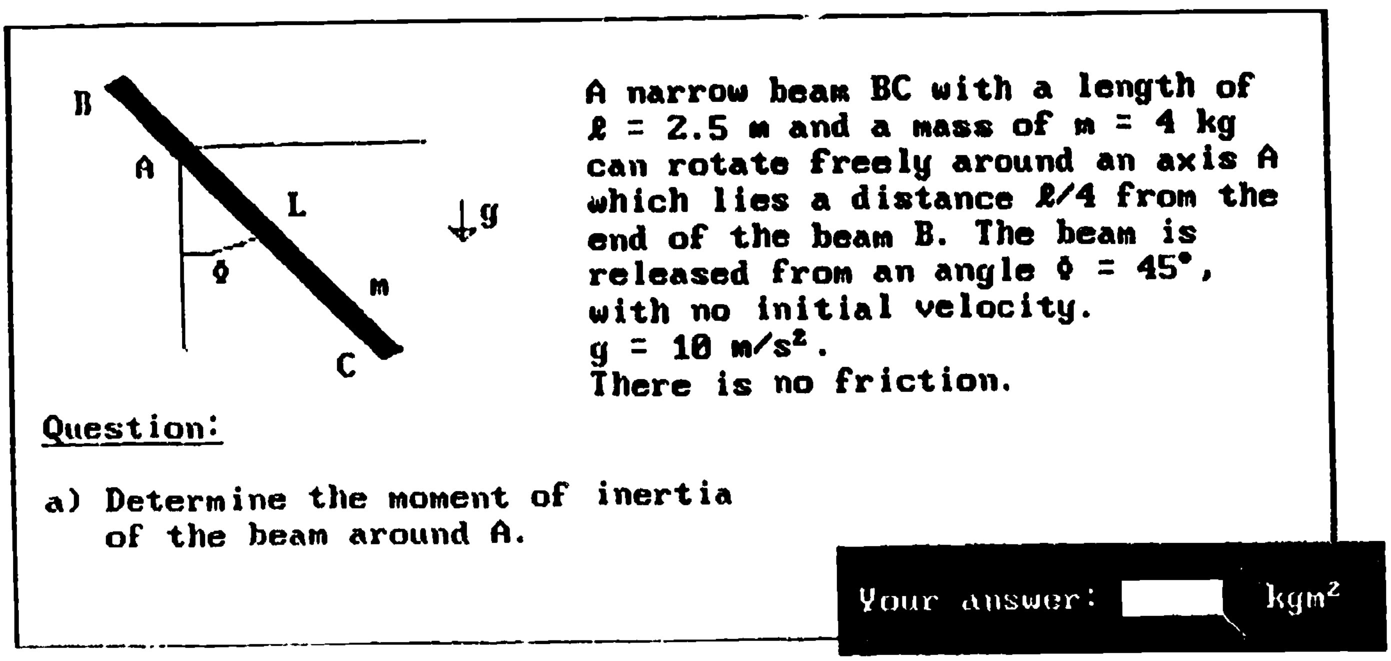


Figure 1. Example of a question in the computer tests.

**The tests.**

Every computer test consists of approx. 7 questions. Every question requires one numerical answer from the student. An example of such a question is given in figure 1. The student is allowed to answer three times. The first wrong answer may be a calculating error and will subtract only 1 point from the maximum of 10 points which can be obtained per question. The second wrong answer "costs" the student 3 points. The student can also get help if he wants. This help consists of instructions which guide the student to find the right approach to the solution of the question. If the student asks for help he loses 3 points. When the student answers wrong for the third time he loses all points. After that the computer immediately gives the right answer.

Just like in a "normal" test the student can stop a question and return to it afterwards. The computer stores the status of the question in its memory.

To avoid that students get the same questions each problem type has four alternative questions of the same type, out of which randomly one is chosen. In addition the computer randomly chooses values for two variables, between a lower and an upper limit. This makes every answer to a question practically unique. This answer is calculated by the computer in real time by means of an algorithm.

**Results.**

In the MI course the regular computer testing has been used for 2 years; in the FM and MII courses for only one year.

In table 1 we present the data concerning the participation of students on the tests and the written examination, the results of the final examination and the transfer rate after the subsequent examination. These data have been compared to the situation in which the course was taught in the "classical" way, without the computer tests. In the academic year '88/'89 the MI course was conducted in this way for the last time. It was then spread over 2 - 8 weeks, along with several other courses that were running simultaneously. In the year '89/'90 the FM and MII courses were conducted in the "classical" way for the last time.

| | M I | | | F M | | M II | |
|---|---|---|---|---|---|---|---|
| | 88/89 | 89/90 | 90/91 | 89/90 | 90/91 | 89/90 | 90/91 |
| Total number of students | 310[1] | 250[1] | 300[1] | 230[2] | 185[2] | 230[2] | 185[2] |
| Number of participants in tests | | 237 | 280 | | 105 | | 105 |
| First-time participants subsequent examination | 188 | 228 | 254 | 107 | 120 | 70 | 120 |
| Result of subsequent examination > 5 (pass) | 64 % | 66 % | 64 % | 59 % | 74 % | 81 % | 76 % |
| = 5 (comp.[3]) | 11 % | 14 % | 15 % | 12 % | 18 % | 7 % | 9 % |
| < 5 (fail) | 25 % | 20 % | 21 % | 29 % | 8 % | [illegible] % | 15 % |
| Transfer rate (overall) | 42 % | 73 % | 65 % | 30 % | 60 % | 26 % | 59 % |
| Transfer rate (pass only on written examination) | 39 % | 60 % | 54 % | 27 % | 48 % | 25 % | 49 % |
| Improvement factor | ----> | 1.5 | 1.4 | ----> | 1.8 | ----> | 2.0 |

[1] 1st year; [2] 2nd year, estimated; [3] 5 means: 5 out of 10, can be compensated.

Table 1. Data for the courses Mechanics I (M I), Fluid Mechanics (F M) and Mechanics II (M II).

If we compare these data, we have to be careful to do an "honest" comparison. Taking the test result into account does affect the final mark for the course. Therefore we have also included the transfer rate of students who passed the written examination only. The level of the questions in the final examination has not been affected by the different way of running the course. Hence we assume the comparison to be fairly honest. It is striking that the transfer rate (pass only on written examination), defined as: number of students who passed the written exam divided by total number of first or second year students, has increased significantly for all 3 courses, whereas the pass rate for the examination , defined as: number of students who passed divided by number of students who participated in the examination, remained nearly constant. The increase of the transfer rate can be mainly ascribed to the strongly increased participation of students on the written examination. Apparently the chang es in the way the course was taught cause a decrease in students neglecting their regular work for the course. An important remark we wish to make is that it cannot be fully determined whether this is only caused by the introduction of computer tests or also by the introduction of block/modular teaching. If we compare the data from the 3 mechanics courses with other courses that have changed to the system of block teaching, but which use no computer testing, we see that for the latter the transfer rates have not increased.

**Effects on study behaviour.**

Of course the time that students spend on the course is an important factor. According to the norm the students are supposed to spend approx. 80 hours on the MI course. From time measurements in '89/'90 it appeared that students spent an average of 75 hours on the course. This can be called satisfactory, especially taken into account that the number of contact hours was limited. For the FM and MII courses the figures are equivalent. Students express a very positive attitude towards the computer tests. In a written inquiry they clearly indicate that the computer tests stimulate them to work regularly on the course. Competition between students is stimulated by the fact that students do the tests together in groups of 50 and their results are immediately available. Inside the test room students work conciously and outside the test room vivid discussions arise between students about the right solutions to the questions. The students are working actively on the tests in an atmosphere of mutual competition. The increase in student motivation, as compared to previous years, is also noticeble in the lecture theatre. Apart from motivation, competition also increases stress. To a certain extent stress can work positively on motivation, but we ask ourselves how far one can go. It does not seem desirable to implement this system for all courses in the first and second year.

The tight organization of the course (the tests have to be done in groups at a scheduled time) is experienced as very positive by the students, and not at all as scholastic . On the other hand it urges the lecturer to organize the computer tests perfectly, because students are distracted easily by small weaknesses in the organization of computer aided testing, especially because they take it very seriously.

**Conclusions.**

The conclusion seems justified that these computer aided tests are a good and effective means to stimulate students to work regularly on mechanics course. The positive results of the system can be ascribed mostly to the computert tests, together with the introduction of block teaching. Block teaching itself, without computer tests, does not increase transfer rates. Students react positively if the system is implemented in several courses in the first and second year. The system has a positive result on the transfer rates, or, more generally, a more regular way of studying can be stimulated throughout the whole curriculum by these computer tests. It requires a good attuning of learning materials, lectures, computer tests and written examination. Hence a perfect organization is necessary. Finally it is our belief that, for courses like mechanics, the computer tests give the student a good alternative if the personal assistance from an instructor in tutorials is not available.

**Literature.**

Information on the authoring system used to produce the computer tests can be found in:

Laagland, E.F. (1986). TAIGA, a graphic authoring system . In: Proceedings of the 27th ADCIS Conference on Computer-Based Education and Training (pp. 84-89). New Orleans, LA.

Selected Formal Papers From the

# Special Interest Group for Computer-Based Training (SIGCBT)

# SETTING THE SCENE: SIMULATIONS IN CBT

*Linda Blumstein and Rich Boyer*
*The Emdicium Group, Inc.*

**Abstract**
CBT has proven to be an effective medium for training. However, it achieves its full potential when simulated scenarios are incorporated into lessons. Scenarios provide realistic situations and allow learners to practice tasks within specific job functions. This paper discusses the theory for using scenarios within CBT and specific examples from actual courseware. The examples include data entry functions, a product planning system, a customer service situation, a publishing system, and a collections system.

**Introduction**
Developments in technology over the past few years have produced many new ways of using computers to provide training and improve job performance. In this paper we first provide a brief review of literature defining what simulations are and how they are used to improve learning of job-related skills. Then we show how we've been able to incorporate simulations into actual training situations.

According to Niehoff and Romans (1987), training programs have traditionally provided transfer of knowledge and skills. When applicability on the job was largely unsupported, then knowledg and skills were lost. "Research has shown that learning by active participation is much more effective than listening to lectures. Adults, especially, want meaningful, practical learning experiences which they can put to work immediately" (Niehoff and Romans, 1987, p. 3). The content is important to adult learners. They want to work on solving specific problems and finding real solutions. When this happens there is a greater likelihood of skill transfer to the job.

As microcomputers become more powerful, realistic scenarios are being designed and developed for an increasing number of industries using computer-based training (CBT) simulations. Corporations, insurance companies, manufacturers and finance companies use simulations that "feature decision making and management skills in realistic scenarios" (Haslam, 1990, p. 10). Banks and credit companies are training tellers in on-line tasks via simulations.

What is a simulation? According to Spannaus (1978) "simulations operate under fixed rules, relationships, and models" (p.16). Haslam (1990) states that "a simulation is an operating model of the central features or elements in a real or proposed system, process, or environment" (p. 10). The model for a simulation must contain the relevant cause-and-effect relationships, producing consequences as a result of the student's actions or decisions. In a simulation, learners become aware of, and deal with, constraints and demands simultaneously. A simulation "is dynamic as opposed to static; includes only selected elements of the referent system; and includes different types of referent systems" (Haslam, 1990, p 10).

Simulation participants interact with the setting by making decisions and dealing with the consequences of their actions. Simulations include "playing roles, achieving goals, performing activities with constraints and payoffs, and linkages with all of these" (Haslam, 1990, p. 10). In order for the activities to be of value, learners must be aware of the relationships. The simulation activity must be related to real life, it must be based on a model of reality. The objectives of the simulation "must be at the level of application" (Spannaus, 1978, p. 17).

The use of scenarios in computer-based training simulations allows the learner to "devise strategies to solve problems and tap opportunities" ("Management Training," 1987, p. 58). Scenarios written for computer-based simulations allow us to use computers to "improve specific work-related performance and productivity" (Ganger, 1989, p. 116). Effective skills training usually involves training that simulates the job or skills to be performed. Formal computer-based training using realistic scenarios in simulations relates directly to this concept.

The following examples, created by The Emdicium Group, Inc., demonstrate the use of scenarios in CBT simulations that is directly applicable to job skills needed by the learner. In these examples the learner is actively participating in his/her learning and solving job-related problems, as well as gaining practical skills.

**Examples 1 and 2**

By using realistic scenarios when developing CBT simulations, we provided the learner with specific job-related problems for them to solve. Ganger (1989) describes the use of a computer-based training simulation with "maximum transferability to actual work procedures." The following CBT simulations were developed to train data entry procedures. Scenarios were created using simulated data so that training mistakes did not affect the integrity of the real database. But the procedures taught were real because the training medium was the same as the work medium.

***Health Care Benefits***

At a major manufacturer, personal benefits representatives (PBRs) were sending paper forms to the company's insurance carrier to change information on employees' benefits records. The insurance carrier offered a new system that let PBRs access the carrier's computer system and enter the changes themselves.

Computer-based training was used to teach the PBRs to convert the manufacturer's codes to codes used by the insurance carrier using a jobaid provided by the insurance carrier and enter changes to an employee's record using the form filled out by the employee.

We developed a printed Learner's Guide to set up scenarios involving common changes that PBRs would encounter. The guide contained reproductions of forms filled out by employees and portions of the jobaid for conversion of codes.

Use of scenarios that directly related to the PBRs' jobs enabled the PBRs to learn and become productive with the new system in about three hours.

***Publishing***

A publisher was implementing a major new system to handle its customer and advertising databases. Implementation involved reorganization of workflow and departments, and totally changed the way in which many employees performed their jobs. Furthermore, training for the system had to take place during negotiation of a new contract with the employees affected by the new system.

To ensure that employees had enough practice to feel comfortable with the new system, we produced about 4,000 scenarios to be used with computer-based training and a training database. Learners attended 30 two-hour sessions scheduled across a four-month period. At each session, learners received 20 to 40 minutes of computer-based training and then practiced with a packet of scenario exercises on the training database.

During the training, learners managed to overcome extreme resistance to the change occurring in their workplace. The heavy use of scenarios allowed them to fully understand the change and prepare for it before the new system was implemented. The intensive practice with a training database in short sessions over a long period of time allowed learners to gradually adapt to the new system and work on accuracy and speed.

When the system was implemented, users were able to switch immediately to their new job responsibilities and maintain the same level of productivity. Even when problems arose from incorrect or incomplete data conversion from the old system to the new, users were able to quickly identify the problems and devise solutions using the new system.

**Example 3**

According to Clements (1988) relevance of scenarios to the target population is also of paramount importance. Clements uses the term case study which we refer to as scenarios. "In order to provide relevant simulation to each employee subpopulation, a case study bank must be developed concurrently with the training. Many cases may be universally relevant to major subpopulations such as hourly or salaried employees. Universal case studies are those in which the root circumstance is familiar to the overall population. Case studies must also be included which represent the unique or high-risk circumstances peculiar to smaller subpopulations" (p. 9). In the following example, we created a simulation that allowed different audiences to access only those scenarios that were relevant to their specific job functions along with a universal scenario which was relevant to the overall population.

***Product Planning***

A manufacturer was preparing to implement a new system for the planning of new products. The system would bring together information entered and used by nine different job functions in five departments. Users would be scattered in many locations throughout the US, and would use the system to communicate all decisions and information concerning the planning of any new product to be offered by the company.

Although each one of the nine job functions used only a portion of the new system, users needed an understanding of the overall flow of the system and the interaction among tasks performed by the individual job functions.

We developed a universal scenario to first present the system flow and interaction among tasks. We created a brief video showing the involvement and decision making for the various job functions. We then developed CBT to guide learners through the progression of tasks performed by all functions. The CBT simulated the planning of a plausible new product from start to finish.

After the overview of the system, each learner took additional CBT lessons that gave detailed instruction on the specific tasks to be performed by the learner's job function. Instruction for the tasks used the same universal scenario from the overview, thus allowing learners to review the overall flow and to learn how their specific tasks affected others using the system.

**Example 4**
Smith (1988) discusses the need for assessing competence in order to provide accreditation for vocational qualification. He states that "to carry out such a wide-ranging assessment on-line in a high-speed, high-volume continuous process is unlikely to be considered a practical proposition, especially as regards assessing competencies in fault diagnosis and correction" (p. 68). In another article ("Management Training," 1987) the author indicated that "business simulation programs allow companies to develop and test management skills in a risk-free context" (p. 58). In the following example we assessed skill competency by creating a simulation of a realistic situation to evaluate the learner performance.

***Collections***
A finance company was implementing a new on-line system to track collection of delinquent accounts. Users had to interact with the system while they were talking with customers on the phone.

Because of the sensitive nature of the tasks involved, the company wanted to be sure learners could correctly interpret information received over the phone and enter the information, correctly coded, into the system.

In order to make the evaluation as realistic as possible, we scripted and recorded a series of phone conversations on tape. After listening to a scenario on the tape, the learner had to use the simulated system to inquire for specific information and enter data related to the taped phone conversation. Using the CBT simulations and taped conversations, we were able to evaluate the learners' ability to use the new system properly and correct for errors without affecting a real customer.

**Example 5**
Smith (1988) also points out that learning takes place as a result of "doing something, thinking about it, drawing out general principles from the experience and finding a way of testing conclusion" (p. 67). Activity is essential for effective learning to take place. In the following example we provided activities to help learners develop and consolidate sound conceptual understandings of their job and the required performance by simulating it, and allowing "free play" with parameters affecting the system.

***Customer Service***
A company was replacing the computer system used in its pharmacies. The new system had a consistent, intuitive design that allowed users to complete 90% of their tasks from one screen. Because of the excellent system design, training could be kept to a minimum, allowing learners to attempt simulations of tasks and receive instruction only when necessary.

We developed computer-based training employing a story line of the pharmacist's "first week" of using the new system. By simulating a week in the pharmacy, scenarios could logically cover common activities as well as those occurring only occasionally.

On the first "day" of the simulated week, scenarios introduced all the common features of the system. In these lessons, the instruction was overt, making sure that all learners received the basic information necessary to use the system.

On subsequent "days" of the week, scenarios provided learners with the stimulus for tasks (prescriptions, health care cards, etc.) and allowed them to practice tasks within a simulated environment. If learners completed the tasks correctly, no prompts or instruction was given. If learners experienced problems or requested help by pressing the system help key, the simulations would then display instruction specific to the task.

**Summary**

As the above examples show, the use of scenarios in CBT to create realistic simulations offers a number of benefits to the training situation. The learning process is dynamic, not static and therefore the learner is involved in his/her own learning as a participant. Active participation allows the learner to take control of his/her own learning. Learners are able to develop higher-order thinking skills when participating in simulations that focus on problem solving. They must not only act, but analyze, recall, synthesize and create solutions. Use of CBT simulations reduces training time as learners become competent in relevant tasks and job skills in a shorter period of time. The reduction in training time also reduces training costs over time. Also, built-in assessments pinpoint areas that need improvement and therefore training becomes cost efficient. Use of realistic scenarios in CBT simulations improves learner performance and decreases training costs and time.

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# QUANTITATIVE AND QUALITATIVE EVALUATION IN FLIGHT TRAINING

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**ABSTRACT**
This paper deals with a research field trial at Boeing Commercial Airplane Group. The question we attempted to answer here is whether CBT training delivered in a crew (dyad) mode is more efficient, effective, and perceived more positively by the student than CBT training delivered in an individual mode. Implications for Computer Managed Instruction (CMI) will also be addressed.

**STATEMENT OF THE PROBLEM**
Computer Based Training is utilized by the students at Boeing Commercial Airplane Flight Training on a one student one terminal basis. Their actual work environment is a crew of two. This presents a question as to what is the best way to train students, in an individual environment or in a crew (dyad) environment.

There are several factors that one must take into account when making a decision to change a training delivery method:

1. More efficient use of the Computer Based Training hardware.
2. More effective instruction through the use or availability of contingent feedback as a direct result of pairing students into crews.
3. Reinforcement of cooperative learning and cooperative work skills. This is in support of the AQP from the FAA. The FAA will be requiring new approaches to training, one of these is training in Cockpit Resource Management (CRM).
4. The cultural factor, approximately 80% of the students come from non-English speaking countries
5. The affective component. How will the students feel about this type of training.
6. The effect of the Advanced Qualification Proposal(AQP) from the Federal Aviation Administration (FAA).

The mission of this training organization is to provide the most efficient and effective training possible. This is a great responsibility as the recipients of this training are responsible for thousands of lives every day.

The question that this research will attempt to resolve is the following:

**Training with CBT in a crew mode (dyad) is more efficient, effective, and perceived more positively by the student than CBT training delivered in an individual mode.**

**LITERATURE REVIEW**
A review of research literature finds a number of studies conducted in:
- -Cooperative learning
- -Dyad/triad groups on Computer Based Training/Computer Assisted Instruction for children
- -Crew training for tank operators in the army on CBT or simulators
- -Flight simulator training for aircrews in the military and civilian environment

Nothing specific was found about the use of CBT in a crew mode for pilot training.

The review was directed to find all applicable articles that were directly or tangentially related to the problem statement. Implications are listed at the end of each review to relate findings in the literature to the problem statement under investigation.

**SUMMARY OF FINDINGS**
1. Students working in pairs worked significantly more problems on the CBT than those working individually on CBT. (Fisher et al, 1975)

**Implications:**
Working as a crew could be more efficient and take less time to accomplish the same tasks as an individual learner.

2. Pairs that work together and vocalize (talk through) the problem solving or concept learning strategies necessary for accomplishing a learning task appear to have higher mastery of the material and better retention than individuals or pairs who do not vocalize. The ability to explain to or work with a partner allows the learner to form his or her own strategy for problem solving. This allows for longer retention of information and more accurate recall of information. Instructional time is more efficiently used by individuals but more effectively used by pairs when problem solving is considered. (Durling et al., 1976), (Johnson et al., 1985), (Carrier et al., 1987)

**Implications:**
Crew training seems to be more effective in the areas of problem solving and enhances retention of training. Efficiency in terms of time on task of the crew based system may be less but seems to be offset by the effectiveness of this approach over the individual approach.

3. Student vocalization and interaction during CBT with the second person acting as a confederate (learning together) or a teacher (one teaching the other) was more effective than vocalizing to an experimenter (someone not involved in the process with the student by either supporting the student or being taught by the student). (Carrier et al., 1987)

**Implications:**
Talking through the procedure or task during the instruction session with your partner is more effective than explaining it to someone not directly involved with your task.

4. Contingent feedback (information about what you did wrong, why and how it should have been done better) was more effective than generic feedback (No, try again, etc.). (Gilman, 1969) This type of feedback could be supplied by the lesson or by a confederate who has more content knowledge.

**Implications:**
Designing this type of beneficial feedback into a program is costly. Creating an environment for this type of feedback through crew training could allow this type of feedback to occur naturally through interaction between members of the crew.

5. Students working in pairs requested contingent feedback more often than those working alone. (Carrier et al, 1987)

**Implications:**
Asking for specific feedback may imply that you are cognitively processing the information at a deeper level. Students working together appear to be spending more time processing this information, thereby contributing to the transfer and retention.

6. Studies of three/four students per terminal; two per terminal; and one per terminal found that the three/four per terminal groups completed the training faster and with less variability in their training times than students in other conditions.(Okey and Major, 1976)

**Implications:**
Grouping students together may allow them to finish at a more standardized (homogeneous) rate than individually or in smaller groups. This has implications in scheduling training sessions.

7. Individuals in groups learn as well as individuals working alone with conventional computer-based training, however, they take somewhat longer to complete each lesson/module. In spite of this, large cost savings resulted since the group took significantly less time than had each individual working alone. (Cartwright, Glenn, Cohen, Penny, 1977)

**Implications:**
Consensus appears to have a positive effective on a crew-based CBT configuration. Training in a group may be more efficient.

8. Individualized learning can take place in a group setting through the use of differential interpretation of feedback. The student maintains his/her own response and compares it to the feedback offered by the computer. In this way learning may occur among several members of the group as they are able to test their own hypothesis independent of the group. (Cartwright, 1976)

**Implications:**
The lesson should be designed to accommodate students who want to test their own hypothesis while working in pairs or in groups. This may prove to be an inefficient method of providing feedback to the learner.

9. Peer tutoring and cooperative learning have yielded significant gains in increasing academic achievement. Cooperative learning benefits both the high and low achieving students. (Moersch, 1987)

**Implications:**
The main principle in cooperative learning lies in the philosophy behind positive interdependence. This goal emphasizes the need to be concerned about the performance of all the group's members as well as the individual's. Individual accountability ensures every student's mastery of assigned material is assessed, each student is given feedback on his or her progress and the group is given feedback on how each member is progressing so that the other group members will know who to help.

This approach has positive implications to the issue of AQP and CRM training.

10. CBT delivered in a crew mode was more cost-effective than individualized CBT. Training time was significantly lower and less variable for the crew-based CBT students than for the students in the individualized mode. There seems to be some disagreement regarding students of low ability. Schlechter in his report cited Morrison, (1986) who found that individualized training elicited better performance with low ability students than a crew-based approach. He also cites Hagman and Rose (1983) who state that the low ability students tend to benefit more from crew-based than individualized. (Schlechter, 1986) A well designed Computer Managed Instruction (CMI) package that collects both quantitative and qualitative data would help to resolve this issue.

**Implications:**
Pre-tests may be given to students with the goal of separating out the low ability from the high and pairing them equally. This could allow the lower ability student to have the type of differential feedback that would be necessary to learn the material and give the higher ability student the opportunity to process the information more deeply by explaining it to the lower ability partner. There is a frustration factor that will have to be dealt with here, some higher ability students will feel held back if matched with a lower ability student and may object to this. This could be a subject for further research.

**METHOD**
The decision to use a Crew Computer Based Training approach should be supported by empirical data collected by an assessment of the performance and attitude of the students in a crew and individual setting. The attitudinal assessment will be done with the same group of students in both individual and crew approaches.

**Proposed assessment procedure:**

a. Select lessons to be used in assessment. In this case all the CBT lessons (71) will be used.

b. Design assessment approach and tools. There were three tools designed for this study:
   1. A demographics form
   2. An attitudinal survey form for the crew and individual approaches.
   3. A Computer Managed Instruction (CMI) Program
   4. A qualitative data gathering capability will exist with the CMI program to allow the students to leave individual or crew comments on the lesson or particular frame (screen of information). This will allow more accurate analysis of their areas of concern.

c. A field test was done with Subject Matter Experts and Leads to obtain formative evaluation feedback on the process and instruments.

d. Identify students to be used in test. Assure that they are a representative sample of the student population. Students were selected from the next five classes to arrive at the training center. A total of 40 students were to participate in this study.

e. Data gathering was planned to be done by observation, survey questionnaire, interview and Computer Managed Instruction. The CMI program was not available as scheduled but the implications of it's use will be discussed. The crews were divided into two groups, A and B. The first group took the first half of the CBT lessons in a crew configuration and the second half in an individualized configuration. The group B students did the opposite. This gave us the opportunity to have all CBT lessons taken in both configurations.

f. Analyze data
Data from the demographics form were consolidated for a descriptive treatment of the students as a whole.

Data on performance in the CBT lessons was to be gathered unobtrusively through the use of the CMI program. This is the data that would allow us to examine the efficiency and effectiveness of the two delivery modes.

The data to be captured is:
- Student Identification
- Time through the lesson
- Response latency on practice items
- Number of correct answers in a lesson
- Number of times the student has gone through the instruction and the practice section of the lesson
- Individual/Crew Comments on the lesson

g. Make recommendations
Recommendations will be made after a significant number of students have gone

through the training.

**PARTIAL RESULTS**

The following is a description of an on-going study. Computer Managed Instruction Results: The gathering of Computer Managed Instructional data has been delayed due to limited programmer resources.

**Affective Results:**
**N=21**

1. Learning on CBT as a crew was more effective (better).
   Range 1-5, X = 3.7 , SD = .98

2. Learning on CBT as a crew was more efficient (faster).
   Range 1-5, X = 3.95 , SD = 1.13

3. Pro-Crew: Open ended responses: (not all students responded)
   -Very happy about crew approach
   -Consultation was good
   -Discussion was good
   -Two persons are more active, it's more difficult to fall asleep

4. Learning on CBT as an individual was more effective better).
   Range 1-4, X = 2.95, SD = 1.21

5. Learning on CBT as an individual was more efficient (faster).
   Range 3-4, X = 3.43, SD = .73

6. Open ended responses: (not all students responded) Pro-Individual:
   -I can go at my own speed
   -I can repeat questions
   -I didn't like the crew because my partner wanted to go faster.

7. Overall I liked ____ best (not all responded)
   -Crew 9
   -Individual 7

**IMPLICATIONS AND RECOMMENDATIONS**
**EARLY IMPLICATIONS:**

1.The research literature implies that paired (crew)learning can be more effective than individualized learning when the pair can verbalize as part of the learning activity.

   A possible restructure of lesson flow to incorporate procedure activities that require verbalization from both crew members could enhance retention of the procedural knowledge and make for more effective instruction.

2.Paired learning is somewhat less time efficient than individualized learning, however there is a larger benefit to be realized in the retention of knowledge over time. If we are able to double the efficient use of each CBT workstation by using the crew concept we will more effectively use the resources in our CBT instructional area.

   Any incremental increase in training time in the individual vs. crew approach could be offset by the increase in effectiveness and overall quality of instruction.

3.Crew training would have to be coordinated with individualized testing. This could be done with a content and procedural knowledge computer based testing approach.

**Implications for Using Computer Managed Instruction in the Collection of Data**

In using the Instructional Systems Design model one of the areas that is usually omitted or not done well is the evaluation step. A formative evaluation is usually done in order to initiate full-up production in a timely manner. The summative evaluation usually left for the end is forgotten or done in a rather cursory manner.

We will now discuss the design and development of a Computer Managed Instruction system that will allow the formative and summative evaluation to be performed in a timely and objective manner.

The Federal Aviation Administration (FAA) has released an Advisory Circular (AC) that has been signed and is in effect. This AC proposes an Advanced Qualifications Program (AQP) that will change significantly how the air industry performs the training function. It specifies a systematic approach to design and development as well as a methodology for the validation of training performance through the use of performance objectives.

The tracking of the student performance on these objectives must be reported. The development of these objectives and the results of the student's performance must be trackable through the use of an Instructional Audit Trail.

This section of the paper will describe the development of CMI in light of gathering data on the crew vs. individual debate.

**AQP Evaluation requirements**

Evaluation in the terms of the AQP must have

the following components:
- -Careful appraisal of an individual
- -Standards required for a specified level of proficiency
- -Instructional Audit Trail
- -Criticality Analysis, the impact of substandard performance on safety.
- -Performance objectives must be systematically maintained, developed and validated.
- -Formative and summative evaluation must be conducted
- -Use of the Instructional Systems Development model

**CMI Definitions**
In order to clarify the function of the CMI program and its' component parts some definitions are in order:

Registration: A function that allows a registrar to identify students to the system and give them an identifier to permit access to the system. This will also gather some demographic data and allow registration of the student to a particular airplane configuration.

Logon: Allow the student access to the CBT lesson menu which fits his airplane configuration. This also identifies the student to the system and initiates the process of data collection.

Course management: This allows the tracking of the progress of classes of students by an instructor/administrator and gives individual feedback to the student as to their progress through the course.

Student performance: The student's time through the lesson, number of correct vs. incorrect responses and their response latency will be tracked.

Data Collection, quantitative, qualitative: Quantitative data will be collected on student performance (above), qualitative data will be collected at the screen level and the lesson level. This data will consist of the student's comments on the quality of audio, video, graphics, technical content level of the lesson and any open ended responses the student may have.

Formative evaluation: This is conducted with prototype lessons and will give immediate, objective data on the way prototype lessons are used.

Summative evaluation: This will give long term or longitudinal data on the performance of students and lessons over time and over diverse groups of students.

Reports for management, instructor, instructional designer: These will consist of student performance, lesson performance, course performance and qualitative feedback from students for overall courseware improvement.

**CMI Implementation for Flight Training**
Our program has certain specific needs that can be generalized to other programs. The ISD process allows us to create courseware of a consistent quality. The main need is to assure that this quality is high. The approach to improving quality is through meeting the following needs:

- -Specific, objective quantitative data collection; student performance data, courseware management
- -The ability to make informed/accurate decisions for future directions of Flight Training
- -Allow for adherence to AQP requirements (future)
- -Collection of comments, qualitative data

**How CMI meets Evaluation requirements**
The use of CMI will help us to collect useful data and allow us to meet the requirements outlined above as well as meeting our specific needs. CMI accomplishes this through the following functions:
- -Individual performance tracking
- -Ability to set a mastery level for each objective or lesson
- -Records / analyzes performance on proficiency objectives across all students
- -Instructional Audit Trail
- -Allows for maintenance and validation of performance objectives
- -Provides methodology for collecting objective data for formative and summative evaluation

Future use of CMI for quality control of training
CMI will be an integral part of our training system. There are a number of future areas that will be examined in the Phase II and Phase III development. Some of these issues are:
- -Computer-based testing - procedure oriented
- -Refinement of revision process for CBT
- -Objective, non-intrusive data collection for research into transfer of training issues.

**Future of CMI**
CMI can also be used across other areas other than strictly in the CBT domain. The future training function cannot stop at the classroom door but must be carried on (and tracked) in other environments and over a longer period of time. Some of these areas are the following:

- -Procedures training (FBS/CBT)
- -Maneuver Techniques (FFS)
- -Operations (airplane)

There are already some approaches in place to use flight data recorder data to recreate scenarios and replay them in a CBT/Simulation session. Further investigation in the use of this type of feedback to the pilot would be useful.

The use of an expert system as a monitor/tutor in a CMI role would allow more efficient presentation of instruction, feedback and testing.

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# COURSEWARE DESIGN IN THE TOOLKIT AGE

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**Abstract**
The extensive capabilities of today's systems have made the development of state-of-the-art courseware a formidable task. To make these sophisticated capabilities accessible to people without extensive programming backgrounds and to significantly speed up program development even for people with such backgrounds rich software toolkits have been developed. The Macintosh toolkit has been around for several years, but Windows 3.0 for DOS systems has only recently come onto the market. In the workstation arena, we are even seeing high level toolkits become available that are built on lower level toolkits, as Motif is built on Xwindows.

The paper discusses how five standard toolkit design elements can be applied to computer-assisted instruction applications: pulldown menus, popup windows, scrollable windows, dialog boxes, and help tools. The author strongly encourages the use of these elements to standardize user interfaces, whether through programming languages or menu-driven authoring systems. He feels that doing so will allow courseware to obtain the standard "look and feel" of other applications and thus help students to concentrate on the subject matter they are trying to learn rather than the mechanics of running the course.

**Keywords:**
computer-assisted instruction
user interfaces
screen design
courseware design and development
software toolkits

**Issues in Courseware Design**

In 1983 I authored a small book entitled Screen Design Strategies for Computer-Assisted Instruction. One of the major issues that book tried to address was to provide a basis for response to James Martin's 1973 lament:

> As yet, no acknowledged sense of style has developed for CAI. ... In the meantime, however, some singularly unstylish CAI programs are being written (Martin, 1973).

Style remains one of the major issues in courseware design to the present day. While human factors research has helped us gain insight into the best ways to use design components such as functional areas, icons, and menus, the capabilities of today's systems have expanded so quickly that researchers have been hard-pressed to keep up with the myriad of developments. The net result is that even as our knowledge grows about what constitutes good courseware design today, we are continually asked to reevaluate our knowledge in new contexts. There are far more choices for courseware designs today than there were when I wrote my book in 1983, and the problem is orders of magnitude more complex than when Martin found it so lamentable in 1973.

Only one factor remains constant: our desire to develop courseware that meets the needs of our students. With today's systems it is easy to become so enamored of the hardware and software capabilities that we lose sight of this desire. The "KISS" (Keep It Short and Simple) principle is often violated as developers fall victim to afflictions such as "font-itis and color-itis" (van Dam, 1990) using too many fonts or colors on the screen at one time. As far back as 1971, researchers found that the excitement experienced by instructors in preparing programs for classroom use did not necessarily transfer to their students (Desmaisons et al., 1971).

The main issue, therefore, is really the same as it was when Pressey introduced his first "simple apparatus which gives tests and teaches" in 1926: how can we harness the truly fantastic capabilities of today's systems to serve the needs of our students? Clearly, there is no simple answer to this question. I attempt in this paper, however, to point the way to the multiple answers provided by the de facto standards evolving out of the programs now available for today's systems.

**The Toolkit Revolution**
It has long been argued that to educators interested in using computers in instruction, programming is at best an undesirable chore and at worst an insurmountable obstacle. Some feel that all instructional developers should have at least a basic knowledge of

programming, while others feel that such knowledge may actually be counterproductive.

One of the strongest advocates of programming is Paul Tenczar, President of Computer Teaching Corporation, which markets the TenCORE family of products. The TenCORE language is a modernized and expanded version of Tutor, the language that Tenczar developed for the PLATO system in the early 1970s. Tenczar argues:

While authoring systems requiring little or no computer literacy can open the field to a wider pool of authors, a "programmerless" authoring environment is as limited as a doctorless hospital. ... Programming is one of the elements required by a professional courseware team... (Tenczar, 1990)

Robert Becker expresses a similar view: Perhaps the most underrated function on an interactive training development team is programming. Programming is generally equated with implementation an uncreative, mechanistic class of behavior that is supposed to follow instructional design and development in lock step...

[Some advertisements foster] the idea that interactive multimedia training can be created without programmers. Because their work is merely procedural rather than creative, why not automate it by using an authoring system? The simple answer is that programming is not merely procedural. It is also among the most creative tasks in multimedia development. A project team that does not solicit design recommendations and guidance from a capable programmer is almost certainly doomed to produce mediocrity even with the best authoring system in the world. (Becker, 1991)

Not surprisingly, advocates of iconic and object-oriented systems take a somewhat different view. One of the strongest advocates of programmerless systems is Michael Allen, Chairman of Authorware, Inc., which markets the Authorware Professional family of products. Authorware is an outgrowth of the PLATO Courseware Design, Development, and Delivery (PCD3) authoring system, developed by Control Data Corporation in the mid-1980s. Allen claims that:

Through evolution of an approach that is graphic, not based on programming, and uses object-based technology, we feel it is actually a conservative statement to say the Authorware products are at least a generation ahead of even the most costly systems, including PLATO. (Allen, 1988)

It must be recognized that although their approaches differ, both Tenczar and Allen have the same goal: to simplify the process of creating quality computer-assisted instruction (CAI). Allen is no more an advocate of having computer neophytes develop CAI than Tenczar is of having courseware developers work in assembly language (Allen, 1990; Tenczar, 1990). On closer examination of their respective products, one notices an interesting regression to the mean: Computer Teaching Corporation now markets TenCORE Producer, a tool that provides many of the basic capabilities of the TenCORE Language Authoring System through a menu-driven interface. And among Authorware Professional's standard set of icons, one notices that within the framework of the deceptively simple "calc" icon, one can actually write code that looks very much like C. In addition, both systems have long acknowledged the desirability of being able to call out to and be called by external programs.

These developments are extremely important to courseware developers. We certainly want to use the powerful capabilities of systems such as TenCORE and Authorware Professional for organizing instruction, managing multimedia presentations, evaluating student input, and tracking student progress, but we cannot afford to be "locked out" when we need additional capabilities that these systems do not yet provide. We need to be able to pick and choose among all options for improving the quality of our on-line instruction. As Gloria Gery (1986) has said, "I want it all!"

This is where the concept of toolkits comes in. Software development on today's systems is indeed a highly skilled task. It is so complicated, in fact, that only the most diehard bits and bytes programmer would relish writing a program with a state-of-the-art user interface "from scratch." Imagine writing a Macintosh mouse device driver and a complete set of menu subroutines each time you wanted to write an application that uses a pulldown menu! To avoid this, the Macintosh provides a "toolkit" of such routines that high-level programs can call. A similar toolkit is now provided for DOS systems in the Microsoft's Software Development Kit for Windows 3.0. In addition, we are now seeing higher-level toolkits that make these routines even easier to use. For example, it wasn't long after MIT made the Xwindows toolkit available to workstation programmers that a higher level toolkit was developed: Motif.

At the user level, the toolkit concept is also critically important, because few people today use only one software package. As the number of packages that any one person uses on a regular basis continues to grow, it becomes increasingly important that these packages:

(1) share a common user interface so that it is easy to move among them, and
(2) can exchange textual and graphic data so that redundant efforts can be eliminated.

Macintosh users have long enjoyed relatively seamless boundaries between software packages, and DOS users are now starting to enjoy the same benefit with Microsoft Windows 3.0. Donald Norman has stated:

... the development of the internal toolbox has caused developers to be consistent in their use of screen, mouse, and key-board, even when their natural tendencies would have led them elsewhere. As a result, most new programs can be used immediately, with little or no study, often without even opening the manual. (Norman, 1990)

Thus, programming toolkits have made possible application toolkits, and already some users are demanding that all applications they consider for use conform to high-level toolkit standards for user interfaces and data exchange. When courseware applications achieve these goals, they can become part of the complete set of software tools that people in all levels of education and training need to get their jobs done. On-line instruction can now become part of a total application package rather than a separate add-on.

**Toolkit Design Elements**

Is it possible to serve the dual masters of student needs and toolkit standards? I think it is. Today's toolkits are rich in interaction styles, most of which lend themselves very well to instructional purposes. The window metaphor is particularly useful, as instructional designs often call for overlaying graphics or the output of other programs with explanatory text. Let us look at five basic toolkit design elements to examine how they can be applied in instructional sequences.

**Pulldown Menus**

Virtually all instructional programs provide their users with choices via menus. Some common applications of menus are:

•selecting the unit one wants to study within a specific course
•switching to another course
•exiting the courseware system altogether
•requesting help on using the courseware system
•requesting help on the course subject matter
•looking up words in a glossary
•responding to multiple choice test items

Over the years, courseware developers have come up with a large number of creative ways to present options such as these to students. Indeed, many different techniques have been shown to be effective. With the advent of toolkits, however, the use of pulldown menus has far outstripped all other techniques. In this technique, a list of main menu options (called a "menu bar") appears horizontally across the top of the screen (or window). When an option is selected, a list of suboptions appears below the main option (see Figure 1).

This type of menu is probably so familiar to most readers that they wonder why I am even mentioning it. That is precisely the point. This type of menu is so familiar because so many programs use it. It is a de facto standard, and it can be generated by routines available in virtually all menu toolkits available on DOS and Macintosh systems. While it is impossible to argue that this is the only viable format for designing menus today, I can argue that unless one has a specific reason that warrants designing menus differently, one should use this format. The advantage is two-fold:

(1) the menu format is so familiar to most students that they need no training in its use on the contrary, many students now consider use of menus in this format intuitive, and

(2) the format is easily implemented through routines available in most toolkits.

Not only is the menu format shown in Figure 1 a de facto standard, but the words chosen for the options, the order in which they appear, and their associated "hot keys" (underlined in the figure) have also become standardized. The interested reader may find extensive discussions of these issues in, for example, Apple's Human Interface Guidelines (1987), IBM's Common User Acess Advanced Interface Design Guide (1989), and the Open Software Foundation's Motif Style Guide (1990). Note that these guidelines also include standards for "pullright" menus submenus of the individual entries on the pulldown menus.

It is interesting to consider what options courseware designers should put on their menus and what actions these options should take to adhere to these toolkit standards. Following is one possibility. Each of the boldface words listed below would appear as an option on the menu bar, with the words in normal text appearing as options on their pulldown menus.

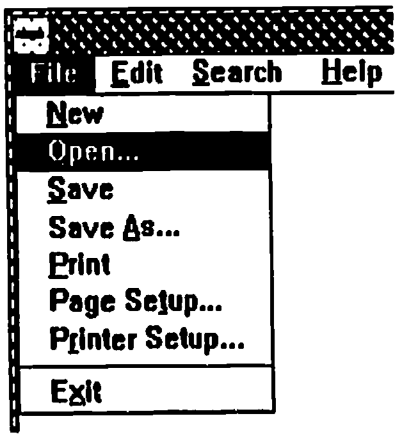


Figure 1. A menu bar and pulldown menu.

<u>File</u>

| | |
|---|---|
| New | switch to a different unit or course |
| Open | temporarily switch to a different unit or course with the possibility of returning to the current unit and course |
| Save | save all data stored on my work up to this point so that I can restart this course at this point after I exit |
| Save As | let me specify the name of the file in which my student data will be stored |
| Print | provide a hard copy of the current page or other data relevant to the course |
| Page | adjust various screen Setup parameters such as colors and type sizes |
| Printer Setup | let me specify the type of printer I want to use |
| Exit | leave the courseware system entirely, with the system saving the data on my work if it has not already done so |

<u>Edit</u>

| | |
|---|---|
| Undo | ignore my last response and let me try again |
| Copy | copy the material I have highlighted to a file so that I can examine it later, perhaps with another software tool |
| Paste | take input from a file I have already created |
| Calculate | give me a calculator that I can use |
| Call | let me call another program and return here |

<u>Support</u>

| | |
|---|---|
| Detail | provide additional details on this topic |
| Example | show an example of the concept being discussed |
| Summary | summarize this section |
| Exercise | present exercises related to the current section |
| Test | test me on this material |

<u>Help</u>

| | |
|---|---|
| Subject | I don't understand this; explain the current subject matter in another way |
| Index | show an index of all help topics |
| Keyboard | provide help on using the keyboard and the meanings of any special key stroke combinations |
| Commands | provide help on the commands available to me at this point |
| Using Help | provide help on using the help system |
| About | tell me the date and version number of this course |

All of the items in this menu structure would not, of course, be relevant to all courses, and others would be needed for some courses. This sample structure does demonstrate, however, that the major properties of the standardized pulldown menu structures we see in other applications can easily be adapted for computer-assisted instruction applications.

**Popup Windows**

One of the most difficult aspects of courseware design is the management of screen space, simply because there is never enough of it. In my 1984 book I devoted an entire chapter to the issue of functional areas, a term I used to refer to the practice of always putting messages of a certain class in the same area of the screen. For example, I recommended setting aside functional areas for instructions, student entry prompts, help feedback, and error messages. It wasn't long after the book was published, however, that I modified my recommendation to include the use of windows (Heines, 1985).

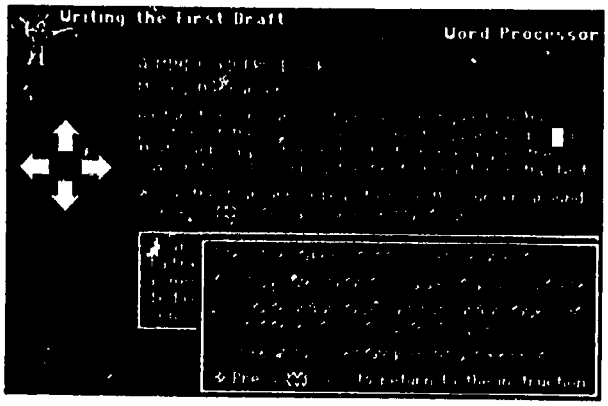


Figure 2. A popup window showing the objectives for the current module. Copyright 1985, KJ Software, Inc.

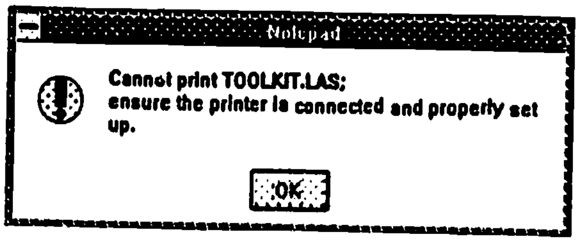


Figure 3. A Windows 3.0 popup window.

Figure 2 shows the use of a window in a course I developed on writing. This window is used to explain the objectives for the current module, overlaid onto a screen explaining how to use the arrow keys in a word processor. Note how the use of a window in this situation maintains the instructional context and lets the student relate the information provided in the window to the task at hand. In addition, it would be impossible to reserve a functional area large enough to display the information in this window. When the student presses Enter, the underlying screen is restored exactly as it was when the student pressed the hot key calling up the objectives display.

The windowing capabilities of today's toolkits are considerably more sophisticated. Consider, for example, the properties of the standard Windows 3.0 information popup window show in Figure 3, which displays an error message for an improperly configured printer. On first examination, this window appears merely to contain four visual elements missing from the window shown in Figure 2:(1) a title bar

(2) a system pulldown menu at the extreme left of the menu bar
(3) an icon (the exclamation point) indicating the type of its message
(4) an OK button to remove the window from the screen

It has two other important properties, however, that cannot be seen visually but that are even more important:

(5) it can be moved about the screen through standard Windows 3.0 protocols
(6) it can remain on the screen while the user takes the actions suggested it is only removed from the screen when the user clicks on OK

This last property is critically important in instructional situations, where if students request help, they typically want it to remain on the screen while they answer a question.

**Scrollable Windows**

Another common courseware design problem raised by my 1984 book is that no matter how interactive and graphic-based we strive to make our courseware, at some point we are always faced with the need to present more text than can comfortably fit on a single screen. In 1984 I argued against pausing between successive displays unless the student had a clear and easy way to get back to the text that was erased when new text was displayed. As much as all proponents of interactivity deplore excessive press-return-to-continue scenarios, I felt that this technique was preferable to erasing information before students may have had a chance to digest it.

Once again modern toolkits come to the rescue by providing us with scrollable windows (see Figure 4). These text presentation tools allow students to view any amount of text in a convenient package. They can advance or backup through the text a line at a time (by clicking on the up and down arrow keys on the vertical scroll bar at the right of the window) or a screenful at a time (by clicking on the scroll bar above or below the position marker). Students can also quickly advance to any point in the text by dragging the position marker up or down.

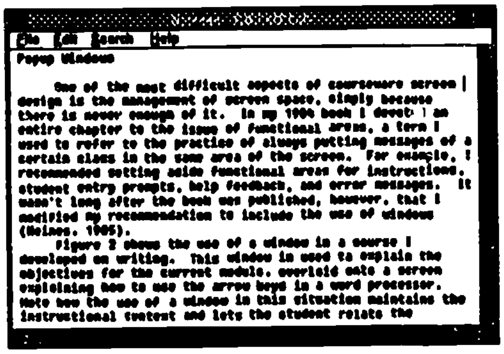

Figure 4. A Windows 3.0 scrollable text window.

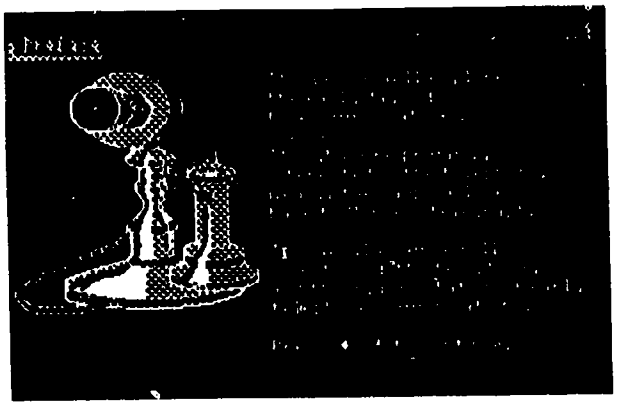

Figure 5. Use of a marker similar to that in a scrollable window to provide orientation information on a student's position in a course.

The marker is the diamond at the left of the line at the bottom of the screen. Copyright 1988, Cooper & Associates, Inc.

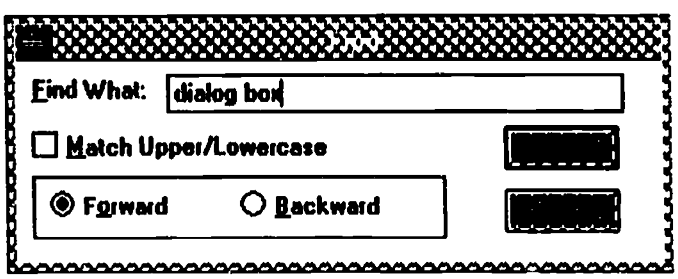


Figure 6. A Windows 3.0 dialog box.

It is interesting to note that the use of a scroll bar also provides important orientation information recommended in my book students can easily tell how far they are through the text by the relative position of the marker. This type of orientation information has been implemented in the Teletutor series of telecommunications courses from Cooper & Associates in Portsmouth, New Hampshire. Their Introduction to Telecommunications course (1988) used a diamond-shaped position marker on a line at the bottom of the screen to indicate the student's position in the course (see Figure 5). Unfortunately, this course was developed before toolkits were available that allow students to move the marker and actively adjust their position in the course.

**Dialog Boxes**

Today's toolkits handle the majority of structured data entry through tools known as "dialog boxes." These tools provide a large number of interaction styles, three of which are shown in Figure 6.

(1) The Find What field is a text entry field or edit box. The cursor appears as a vertical bar and may be positioned using the mouse or the arrow keys.

(2) The Match Upper/Lowercase option is a toggle or check box. Clicking in the box turns this option on, signified by the presence of an "X" in the box. Toggle box options are usually independent; each toggle box may be turned on or off without affecting the state of other toggle boxes.

(3) The Search Direction (Forward and Backward) options are radio buttons. Clicking in either of the circles turns the corresponding option on, simultaneously turning all other radio buttons in the same group off. Radio button options are usually mutually exclusive; only one of each set may be on at any given moment.

Other basic dialog box interaction styles include slider scales, in which values are specified by sliding an icon left and right (or up and down) on a numeric scale, and menu lists, in which choices are presented in a menu and the user highlights the option he or she desires. Detailed information on the use of these styles is provided in Murray and Pappas (1990), Young (1990), and Open Software Foundation (1990).

The interactions in dialog boxes are extremely intuitive, especially when one is using a mouse or other such pointing device. In addition, it is easy to find applications of these techniques in instructional settings. For example, multiple choice questions lend themselves perfectly to radio buttons, while questions such as "indicate all possible values of the discriminant when A=1, B=2, and C=3" lend themselves perfectly to a set of toggle boxes. Use of these toolkit techniques can foster valuable consistency between courses, making it easier for students to concentrate on subject matter rather than the mechanics of specifying their responses.

### Help Tools

The last courseware design toolkit technique I want to discuss is on-line help. The help available on the Macintosh and Windows 3.0 today are highly sophisticated software tools. In fact, writing help for sophisticated applications using these systems is itself a skilled art. These help systems allow users to get context-sensitive help on the task at hand, access an index of all help topics available, backtrack to topics they have seen in the past, browse forward and backward through help on other subjects, and search for help on topics containing specified key words (see Figure 7). In addition, the text may contain "hot spots" graphical or textual on which users may click to jump to linked help messages in a hypertext manner. (Such hot spots are underlined in Figure7.)

Help tools will surely continue to develop until they evolve into complete computer-assisted instruction authoring systems. Indeed, a number of the companies with which I consult are looking at having their software call courseware written in TenCORE, Authorware Professional, or other such tools to provide learning environments for their products. I believe that this level of integration will represent a major shot-in-the-arm for computer-assisted instruction, and truly allow software systems to make possible what Allen has called "Just In Time Learning" the ability "to provide instruction on the user's selected topic on demand" (Allen, 1989).

Occasionally one hears the assertion that toolkits suppress creativity. "Why should we use toolkits that almost force us to conform to a user interface standard that is still evolving?" the resisters ask. "Sure, it makes implementation easier," they admit, "but the price of restriction on our creativity is too high." There are two answers to such arguments, and both are expressed in the main issue I raised at the
beginning of this paper: "how can we harness the truly fantastic capabilities of today's systems to serve the needs of our students?"

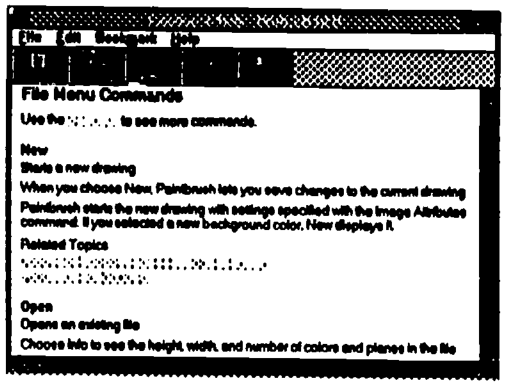


Figure 7. A Windows 3.0 help window. Using Toolkits Creatively

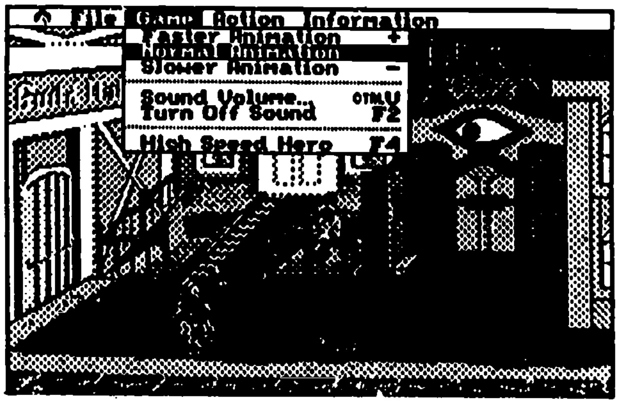


Figure 8. Use of pulldown menus in a computer game.
Copyright 1989, Sierra On-Line, Inc.

The first answer is that today's toolkits are quickly growing in depth and scope, providing an increasingly rich set of user interface techniques that can be applied in highly creative ways. One of the best examples of such creativity may be found in computer games. Figure 8 shows a screen from Hero's Quest I (Cole et al., 1989), a game which makes heavy use of pulldown menus dialog boxes, and other such toolkit techniques that game enthusiasts move through with amazing speed to get to the competition. Such users are seldom interested in implementation issues; they simply want to know the rules and begin competing as quickly as possible. The creativity in these user interfaces can be found in their layout, choice of type fonts, use of graphics, and the options that they provide. The interaction techniques themselves are very secondary especially to the 8-12 year old boys who form the vast majority of these programs' users but they are essentially the same as those discussed in this paper.

The second answer is that we must constantly remind ourselves that the purpose of courseware is to meet the needs of students, not instructors. Most students care very little about whether they select an answer by pressing a key or by clicking a mouse button. They are vastly more concerned with the correctness of their responses than the techniques they use to indicate those responses. The consistency provided by toolkits can virtually eliminate the need for modules that teach how to take a computer-assisted instruction course, allowing students to concentrate exclusively on the subject matter.
We must also keep in mind that the programming/ programmerless authoring system argument is of absolutely no interest to students. Their only concern is with the courseware they must try to learn from, regardless of how it was developed. It is interesting to note that few of us who make a living developing courseware have actually ever taken a CAI course as a student. We have all tried courses out as students, but how many of us have actually taken a course for academic credit in which CAI is the main instructional medium? Courseware development is the construction of a piece of software. The building blocks are computer subroutines, and one may join them together by writing code or by arranging icons representing them in a logic diagram. The important point is not to "reinvent the wheel," but to use standard toolkits so that the product has a standard "look and feel" and can be completed in time to allow revisions when it is tested with students.

It has been shown that few people read manuals before they use familiar devices such as radios, lawn mowers, and microwave ovens. (When was the last time you rented a car in which you could even found the owner's manual?) The user interfaces to everyday devices have become so standardized that their use is intuitive to most children as well as adults. Courseware design based on toolkits will allow us to achieve the same intuitiveness in on-line instruction. We can then focus on our students' needs and spend our time and energy experimenting with creative solutions to problems dealing directly with their mastery of the subject matter.

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# COCKPIT RESOURCE MANAGEMENT TRAINING: MULTIMEDIA SITUATED LEARNING

*Hilary McLellan, Kansas State University*

**Abstract**
Line-Oriented Flight Training (LOFT) for flight crews, developed to promote effective cockpit resource management, is an example of situated learning in a sophisticated multimedia training environment. All six of the critical situated learning components --- Apprenticeship; Collaboration; Reflection; Coaching; Multiple practice; Articulation --- are present in the LOFT training program. The LOFT program has several important implications for designers seeking to implement training in accordance with the Situated Learning Model: 1) the debriefing or reflection process for a team of learners, rather than an individual learner must be designed to provide feedback for both the team and the individual; 2) it is essential to differentiate between training and testing in the situated learning environment and to make sure that this distinction is clear to both the instructor and the learner; 3) the role of the instructor in a situated learning environment must be carefully designed as part of the overall design of the situated learning training program; 4) the selection and training of the instructor must be explicitly considered and planned for in situated learning, as in other training contexts; 5) the pacing and coordination of complex interrelated events in the situated learning scenario or script must be carefully designed in order to promote both realism and learning; and 6) it is necessary to design customized scenarios to meet the needs of different learners.

**Introduction**
A high-technology training program for airline pilots and crew members that has been instituted over the past decade exemplifies the Situated Learning Model of instructional design. Within the airline industry, there is increasing concern with pilots' effective management of human and technical resources in the cockpit, in addition to the technical skill traditionally required of pilots. This new area of concern is called Cockpit Resource Management. One outcome of this concern has been the development of Line-Oriented Flight Training, a program that teaches pilots and crew to work together on a full-length flight mission so that an unexpected series of small problems on a flight doesn't escalate into a catastrophe. Line-Oriented Flight Training (LOFT)

> synthesizes high-fidelity aircraft simulation and high-fidelity aircraft simulation and high-fidelity line operations simulation to provide realistic, dynamic pilot training in a simulated line environment. LOFT is an augmentation of existing pilot training which concentrates upon command, leadership, and resource management skills. (Lauber & Fouchee, 1981)

The LOFT training program provides an example of how the Situated Learning Model can be adapted to computer-based multimedia training. Using complex computer programs, LOFT instructors can create almost any mechanical problem in the aircraft or problems with the navigation aids at the destination airport. Line-Oriented Flight Training provides pilots with training and practice in effective dilemma-handling --- the moment-by-moment contingencies that constitute the conditions of situated actions.

John Seely Brown and his colleagues at Xerox PARC (Brown, 1989; Brown, Collins, & Duguid, 1989) developed the Situated Learning Model in the course of searching to uncover and analyze instances of successful learning that could provide insights for the design of instructional systems. The Situated Learning Model is a promising new paradigm for instructional design.

The new training program for airline pilots that goes by the name Line-Oriented Flight Training (LOFT) is an example of a complex multimedia instructional system that exemplifies the Situated Learning Model. This pilot training program provides an example of how sophisticated computer-controlled training simulators offer the potential for training applications that can take advantage of Situated Learning. Simulators used for training pilots and other professionals who work in technologically sophisticated work environments, such as air traffic controllers and nuclear power plant operators, are now so realistic that they constitute a "virtual" copy of the real-world work environment, with one important difference: safety is not a problem. It is interesting to note that some of the U.S. military pilots who served in the recent war with Iraq trained entirely in simulators. Now that this kind of sophisticated simulator technology is available, how can it be used to promote optimal training? The Situated Learning Model provides some valuable guidelines for harnessing this simulator technology to promote effective learning (Brown, 1989; Brown, etal., 1989). Some simulator-based training programs such as LOFT that are already in use, exemplify the Situated Learning Model. What can be learned from this simulator-based training program --- Line-Oriented Flight Training --- about the design and implementation of training programs that conform to the Situated Learning Model? This paper will address this issue, after first describing the Situated Learning Model and the LOFT training program in greater detail.

**Situated Learning**

Brown and his colleagues developed the Situated Learning Model based on an analysis of successful learning programs. Brown found one highly successful example in skiing, where the learning time has gone down from two years to two weeks. In examining this example, Brown found a "pervasive use of technology," that included several components. The first component was the advent of the chair lift which facilitated multiple practice. With the chair lift, skiers didn't have to expend time and energy climbing back up the ski slope after each run, so the novice skier could get in far more practice runs than ever before. Safety bindings and new, better designed ski boots provided extra support and scaffolding so that a novice skier was less likely to sustain a serious injury and could thus continue practicing longer and more safely, reducing the possibility of injury due to inexperience. In addition, the institution of the Graduated Length Method (GLM), using gradually longer training skis for practice, provided the opportunity for wholistic learning and increasingly complex microworlds. The use of video replays facilitated reflective practice: the learner could review with the ski instructor his or her performance, while actually watching it on video, thereby gaining the advantage of visual feedback, in addition to verbal guidance. This use of video replays was part of a larger improvement in skiing instruction: better models of coaching. Another innovation was to shape or modify the environment in order to let the environment separate and articulate the component skills to be learned. For example, in order to learn gliding, you need to be able to stop. Can these two skills, gliding and stopping, be separated? Yes --- by manipulating the environment, including the steepness of the slope and the length of the skis (Brown, 1989; Brown, etal., 1989).

Brown reports that he and his colleagues at Xerox PARC identified several examples of successful learning, such as the skiing example described above. They identified the features that these examples shared in common and found a set of six useful strategies for successful learning: 1) Apprenticeship; 2) Collaboration; 3) Reflection; 4) Coaching; 5) Multiple practice; and 6) Articulation (Brown, 1989; Brown, etal., 1989). All of these strategies can be embedded in a multimedia simulator-based training system. Indeed, these complex and realistic simulators appear to be ideally suited for facilitating situated learning for jobs in complex technical work environments.

According to Brown, knowledge is situated; it is a product of the activity, context, and culture in which it is developed and used. Activity and situations are integral to cognition and learning. Therefore, this knowledge must be learned in context --- in the actual work setting or a highly realistic surrogate of the actual work environment (Brown, 1989; Brown, etal., 1989).

**Airline pilot training in a situated environment**

Line-Oriented Flight Training was developed in response to information showing that most airplane accidents and incidents, including fatal crashes, resulted from pilot error and poor coordination in the cockpit under crisis situations. It was found that most accidents could have been avoided if the non-flying pilot in the cockpit had taken action. The data indicated that the traditional pilot training required by regulation, concerning technical skills such as how to recover from a stall and how to respond when an engine fails, really did not really address the kinds of problems that resulted in most accidents or incidents. LOFT was developed to address these resource and crisis management issues through training (Ruffell Smith, 1979; Stockton, 1988;

Coffman, 1989).

The LOFT training program provides practice in team building and crisis management (Lauber & Fouchee, 1981). Pilots learn to work together effectively so that an unexpected series of small problems on a flight doesn't escalate into a catastrophe. This training program is designed to promote a work environment where there is a high level of technical skill coupled with a high regard for people. Captains are urged to take charge in their cockpits but at the same time they are encouraged to listen to what other crew members have to offer (Lauber & Fouchee, 1981; Stockton, 1988; Coffman, 1989).

In Line-Oriented Flight Training, the goal is to replicate, as closely as possible, the actual flight environment, complete with delays, adverse weather, even unruly passengers (Lauber & Fouchee, 1981). Evidence suggests that crews often get into trouble when they get distracted by the unexpected. They sometimes forget procedures designed to ensure safe flight operations. The premise underlying LOFT is that by having flight crews practice handling those kinds of distracting situations in sophisticated simulators, they will be prepared for real-world emergencies. Using complex computer programs, LOFT instructors can create almost any mechanical problem in the aircraft or problems with the navigation aids at the destination airport.

On a typical LOFT simulated flight, more than one thing goes wrong. Rather than catastrophic problems, the LOFT crew encounters a series of small difficulties that demand teamwork and coordination. In the Line-Orieted Flight Training simulations, there is no instructor intervention; the crew is allowed to follow its own course wherever it may lead. The consequences of crew decisions and actions during a LOFT scenario mount up and impact the remainder of the trip in a realistic manner. In the best LOFT programs, a television camera records the flight crew, pilot and co-pilots, at work. After the simulated flight is over, an instructor sits down with the crew to critique the pilots' performance. These debriefing sessions are where the learning really occurs. Ideally, there is no punitive aspect to the training. The emphasis is on encouraging pilots to change their habits, rather than on forcing them to do so (Stockton, 1988; Coffman, 1989).

Effective resource management involves the management of human error. According to Lauber and Fouchee (1981), " Effective resource management recognizes that under some circumstances, such as high-workload situations, human error is likely; steps must be taken to reduce the probability of error." Errors, when they occur, must be detected and corrected, in order to minimize the probability of adverse impact upon the overall safety of the operation. Just as it is necessary to practice landing skills in order to gain and maintain aircraft-handling proficiency, it is necessary to practice human-error-management skills. Training in effective error management requires the presence of errors or error-inducing situations.

The LOFT training program for flight crews is an example of situated learning in a sophisticated multimedia training environment. All six of the critical situated learning components --- Apprenticeship; Collaboration; Reflection; Coaching; Multiple practice; A iculation --- are present in the LOFT training program. Within the simulated flight, the environmental conditions are controlled, modified, and articulated by the instructor to simulate increasingly complex conditions. The learning environment is contextually rich and highly realistic. Apprenticeship is present since the instructor decides on what array of interlocking problems to present on each simulated flight. The pilots must gain experience with different sets of problems in order to build the skills neccesary for teamwork and coordination. And they must learn to solve problems for themselves: there is no instructor intervention during the simulated flights; LOFT crews are allowed to follow their own course wherever it may lead. Reflection is scheduled into the training after the simulated flight is over, when an instructor sits down with the crew to critique the flight crew's performance. This involves coaching from the instructor as well. The simulation provides the opportunity for multiple practice, including practice where different factors are both articulated and combined together realistically. The emphasis on collaboration between workers in the cockpit --- a key goal of the LOFT training --- makes this example highly compatible with the Situated Learning Model.

LOFT simulations provide a vehicle for demonstrating the importance of effective cockpit resource management, and they provided crews with vivid demonstrations of operational complications that can result when resources are ineffectively or inappropriately utilized. However, LOFT is not a replacement for maneuver-oriented flight training. An essential prerequisite of effective cockpit management is a highly skilled, highly knowledgeable pilot. Proficiency in manual control of the aircraft and in the operation of its systems is primary --- without it, no amount of management, command, or leadership training will produce a safe, proficient, and effective pilot (Lauber & Fouchee, 1981).

**Stories**

The Line-Oriented Flight Training program for pilots emphasizes stories: stories of real disasters and simulated stories or scenarios of crisis situations that represent all the possible kinds of technical and human problems that a crew might encounter in the "real world." This is another fundamental component of situated learning.

According to the Situated Learning Model, in order to make the training memorable, it must be embedded in a story, a scenario. Brown (1989) emphasizes the importance of stories for effective learning. According to Brown, narratives play a vital role in the transfer and integration of information and discoveries. And stories help people keep track of their discoveries. As stories are shared, fragments of other stories are melded together with them that enhance the meaning of the original stories, as well as transferring information about the discoveries to others in the workplace. According to Brown, troubleshooting is basically storymaking. Swapping stories essentially means bootstrapping on each other's experience. By exchanging stories, we "bootstrap" on a community of experience, our own experience and that of co-workers. Sophisticated simulations, designed to teach people how to make sense out of complex, unclear data to solve problems, are a form of storytelling, or perhaps scenario building. Brown (1989) explains that stories are anchored in episodes. Workers can refer back to stories or scenarios in their training in attempting to make effective decisions in real-life work situations.

This is similar to a model put forward by Brenda Laurel whose background is in the theater. Laurel (1989) articulates a metaphor of computer-as-theater. She comments, "millennia of dramatic theory and practice have been devoted to an end that is remarkably similar to that of human-computer interaction design; namely, creating artificial realities in which the potential for action is cognitively, emotionally and aesthetically enhanced." According to Laurel,

> It is not enough to imitate life. Drama presents a methodology for designing worlds that are predisposed to enable significant and arresting kinds of actions --- where characters make choices with clear causal connections to outcomes, where larger forces like ethics, fate or serendipity form constellations of meaning that are only rarely afforded by the real world. Dramatically constructed worlds are controlled experiments, where the irrelevant is pruned away and the bare bones of human choice and situation are revealed through significant action. The predispositions of such worlds are embodied in the traits of their characters and the array of situations and forces embedded in their contexts. If we can make such worlds interactive, where a user's choices and actions can flow through the dramatic lens, then we will enable an exercise of the imagination, intellect and spirit that is of an entirely new order."

Laurel's vision of dramatically constructed worlds is highly relevant to the design of training environments in accordance with the Situated Learning Model. The Line-Oriented Flight Training scenarios are planned and scripted to be realistic in terms of the pacing and interaction of distracting events, but also so that these events are dramatically combined and compressed to promote learning in an environment that improves upon the natural environment of actual flights for the purpose of learning.

**Implications for the design of situated learning-based training**

The LOFT program has several important implications for the design of situated learning- based training. One interesting aspect of Line-Oriented Flight Training for flight crews is that it is situated learning for teams rather than individuals. The implication here is that the debriefing process must be designed to provide two kinds of feedback: feedback for the team and feedback for the individual. Lauber and Fouchee (1981) describe how this is achieved in LOFT: "During debriefing, both total crew performance and individual performances should be openly discussed and assessed by the instructor. Critical assessment of an individual can be mentioned in the presence of the full crew, but remedial details should be handled privately."

A second implication is the importance of differentiating between training and testing in the situated learning environment. LOFT is designed as a learning experience in which errors will probably be made, not a checking program in which errors are unacceptable. Lauber and Fouchee recommend that for maximum effectiveness, LOFT must be perceived as pure training, not testing or checking performance, by both crew members and instructors. The instructor must set the tone, emphasizing during the preflight briefing that LOFT is designed purely as a learning experience, with no job testing strings attached, although additional training may be prescibed if the instructor determines it to be necessary. LOFT is "learning through experience, which includes making mistakes and errors. To keep minds open, to benefit most from the experience, it is essential that LOFT be entered into with a feeling of freedom, openness, and enthusiasm (Lauber & Fouchee, 1981)." Lauber and Fouchee emphasize that when dealing with issues such as crew coordination, command, leadership, and resource management, insight into individual limitations and weaknesses is an important component of learning and training. And the instructor must be tactful to avoid the appearance of checking rather than training. It is essential to address these factors so that concern with performance evaluation will not detract from training (Lauber & Fouchee, 1981).

A third implication for the design of situated learning-based training concerns the role of the instructor in a situated learning environment. During Line-Oriented Flight Training, the instructor's role is one of communicator, observer, and moderator. During the simulated flight phase of LOFT, the instructor in not an 'instructor' in the traditional sense. Instead, the instructor is "the 'coordinator' or manager of the flight, using appropriate radio calls or responses to direct the flight along the desired path; he must be prepared to accept and manage alternate courses of action that the crew may wish to follow (Lauber & Fouchee, 1981)." These responsibilities require a considerable amount of creativity and restraint on the part of the instructor. The instructor should resist the temptation to 'instruct' or intrude into the situation, thereby destroying the sense of realism that is vital to LOFT training. And the instructor must not offer any hints, or in any other way remind the LOFT crews that they are in a simulator training session. The instructor's role is to manage the training situation, not to 'teach' right solutions, or to 'test' the trainees (Lauber & Fouchee, 1981).

During the debriefing after the LOFT flight, the instructor must guide the discussion to explore the full range of potential approaches to problems that emerge during the simulated flight. The instructor must make sure that key topics relating to cockpit management, such as crew management, crew coordination, and crew communications are discussed. The discussion should also cover the use of Airport Traffic Control and company communications; manuals, charts, and other software; the use of other crewmembers; and the use of the autopilot, autothrottle, and other potential workload-reducing devices (Lauber & Fouchee, 1981).

During the debriefing, the instructor should do everything possible to foster self-analysis while at the same time keeping it at a constructive level. In his role as moderator, the instructor can guide the discussion to areas relevant to the completed LOFT flight that need attention. The instructor should raise questions about certain procedures, decisions, and mistakes that transpired during the LOFT flight. However the instructor should avoid 'lectures' about what is right and what is wrong unless absolutely necessary. And the instructor should try to avoid embarrassing members of the crew (Lauber & Fouchee, 1981).

A fourth implication of the LOFT training program for the design of situated learning training programs is the selection and training of the instructor. Lauber and Fouchee emphasize: "LOFT instructors should receive rigorous training in the philosophy, principles, and conduct of LOFT. " Areas that need special attention include: learning how to maintain a realistic atmosphere and avoid intrusiveness during a simulated flight, effective observation skills, script writing and scenario design, pacing and coordination, creativity and adaptability, and interpersonal skills. The LOFT instructor must also have an in-depth understanding of the dimensions of performance related to the exercise of command responsibilities, crew coordination, leadership, decisiveness, and interpersonal communication. And the instructor must have a thorough familiarity with aircraft systems, performance, and procedures, and they should be able to assess certain intangible assets such as flying skill and "smoothness." Knowledge of, and compliance with, Federal Aviation Regulations and Airport Traffic Control procedures is another area that instructors must know in detail (Lauber & Fouchee, 1981).

A fifth implication is the need for careful design in developing a complex multimedia situated learning training environment during both scenario script development and LOFT flight implementation so that pacing and coordination of interrelated events are designed effectively to promote both realism and learning. Abnormal and emergency procedures and situations must be paced and introduced carefully and realistically. And it is essential for the LOFT instructor to understand the ways in which he can adapt the scenario to handle unforeseen crew actions (e.e., rendering navigational aids inoperative, closing airports because of adverse weather, etc.). The creative nature of this aspect of LOFT operation must be clearly understood (Lauber & Fouchee, 1981).

A sixth implication of the LOFT program for the designers of situated learning is the need to consider and design customized scenarios to meet the needs of different learners. Pilots who usually fly short distance routes will need very different scenarios than those flying long, nonstop routes. Much of the realism of LOFT is lost if the scenarios are not consistent with a carrier's route structure or if the crew is unable to use actual charts, manuals, and other materials. And the design and development of a LOFT program should be guided by a consideration of the skills required of an individual pilot, as well as the skills necessary for a fully integrated flight crew, such as crew coordination and cockpit resouce management. A well-designed LOFT scenario should exercise both sets of skills. LOFT is also a good vehicle for providing experience with problems in aviation operations such as distraction, complacency, forgetting, and failure of information transfer. All LOFT scenarios and flight segments should be designed on the basis of a formal and detailed statement of specific objectives and desired end products (Lauber & Fouchee, 1981).

In conclusion, LOFT is a highly complex simulator-based training program that exemplifies all six of the components that characterize situated learning: Apprenticeship; Collaboration; Reflection; Coaching; Multiple practice; and Articulation. In addition, LOFT emphasizes stories: stories of real disasters and simulated stories or scenarios of crisis situations; stories are another fundamental component of situated learning.

As an example of situated learning in a highly realistic surrogate of the actual work environment, the LOFT program has several important implications for designers seeking to implement training in accordance with the Situated Learning Model:

1) the debriefing process for a team of learners, rather than an individual learner, must be designed to provide feedback for both the team and the individual;
2) it is essential to differentiate between training and testing in the situated learning environment and to make sure that this distinction is clear to both the instructor and the learners;
3) the role of the instructor in a situated learning environment must be carefully designed as part of the overall design of the situated learning training program;
4) the selection and training of instructors must be explicitly considered, and planned for, in situated learning, as in other training contexts;
5) the pacing and coordination of complex interrelated events in the situated learning scenario or script must be carefully designed in order to promote both realism and learning; and
6)it may be necessary to design customized scenarios to meet the needs of different learners.

This pilot training program provides an example of how sophisticated computer-controlled training simulators offer the potential for training applications that take advantage of the Situated Learning approach to instructional design.

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# THE DEVELOPMENT OF AN INTERACTIVE SUPPORT SYSTEM SHELL

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**Abstract**
Interactive computer support systems have been developed for student learning during the past two decades on an individual basis. These systems have offered learners the opportunity to evaluate current self-understanding and to supplement personal knowledge with additional relevant information. Instructional professionals were required to design, write programming code and enter data into the application program. The use of an interactive support system shell affords the instructor the opportunity to utilize the instructional software logic and structure while the content data is altered by the instructor to fit the needs of the learner.

A support system shell has been designed to allow the learner to access multiple choice questions, to be presented with the correct answer and a page reference when an incorrect response is given, to have access to an online content area dictionary, and to receive an evaluation of learning report at the end of a review session. The instructor is given the resources to enter the multiple choice questions, to enter the terms and definitions for a content area dictionary, to alter the instructional presentation sequence, to modify the questioning pattern, and to gather learner performance data.

The design of the support system shell and a working model will be presented and demonstrated at the conference.

**Introduction**
During the past decade development and research of interactive computer-assisted instructional programs have been conducted across various content areas using a variety of instructional strategies and techniques (Park & Tennyson, 1986; Tennyson & Cocchiarella, 1986; Goetzfried & Hannafin, 1985a; Kulik, Schwalb & Kulik, 1982, Tennyson & Park, 1980; Hartley, 1978). Within each of these studies, researchers investigated a particular instructional strategy applied to a specific content area. The results of these studies have demonstrated both significant and non-significant results; however, when the results of a particular study were shown to be significant, the flexibility of the program was limited to the embedded content data of the study. An issue which had not been considered in the studies was the importance of using the software application program by educators in alternative content areas. Similar to the development of expert-system shells, which allow for a specific inference engine to access varied knowledge bases, instructional support system shells need to be created from effective CAI studies so that the instructional strategy is maintained within the application program and the content area can be installed by each instructor. In viewing CAI program development in this manner, effective research studies can be taken from journals and professional magazines and placed into the hands of variety of professional educators.

If an effective instructional strategy has been developed for reading comprehension, instructional review, diagnostic testing or another domain using a specific content area then the instructional professional should have the opportunity to alter the content area to one distinct from that used in the research software. The sectioning of the program code so that the content data is not embedded within instructional strategy will help to facilitate the application of effective research studies throughout the educational community and across varied content areas. The development of an interactive support system shell affords the instructor the opportunity to utilize the support system shell and to alter the content data for the needs of a particular learner group and content area.

**An Application Developed**
Several issues need to be considered in the development of interactive support system shells, namely, is there a practical need for the software application and the learning strategy, are the research results significant for the educational strategy or technique, and is it feasible to separate the program logic from the content data. Research studies (Robyler, 1985; Ross, 1984; Hannafin, 1984) have considered the first two of these points; however, little has been stated in the body of research literature concerning the application of a particular study to alternative content areas. Most presentations and/or publications focus on the significance of the research study, and illustrate segments of the application program concerning the structure and the strategy of the

software. For those with design and/or programming experience this is of great benefit, but this situation leaves many with the task of programming in their own content data or matching content needs exactly to that of the research study in order to utilize the results in their own particular area of interest.

It seems reasonable to assume that in the future, programming professionals on the research team will consider the structuring and access of the program code separate from the creation and access of the content data. The use of external files and databases can be designed to facilitate the process of separation of program logic and instructional content. This would allow for the utilization of content data from various curriculum areas with instructional algorithms and strategies from research studies demonstrating significant results.

**The Review Program**

During the 1989-90 academic year a computer-assisted instructional review program (Michelini, 1990b) was developed to assist sophomore college students in learning computer concepts. The program was designed to supplement the material covered in the weekly lectures of an introductory computer course within the School of Business. The review program consisted of approximately 800 multiple-choice questions which were subdivided into 18 chapters dealing with specific aspects of computer technology.

Each student was given a distinct logon identification name and unrestricted access to the review program during normal computer lab hours. Upon entry into the review program the student was presented with an introductory screen explaining how to use the program. Students selected a particular chapter for review and the program would proceed to present multiple choice questions pertaining to that specific chapter. A question was presented on the terminal screen; the student was asked to select the correct response; in the event of an incorrect response by the student, the student was given another opportunity to select the correct response. Some form of recognition was given to the student after answering each question -- acknowledgement of the student's correct response, acknowledgement of an incorrect response by the student followed by the correct response and a page reference to information related to that specific question. Student data was collected by the program reflecting each individual question and cumulative totals for that particular chapter. At the end of each review chapter the student was given a performance evaluation with respect to that specific chapter.

Chapter questions were presented to each student in random order during a given review session, and a chapter review session was based upon a fixed number of questions, a learner determined number of questions, or a last four question response pattern algorithm. The flexibility of random order question presentation allowed a student to review work on separate occasions and be presented with a distinct pattern of questions. The random order also provided instructional security in the event that two students sitting at adjacent computers would not receive the questions in a similar pattern.

The review program was written in the BASIC programming language; run on a Novell network using 48 IBM PCs with 640K RAM. The review program was down loaded to each individual PC and the program accessed the system hard disk to retrieve chapter questions and to maintain student records. Students were not aware of the fact that response data was being collected; however, they were aware of the correctness of each response and of their overall performance within a given chapter. An advantage to implementing the review program using a network configuration was the ease of maintaining the program and the question data, the ease of collecting student response data, the flexibility to handle multiple users on the same system, and size of the data files could be expanded without user disk swapping inconvenience.

The review program (Michelini, 1990a) was expanded during the spring and summer of 1990 to include an online dictionary of computer terms. The dictionary could be accessed by the user during the review session for the definition of terms related to a particular chapter question or a specific computer concept. The dictionary of computer terms was created by the instructional developer prior to program use by the learner and expanded or maintained by the instructional developer whenever necessary.

**Modification toward an instructional shell**

During the Fall of 1990 a reevaluation of the review program and the online dictionary of terms was made in an attempt to generalize the software for use by professionals in other academic areas. Attention focused on two distinct areas of the review software: the entry by the instructor of alternative content areas for the multiple-choice questions, and the creation and use of an online content area dictionary in conjunction with the multiple-choice questions. Since the review program was constructed using external data files, the content data was already separated from the program structure itself. It seemed reasonable to assume that the program could be modified to allow professionals from other educational areas the opportunity to supply their own dictionary and multiple-choice questions while utilizing the program structure. This was accomplished by creating a variable that would allow for an indirect reference to the external file containing the relevant data -- either one of the multiple-choice questions or a content area dictionary definition.

A program written in the BASIC programming language would include the following statement to open an external file containing question data for input into the program:

```
290 OPEN "MEMORY.DAT" AS #1 FOR INPUT
```

This statement is identifying the external file that the program must access in order to retrieve a multiple-choice question for use in the program. As written this external file name is locked into the program by the programmer and cannot be changed during runtime; the program code needs to be altered by a programmer in order for a different data file to be accessed.

Using an indirect reference technique the program is altered to contain the following code,

```
190 INPUT "Enter the name. ", CHAP11$
...
300 OPEN  CHAP11$  AS #1 FOR INPUT
```

which allows the instructor the opportunity to name the external file and to reference the external file by one's own eight character identifiers (B:TELECOMM.DAT). The program logic is still built around a fixed identifier, CHAP11$; however, the instructor is only aware of the variable name (B:TELECOMM.DAT) entered by the instructor, and the computer system stores the file under this name. This procedure allows the instructor to create and maintain the external files. The programmer has used a series of fixed identifiers (CHAP11$) as in line 300 of the program, but what the the instructor has done is assign that identifier an external file name. What the instructor experiences is the system asking for a chapter file identification; once the identification is given the program maintains the appropriate references. A positive aspect of this type of file identification is that the instructor can vary file placement according to the characteristics of the local system, namely, files can be stored or various disk drives (A:, B:, C:, or in a network setting).

The use of this indirect naming technique is not without some restrictions or limitations. The review program assigns variable names (CHAP11$, etc.) to hold instructor supplied chapter and data dictionary identifiers. Since the programmer needs to determine identifiers before runtime, the program is limited to the number of chapters assigned by the program code, and by the fact that the program needs to create a special external data file to store the chapter variable names assigned by the instructor. All the chapter variable file names need to be stored and maintained between sessions of program use, otherwise, those names would be lost to the program and data access would not be possible. A chapter variable file is created to maintain the chapter naming references of the program for the future use of the program.

**Results and implications**

The initial interactive review program has been well received by the students taking the computer concepts course. In each of the past four semesters students have indicated on teacher evaluation forms and verbally that they had profited from the review program. This evaluation was in respect to both improved personal understanding of the computer concepts, and in test preparation during the semesters. The program was made available to all students registered for the course and an analysis of performance with a control group has not been conducted at present time.

The results of modified program (programming shell version) has demonstrated that the structural aspects of a program can be separated from the content data so that non-programming professionals can utilize the program for their own content area. The programming shell version is currently being used to create new external content data file for use with a new text. Using a shell version of the program offers instructors increased flexibility in molding the content data to one's own needs and to the requirements of the learner. What is of importance here is the fact that the local instructor has the power to determine the content data while the researcher offers a proven learning strategy within the program.

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# AN INTRODUCTION TO INSTRUCTIONAL TRANSACTION THEORY

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**Introduction**

Interactive instruction (computer-assisted instruction, interactive video) is often an extension of programmed instruction developed in the behavioral psychology era. The emphasis is on shaping the behavior of students. In this programmed-instruction-based courseware the primary emphasis is well-designed stimuli presented as displays of text or graphics. Often these displays enable only a limited number of interactions between the courseware and students. The most frequently seen interaction is presenting text and graphics, asking a question, evaluating the student's response, providing feedback, and branching to the next display (Merrill, 1985).

Most CBT authoring systems have a frame-based architecture. The primary element is a display (screen) of information consisting of graphics and text. The learner is asked a question, usually consisting of one of the standard question forms of multiple-choice, short answer, true false, matching. Depending on the learner answer, another frame of information is presented. This alternative path procedure is called branching. Frame-based architecture requires that each frame be individually authored and stored in a data base that resembles a file cabinet of displays that can be accessed in various orders depending on the branching structure.

Many noninstructional computer applications have a different architecture, that is, an algorithm plus data. An algorithm is a sequence of computations that can be repeated over and over with different data. A frame-based CAI architecture may be considered as one kind of algorithm, but a very limited algorithm consisting of branching from one display to another. Subject matter content, the knowledge and skills to be learned, can be separated from the instructional interaction with the learner by which these content elements are learned. The instructional interactions are algorithms for interacting with the learner. The subject matter content is data that is used by these instructional algorithms.

*Instructional transactions*[1] are instructional algorithms, patterns of learner interactions (usually far more complex than a single display and a single response) which have been designed to enable the learner to acquire a certain kind of knowledge or skill. Different kinds of knowledge and skill would require different kinds of transactions. The necessary set of these instructional transactions are designed and programmed once, like other applications such as spread sheets and word processors. These instructional programs are called *instructional transaction shells*. These transaction shells can then be used with different content topics as long as these topics are of a similar kind of knowledge or skill.

Authoring by way of *instructional transaction shells* consists of selecting those patterns of interactions which are appropriate for a given topic and merely supplying the subject matter content in a form that can be used by the transaction shell. There is no need to determine every display; to determine a branching structure; to select what kind of questions to use, to specify answer processing. Once the transaction shells have been developed they can be used over and over again with no need for extensive instructional design or programming. The cost savings of this algorithm plus data approach to the development of courseware is many times more efficient than a frame-based approach. A one hour lesson that may require 200 or more hours of development using a frame-based approach can be developed in 20 or 30 hours using a transaction shell approach. Furthermore, the frame-based approach may limit the interactions to answering questions whereas a transaction can involve interactive environments which enable the learner to explore the subject matter, manipulate simulations of devices, and other more effective and more complex interactions that are impossible or impractical to build using frame-based systems.

**Instructional Transaction Shells**

An *instructional transaction* is a mutual, dynamic, real-time give-and-take between an instructional system and a student in which there is an exchange of information. It is the complete sequence of presentations and reactions necessary for the student to acquire a specific type of instructional goal. It requires active mental effort by the student. Its effectiveness is determined by the match between the nature of the student's interaction and resulting mental processing with the type of task and subject matter content to be learned.

We subscribe to the notion that learners more easily store cognitive representations of knowledge and skill bundled into interrelated knowledge structures rather than unrelated bits and pieces of information. All of the knowledge and skill required to engage in some complex activity -- such as solving linear equations, driving a car, using an electronic spread sheet -- are highly interrelated and constitute a *mental model*. This complex activity, enabled by a mental model, is called an *enterprise* (See Gagné & Merrill, 1990).

We distinguish several other terms: A *transaction shell* [2] identifies the interactions, knowledge representation and parameters needed for a given class or family of transactions. When a transaction shell is instantiated with a particular subject matter and with particular values for its parameters, it is called a *transaction instance*. Both a transaction shell and a transaction instance are pieces of computer code that, when delivered to a student via an appropriate delivery system, cause a transaction or set of transactions to occur. We are not always careful to distinguish the computer objects which cause a transaction to occur from the transaction which is the actual interaction with the student.

A *transaction class* is a set of similar transaction shells which have similar interaction requirements and similar knowledge representation requirements. A *transaction family* is all of the transactions necessary to enable a learner to acquire all of the knowledge and skill required to engage in a particular enterprise. An *enterprise transaction* is a higher level transaction which accomplishes two purposes: first, it functions as a transaction manager, providing the overall direction of the execution of the individual transaction instances in the transaction family. Second, it provides for an integration of the learning facilitated by the individual transactions in the transaction family.

A transaction shell consists of four primary components: *interactions and an interaction manager* which causes the transaction to occur; *instructional parameters* which enable the instruction to be customized for a given learner population, learning task, and environmental situation; a *knowledge base* containing a structural representation of all the knowledge to be taught; and a *resource data base* containing mediated representations of the knowledge to be taught. A transaction shell has three authoring systems: a *transaction configuration system*, a *knowledge acquisition system*, and *resource editors*. The knowledge acquisition system enables a subject matter expert to structure the knowledge to be taught. The resource editors enable the creation of mediated representations of the knowledge. The transaction configuration system enables the designer to provide values for a wide range of instructional parameters.

Transaction shells incorporate intelligence about instructional design in several ways. First, the functions and methods of each transaction shell enable the type of interactions most appropriate for acquiring a given type of knowledge. The designer does not need to reinvent appropriate instructional designs for every application. Second, the knowledge base includes a syntax [34] for knowledge representation that not only enables transactions to use this knowledge, but assures that the knowledge included is complete and consistent. Third, intelligence in the knowledge acquisition system enables subject matter experts to supply the necessary knowledge without knowing the formal syntax of the knowledge representation system. Fourth, the parameters of each transaction shell identify those ways that these interactions can vary for different learner populations and different tasks. Fifth, intelligence in the transaction configuration system contains instructional design rules relating learner and task attributes to various values on the instructional parameters. Thus, the instructional designer needs to supply only descriptive information about the learners and the task, the configuration system can select a pattern of instructional parameter values consistent with this information. However, the configuration system is merely a guide, a designer has access to all of the parameters and can adjust the value of groups of parameters or individual parameters to more adequately fine-tune a particular transaction instance.

**Functions of Instructional Transactions**

The instructional design prescriptions of first generation instructional design are

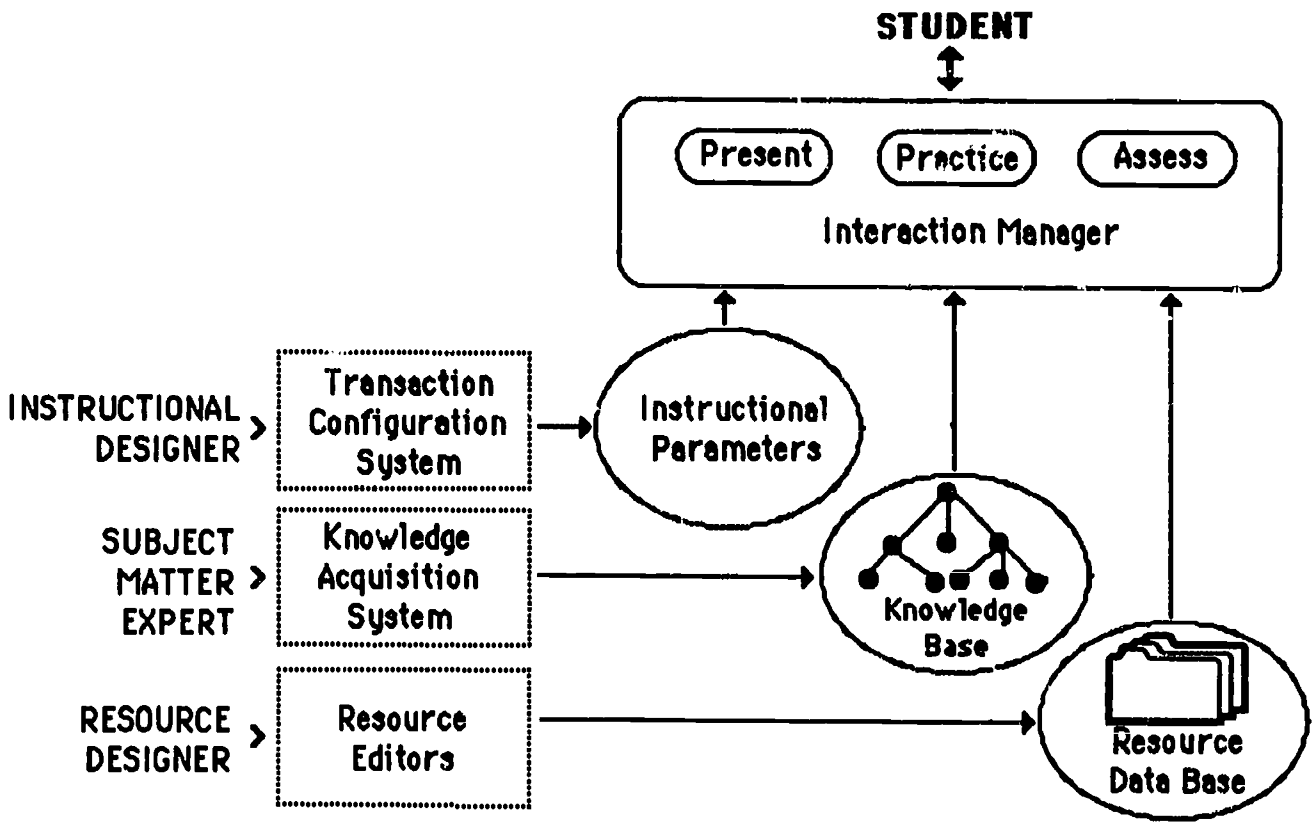


Figure 1 Components of an Instructional Transaction Shell

characterized as "best case" prescriptions. In our own previous work[5] we have identified different prescriptions for each of several performance-content outcomes. These prescriptions identify values for a number of variables which characterize the best instructional strategy for each of the possible outcomes. These prescriptions, however, do not identify the range of values for the many parameters which characterize each prescription, nor do they indicate conditions for which these parameters should assume different values. In other words, each outcome classification has a "best" case prescription and deviations from this prescription are left to the individual instructional designer. Transaction shells do not merely represent a best case. By changing its parameter values it can be configured in many ways to represent a complete range of instructional interactions.

Several instructional functions are necessary in order for an instructional transaction to successfully interact with a learner. All instructional transactions, regardless of the type of knowledge or skill taught, must be capable of performing these functions. The specific parameters that are necessary for a given type of transaction to accomplish these functions will differ from one class of transaction to another. In fact, the difference in the way these functions are accomplished by different classes of transactions is one of the characteristics that distinguish one class of transaction from another.

Each function is accomplished via several *methods* that are specific computer programs that enable the function to be accomplished. These methods require values on a number of instructional *parameters*[6]. These parameter values determine exactly how a given method is applied in a given transaction instance. The interactions enabled by a given transaction can exhibit a considerable variance depending on the values assigned to the parameters which constrain its methods. Instructional design via instructional transaction shells consists of selecting parameter values appropriate for a given learner population and particular learning task. These parameter values then enable the methods of each function to carry out this function in a way consistent with the requirements of a given learning situation.

All instructional transactions must include the following functions: *knowledge selection, knowledge sequence, instructional management*, and *instructional enactment*.

Select Knowledge

From all the knowledge associated with a given transaction instance, the knowledge selection function determines that part which will be taught during a particular enactment of the transaction. Associated with each of the knowledge frames for a given instance of a transaction is a *resource data base* containing the mediated representation which will be presented to the student by the transaction. Each of the frames in the knowledge base may include a large number of components: parts, steps, or events. Each of these knowledge frames may be implemented by several different mediations in the instructional resource data base. The amount of available knowledge often exceeds that which needs to be presented during a given enactment of the transaction. When a transaction is sent a message to do its job, the first parameters it needs are those which tell it of all the knowledge that is available, which specific knowledge elements are to be included during this enactment of the transaction.

**Sequence Knowledge**
The knowledge sequence function determines which of the selected knowledge elements is presented next. Whenever the amount of knowledge to be included in a given enactment of a transaction exceeds that which should be presented[7] simultaneously, then an instructional transaction requires sequence parameters to indicate how this knowledge should be partitioned and sequenced. Knowledge acquisition is facilitated if the knowledge is partitioned into mind-size pieces; on the other hand knowledge assessment often requires the learner to interact with the knowledge as a whole. A given instructional transaction, regardless of the type of knowledge taught, should be able to invoke a variety of instructional sequences.

**Manage Interactions**
The instructional management function determines how the student will interact with the selected and sequenced knowledge. Instructional management is accomplished by the selection of an *instructional strategy*. An instructional strategy is a sequence of *interaction modes*, each of which knows how to either overview information, present information, facilitate the students' practice of the skills promoted, or assess the students' knowledge and skill. The management function also determines when a learner should move to the next interaction mode in the strategy. Instructional strategies can vary from providing information to promoting mastery of the knowledge and skills involved in the transaction. The type and sequence of interaction modes varies from one strategy to another. A given instructional transaction, regardless of the type of knowledge taught, should be able to invoke a variety of instructional strategies.
Enact Interactions

The instructional enactment function determines how each interaction mode in a given strategy carries out its responsibility. The enactment function determines the role a given interaction will play whether presenting information, enabling practice, or assessing a student. The enactment function specifies how the interaction presents information, constrains learner responses, and/or reacts to the learners responses. The enactment function also determines how each interaction is adjusted to provide the type of interaction most appropriate to a given student and subject matter. A given interaction mode, regardless of the type of knowledge taught, should be able to modify the nature of its interaction with the student in a variety of ways.

**Classes of Instructional Transactions**
We propose that instructional transactions can be grouped into a limited number of classes. The nature of the interactions for a given class of transaction depends on the type of knowledge structure(s) that the transaction seeks to promote and the learner performance enabled by the transaction. We assume that different knowledge structures require different types of instructional transactions. We also assume that different transactions promote the acquisition of different types of learner performance.

We have identified three primary classes of transactions: *component* transactions, *abstraction* transactions, and *association* transactions corresponding to the three forms of elaboration in the knowledge representation. The knowledge frames required for a given transaction are called a *transaction frame set*. The transaction frame set for a component transaction is a single knowledge frame and the components which comprise this frame. The transaction frame set for an abstraction transaction is at least a class frame and two or more instance frames from an abstraction hierarchy. The transaction frame set for an association transaction is two or more associated frames from the Elaborated Frame Network.

**Component transactions**
Component transactions enable the learner to acquire all of the components which comprise a single knowledge frame. The term *acquire* in this context has a range of meanings all the way from *denote*,[8] that is, remembering or recognizing the steps in an activity, or events

in a process; to being able to actually *perform* the activity, or *interpret* a process by predicting what will happen in a given situation or explaining what is happening in a given situation. The level of performance required of the learner is a parameter whose value is either specified by the instructional designer or is determined by the transaction configuration or advisor rules of the transaction. A component transaction can apply to a frame at the instance, class, or superclass level. In the later case the components being acquired are generalized components which can apply in a variety of specific cases.

There are three classes of component transactions corresponding to the three types of knowledge frames: *identify* for entity frames, *execute* for activity frames, and *interpret* for process frames. In the following paragraphs the performance, knowledge required, and a brief description of the interactions supported are described.

**Identify**
**Knowledge required.**
An identify transaction requires either an instance or class entity frame. The knowledge base includes a structural representation identifying the clustering of parts and subparts. The resource data base includes a *physical representation* on which the name, location, and function of each part can be identified and/or a *functional representation* on which the name, location and function of each component can be identified.
Performance.

An identify transaction enables the learner to acquire the names, functions, properties, and relative location of all the parts which comprise an entity. The learner knows *what* it is. Learning the names, location, and function of the parts of a entity is a prerequisite to learning how an entity works, or how to operate an entity. Students are shown a physical representation of the entity and asked to identify individual parts, their function, and their immediate connections. Students are shown functional diagrams representing the conceptual structure of the entity and asked to identify individual components, their function, and their immediate connections. Students are shown both the physical and functional representations and asked to demonstrate the correspondence between these two representations.

**Interactions**
The transaction must both present all or a subset of the names to the learner and enable the learner to practice locating the parts and identifying the part name and function.
The transaction must present the functional names to the learner, must pair the functional names with their physical referents. The transaction must enable the learner to practice identifying functional symbols given referents; referents given the functional symbols; names of functional symbol given its graphic representation; and reproducing the symbols.

**Execute**
**Knowledge Required.**
An execute transaction requires either an instance or class activity frame. All activities require one or more associated entities which are the object of the action or the tools by which the action is executed. The knowledge base includes a structural representation identifying the steps and substeps involved in the activity including the kind of each step (activity, action, condition, or loop), the components of each step (action, object, tool), the initial state of the entities involved, and the consequent state of the entities involved. The resource data base includes a physical and/or functional simulation of the entities involved in the activity such that the actual or simulated actions performed by the learner result in the illustration of the consequent state of the entities involved.
Performance:

An execute transaction enables the learner to acquire the steps of an activity. The learner knows *how* and is able to do the activity. Execute performance can be at either the denote or perform level. At the denote level the learner is able to list the steps involved in a given activity or shown the activity identify the steps and their sequence. At the perform level the learner is shown a physical or functional simulation of the entities involved in the activity and asked to carry out the steps necessary to manipulate these entities.

Execute performance differs depending on the type of entities associated with the activity. Execute performances associated with object or device entities include: device *operation* described by verbs such as run, work, manipulate, drive, steer, pilot, play, perform on, use, guide; Device *assembly* or *disassembly* described by verbs such as put together, take apart, fix, repair, collect; device *adjustment* described by verbs such as adjust, test, calibrate, measure; device *trouble shooting*

described by verbs such as identify malfunction, detect faults. The device performance often involves one or more tool entities which must be used to manipulate an application device.
Execute performances associated with person or creature entities include: *interact with* described by verbs such as communicate, direct, supervise, control; *perform* characterized by participation in some event.

Execute performances associated with symbol entities include: *edit* characterized by detecting and correcting errors in a symbolic communication; *compute* characterized by using arithmetic or mathematics to manipulate symbols or solve problems; *report* characterized by preparing a form of standardized communication; and *compose* characterized by creating a unique communication.

**Interactions.**
The transaction must be enable to present the steps of the activity to the learner in a way that the learner can acquire the steps involved, and allow the learner to demonstrate their ability to identify these steps and their sequence and/or their ability to execute these steps in a real or simulated situation.

**Interpret**
**Knowledge Required.**
An interpret transaction requires either an instance or class process frame. All processes require one or more associated entities which are the agents which cause some transformation to occur or are the recipients of the transformation. The knowledge base includes a structural representation identifying the phases, events, and subevents involved in the process. Each event includes the kind of event (event, episode, condition, or loop), the condition (state) of each of the involved entities prior to the transformation. The relationships which describe the transformation. The consequent state of each of the involved entities following the transformation. The resource data base includes a physical and/or functional simulation of the entities involved in the process such that the transformations constituting the events of the process are dynamically illustrated for the learner. The simulation must have the ability to respond to a change in conditions such that the consequent change in transformation for a given event or series of events is illustrated. The simulation must have the capability for the learner to manipulate the conditions of the simulation in order to observe and/or predict changes in the consequence resulting from this change in conditions.

**Performance.**
Interpret performance enables the learner to acquire and understand the events in a process. The learner knows *why* it works and can explain the events which lead to a given consequence or can predict the consequence from given conditions. Interpret performance can be at either the denote or perform level. At the denote level the learner is able to list the events involved in a given process or, shown the process, identify the events and their sequence. At the perform level the learner is shown a physical or functional simulation of the entities involved in the process and asked predict what will happen under different normal and/or faulted conditions and/or to identify the conditions upon which a given occurrence of an event in the process was predicated. Prediction includes the ability to recognize when a given process is faulted or not functioning as expected.

**Interactions.**
The transaction must be able to present the phases and events of the process to the learner in a way that the learner can acquire and understand the events involved. The interactions should allow the learner to engage in "what if" exploration of the process by adjusting conditions and observing the consequences. The transaction must also allow the learner to demonstrate their ability to identify these events and their sequence and/or their ability to predict subsequent events from a given set of conditions or to identify the prerequisite conditions that resulted in a given consequence.

**Abstraction transactions.**
Abstraction transactions enable the learner to acquire skills that require the content from a class frame and two or more instance frames in an abstraction hierarchy. Abstraction transactions promote the ability to *use*[9] a skill acquired for one set of instances or classes with a previously unencountered instance or class. Abstraction transactions enable the student to generalize their knowledge by acquiring an *abstraction model*, knowledge and skills about the general case of an entity, activity, or process.

Different types of abstraction transactions can be discriminated on the basis of the performance required and the different combinations of frames from an abstraction hierarchy involved in the transaction. We have identified at least five classes of abstraction transactions: *judge, classify, decide, generalize, and transfer*. We will describe only the decide transaction in this paper.

**Decide**

**Knowledge Required.**

A decide transaction requires a superclass entity or activity frame with two or more subordinate class frames each of which have two or more instance frames. Entities and their parts are characterized by properties which can assume a value from a set of legal values for that property. The knowledge base must identify the properties associated with each entity or its parts and the legal values that these properties can assume. Classes of entities must include the properties and values which determine class membership. Instances of activities must indicate the properties and values that are associated with the entities prior to the activity and following the activity.

Performance.

A decide transaction enables the student to know *when* to select one alternative entity or activity from another. For an entity this selection is determined by recognizing and selecting those instances which have a certain value on the selection properties or set of properties. For an activity this selection determines an action which is appropriate for a set of conditions, that is the value of appropriate properties prior to the activity. Or by selecting an action which is appropriate to achieve a certain consequence, that is the values that certain properties will assume following the activity.

**Interactions.**

The transaction must be able to present the entities and their parts, whether for selection of the entity or as a condition or consequence of an activity, in such a way that the value of the properties involved can be illustrated or identified from the representation. The transaction must allow the learner to demonstrate their ability to identify an entity or part which has a certain values on a particular property or set of properties and to indicate the corresponding entity to be selected or activity to be performed.

Association transactions

Association transactions enable the learner to acquire skills that require several different associated frames. Association transactions promote the ability to integrate information from two or more knowledge frames into a coordinated set of knowledge and skill. Association transactions enable the learner to use a mental model already acquired to build a modified or new mental model. Association transactions enable the learner to acquire alternative ways to accomplish a given goal. Association transactions enable the learner to invent new entities or activities or to discover new processes.

Different types of association transactions can be discriminated on the basis of the performance required and the different combinations of frames from a set of associated frames involved in the transaction. We have identified at least five classes of association transactions: *propagate, analogize, substitute, design, and discover*. [10]

**Enterprises**

A complex interrelated human activity requiring a combination of knowledge and skills is called an *enterprise*. A primary goal of most instruction is to enable a learner to acquire the knowledge and skill required to engage in some enterprise.

We are currently engaged in a project to design and build transaction shells to train aircraft maintenance personnel. A consultant to the project has identified a number of enterprises that are required for aircraft maintenance (Halff, 1990). These include the following:

"**Operation**. In most maintenance contexts the maintainer must be able to operate, to some degree, the equipment being maintained. Operational skills are used to verify the status of the equipment, to prepare the equipment for maintenance, and to interpret reports from operators.

"**Calibration and adjustment.** Many devices must be configured for particular operating environments, calibrated, and adjusted on occasion. Maintenance personnel are routinely called on to effect such adjustments. These adjustments are often a part of preventive maintenance, and they often constitute repairs.

"**Testing**. Equipment testing is a critical part of maintenance. Maintainers must be able to test an equipment's operational status. They must also be able to conduct particular diagnostic tests during the course of troubleshooting. These tests often require the use of general purpose and specialized test equipment, and this test equipment must itself be properly calibrated and operated.

"**Access and disassembly**. In the course of repair, testing, and calibration, maintainers must gain access to particular components for observation and manipulation. The procedures used to gain access can be straightforward in some cases. In others, special procedures are required to ensure that gaining access to one part of the equipment will not damage other parts. These procedures are normally specified by the manufacturer of the device.

"**Repair**. By repair, I mean the operations needed to return a device to operability once a fault has been isolated. Repairs therefore include replacement of faulted components, cleaning, adjustment, patching, and a host of other operations.

"**Troubleshooting**. Perhaps the most challenging maintenance operation, from a training viewpoint is that of troubleshooting. Troubleshooting is the process of identifying the physical cause (fault) of an existing or potential malfunction of the equipment's operational capabilities. For the most part, troubleshooting takes place after a malfunction occurs, but troubleshooting also comes into play when a test -- say, during preventive maintenance reveals a potential fault."

In order to engage in any of these maintenance enterprises the learner must first acquire a mental model of how a particular device appears and operates. An adequate mental model of device functioning involves the following capabilities:

**Device structure**. "...shown images of the physical equipment ...[learners are able to] identify individual components, their function, and their immediate connections."

**Device function**. "... learners are [able] to discriminate among component states on the basis of some physical depiction of those states."

**Device configuration**. "...shown some of the inputs to an element of the device [learners are able to show] ... how its other inputs must be set in order to achieve a desired function or state."

**Fault recognition**. "...shown the actual outputs and inputs to an element [learners are able to]...determine whether or not the element is faulted."

**Prediction**. "...given information about all inputs to a component or subsystem [learners are able to]... predict the state of the component or subsystem, its outputs under normal operating conditions, and its outputs in each possible fault mode."

**Transaction Families**

Acquiring a mental model that enables a learner to perform some complex enterprise involves interacting with a number of different instructional transactions. Most instruction is accomplished by a group of transactions all working together to convey the knowledge required by the enterprise. The group of transactions required to teach a given enterprise is called a *transaction family*. A transaction family works via an *enterprise transaction*. An enterprise transaction is a higher level transaction which accomplishes two purposes: first, it functions as a transaction manager, providing the overall direction of the execution of the individual transaction instances in the transaction family. Second, it provides for an integration of the learning facilitated by the individual transactions in the transaction family.

In a previous section we identified several classes of transactions. Each of these classes can have a number of specific instances which share all of the characteristics of the class but which is tailored for a particular type of subject matter. For example, we identified an identify class of transaction; in a maintenance training environment a transaction designed to teach device structure is an instance of an identify class transaction, but would have characteristics peculiar to teaching about devices. We identified an interpret class of transaction; in a maintenance training environment a transaction designed to teach device functioning is an instance of this class, but one that has characteristics peculiar to device functioning. Other instances of interpret class transactions include a transaction for device configuration, fault recognition, and prediction. Each of these instances share the characteristics of an interpret transaction class but have additional characteristics peculiar to their particular domain.

Figure 2 illustrates a transaction family for teaching the learner a model of a device. This transaction family consists of an enterprise transaction that is peculiar to equipment

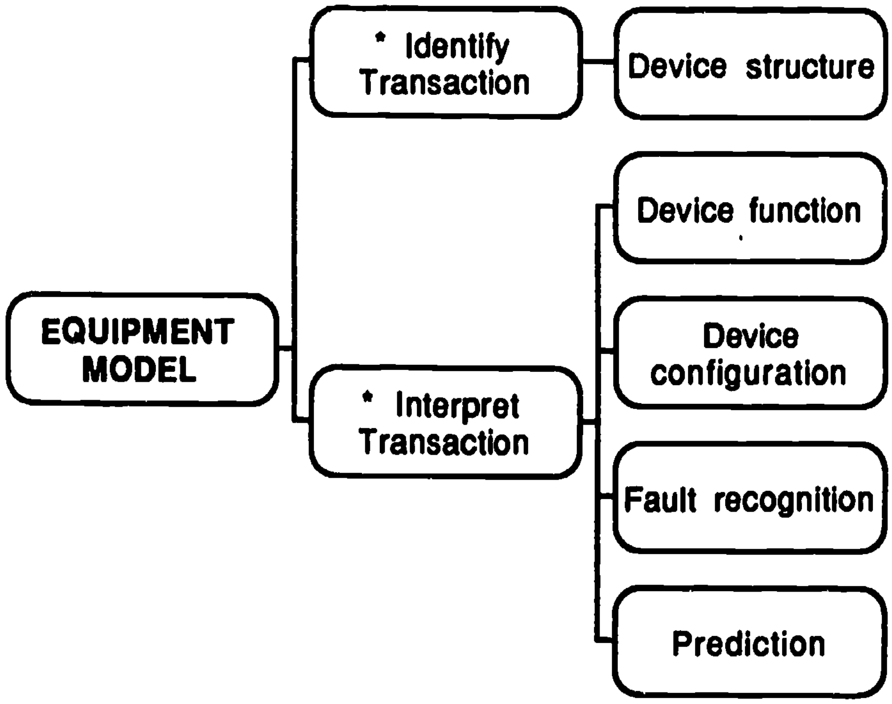


Figure 2 Equipment Model Transaction Family

models, and which manages 5 other transactions: a device structure transaction of the class identify; and device function, device configuration, fault recognition, and prediction transactions of the class interpret.

Figure 3 illustrates a transaction family for teaching the learner the enterprise of equipment troubleshooting. This is a much more complex transaction family which involves the nesting of other transaction families within its scope. The troubleshooting enterprise transaction determines if the learner already has an adequate equipment model, if not, it engages the equipment model transaction family to assist the learner in acquiring this model. The troubleshooting enterprise transaction determines if disassembly is necessary for the troubleshooting procedure being taught, if yes, it determines if the learner has the necessary disassembly skills, if not, it engages the disassembly family of transactions in order for the student to acquire the necessary disassembly skills[11]. The troubleshooting enterprise transaction then engages a logical fault isolation procedure transaction which is an instances of the execute class. If the learner must learn to select from alternative fault isolation procedures it also engages a fault isolation procedure selection transaction which is an instance of the decision class. If the troubleshooting requires operating the equipment the equipment operation transaction family may be engaged; if repair is involved the equipment repair transaction family is engaged. The instruction continues in this manner with the troubleshooting enterprise transaction engaging other enterprise transactions that in turn engage their individual transactions as necessary until the learner has demonstrated his acquisition of the necessary knowledge and skill.

**Summary**

*Instructional transactions* are instructional algorithms, patterns of learner interactions which have been designed to enable the learner to acquire a certain kind of knowledge or skill. A *transaction shell* is computer code that, when provided to a student via an appropriate delivery system, causes a transaction or set of transactions to occur.

A transaction shell consists of four major components: *interactions* and an interaction manager, *instructional parameters*, a *knowledge base* and a *resource data base*. It also requires three authoring systems: a *transaction configuration system*, a *knowledge acquisition system*, and *resource editors*. Transaction shells capture instructional design intelligence via methods for interactions, knowledge base syntax, rules in the knowledge acquisition system, parameters, and instructional design rules in the transaction configuration system.

All instructional transactions must include the following functions: *knowledge selection*, *knowledge sequence*, *instructional* *management*, and *instructional enactment*. Each of these functions is accomplished via methods and parameters which constrain these methods for a particular transaction class.

A *transaction class* is a set of similar transaction shells which have similar interaction requirements and similar knowledge representation requirements. Based on the type of knowledge taught three primary classes of transactions have been identified: *component transactions*, *abstraction transactions*, and *association transactions*. Each of these primary classes include several subclasses. In this paper the knowledge, performance, and interactions required for *identify*, *execute*, *interpret*, and *decide* classes of transactions are briefly described.

A *transaction family* is all of the transactions necessary to enable a learner to acquire all of the knowledge and skill required to engage in a particular complex human activity called an *enterprise*. An enterprise transaction is a higher order transaction that manages a family of transactions which acting together enable the student to acquire the knowledge and skill required by the enterprise. Enterprises for maintenance training and some representative transaction families were briefly described.

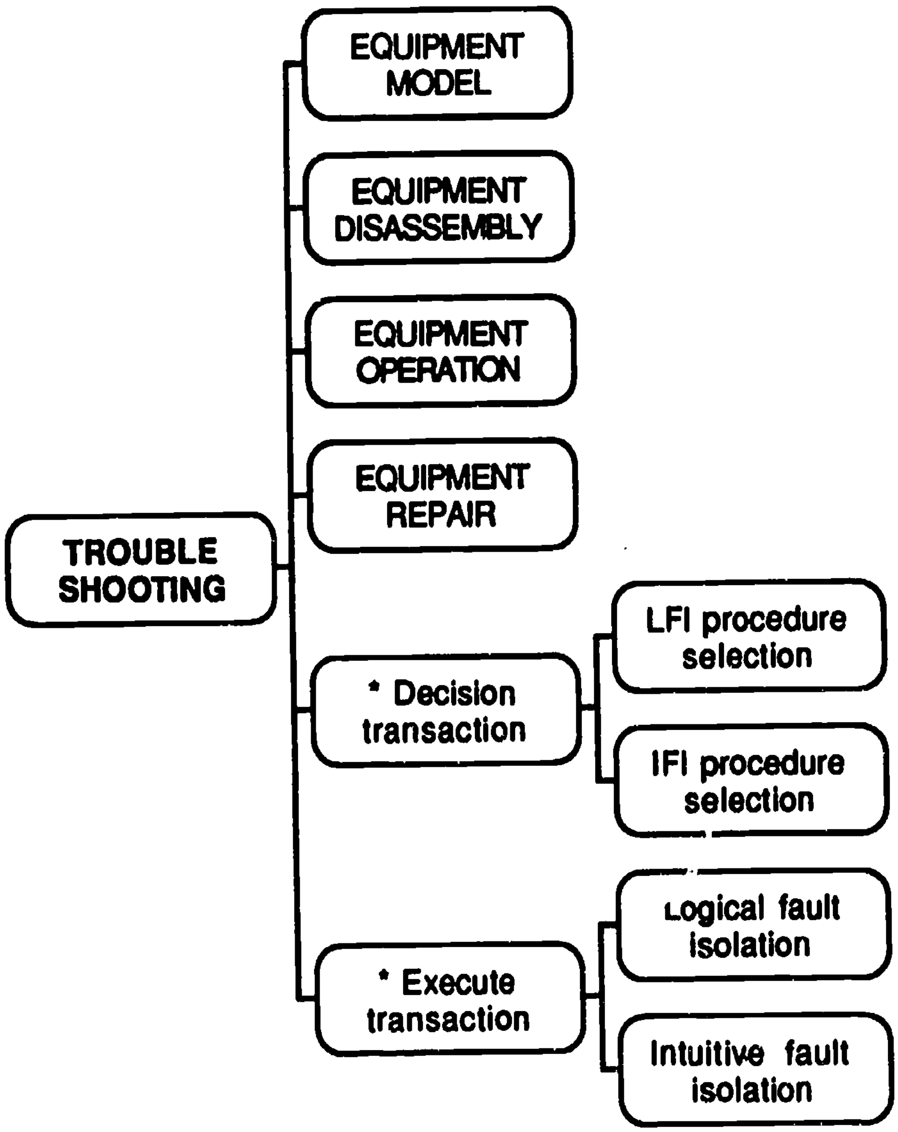


Figure 3 Trouble Shooting Transaction Family

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# THE COURSEWARE DEVELOPMENT LABORATORY AT UTAH STATE UNIVERSITY

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**Abstract**
This paper reviews the Courseware Development Laboratory (CDL) at Utah State University, and Second Generation Instructional Design Theory (ID2) as developed by Merrill, Li, and Jones. The first practical application of ID2 is being implemented at the lab. Training materials are being developed for a corporate client by faculty and graduate students. The paper briefly describes the CDL concept, gives a short overview of ID2, and reports on the implementation project and its results.

In the Department of Instructional Technology at Utah State University, instructional designers, professors, graduate students and media production specialists combine to make possible a unique courseware development laboratory. This laboratory enables some of the most talented people available to produce commercial quality software which explores the latest innovative techniques in educational software design.

**Background**
The Department of Instructional Technology at USU offers a series of graduate level classes in instructional design and a parallel series of laboratory experiences in the design and development of computer based instructional materials. Beyond the introductory courses these are laboratory based classes in which students and faculty design and produce prototypes of instructional products.

**The Courseware Development Laboratory (CDL)**
The Courseware Development Laboratory forms a meta structure separate from, yet integrated with the academic courses. Emphasis is placed on the development of instructional products based on instructional design and on going research concepts. The goal is practical application of the latest instructional design theory, giving graduate students hands-on experience with a real product for a real client. Every attempt is made to simulate a corporate design team experience.

Students selected to participate in the CDL program must have had or anticipate taking the relevant design, production and evaluation classes at least one quarter prior to the use of this information in the CDL experience. A long term commitment, a minimum of nine months, (three successive quarters) is expected of each student. Students are assigned to teams consisting of four to five students. Each team has a team leader who is a PHD student and who is responsible for directing the work of the team. After being assigned to a specific team, which will work on a specific product for a specific client, the work phase progresses as follows:

1st phase - Analysis and Design. (3 months)
2nd phase - Product Development and Documentation. (3 months)
3rd phase - Implementation and Evaluation. (3 months)

The end result of the nine month commitment is a finished product which is delivered to a client. (Courseware Development Laboratory, 1990).

<u>Second Generation Instructional Design Theory (ID2)</u>
For many years traditional instructional design has been very useful for the development of quality instructional products. Most traditional design theories were developed before the so called "computer revolution", and as a result several limitations have been identified. These include:

- Development of CBI is very labor intensive, often requiring 200 or more hours of development time to produce one hour of computer based instruction.
- Prescriptions for course organization strategies using the potential of computer based instruction are superficial or often nonexistent.
- There is a tendency to focus on, and thus teach, components of content rather than integrated wholes.
- There are limited or no prescriptions for knowledge acquisition.
- It is difficult to accommodate new knowledge about instruction, or the learner, as it

becomes available.

* Each phase of instructional development is performed essentially independent of other phases and there are no means provided for integration or sharing of data.
* The development process is very inefficient in that the instructional designer must often build every presentation from scratch. (Merrill, Li, & Jones, 1990)

Second Generation Instructional Design addresses each of the limitations listed above with the net result being much greater efficiency in the instructional design process. The principles of ID2 are especially applicable to computer-based instructional design and development.

**ID2 Instructional Development Process**

Figure 1 illustrates the instructional development process under ID2.

There are three major components in the ID2 instructional development process, represented in figure 1 as square cornered boxes: 1. KAAS (Knowledge Acquisition and Analysis System). 2. SAS (Strategy Analysis System), and 3. Transaction Authoring.

The three ovals identify three subcomponents that contribute to the instructional development precess: 1. Domain Knowledge Base (elaborated frame network), 2. Course Structure (transaction network), and 3. the actual finished course (transactions).

The three remaining curved boxes identify the "human factor" interaction with the system.

**How it Works**

The subject matter experts (SME's) and designers work together to identify and record all the "domain knowledge" that is required for any given course. This knowledge is entered into the KAAS computer program. KAAS contains knowledge acquisition techniques which assist and guide the entry process so that a Domain Knowledge Base is created. This knowledge base is configured and coded in such a way that it can be accessed by the Transaction Authoring system.

Designers and production personnel work with the Transaction Authoring computer program to create the actual course presentations (transactions). The authoring process has access to not only the Domain Knowledge Base, but also the Strategy Analysis System (SAS) and the transaction network from the Course Structure component of the system.

Two important considerations are included in the development process at this point:
1. SAS, a computer program that the designer can interact with, accepts and stores such information as; training goals, student information, environment information, instructional design strategies, mini expert systems, etc. The designer can select from a variety of presentation modes those instructional techniques that best fit the particular subject being considered. 2. The second point relates to the transaction network. One of the powerful tools available in the ID2 concept is the notion of transaction shells. These are shells or containers that have been previously designed and configured by instructional technologists/programmers. They are available in a variety of formats to receive the specific course content that is necessary for a particular course of instruction. This, of course, infers that there are many transaction shells organized into groups or "families" that pertain to specific subject requirements. The selection of this pre-existing shell enables the designer to by-pass the labor intensive "creating from scratch" function of traditional instructional design, thus realizing a considerable savings in development time. These transaction shells exist in two modes, authoring and delivery. (Merrill, Li, and Jones 1990)

**CDL and Second Generation Instructional Design**

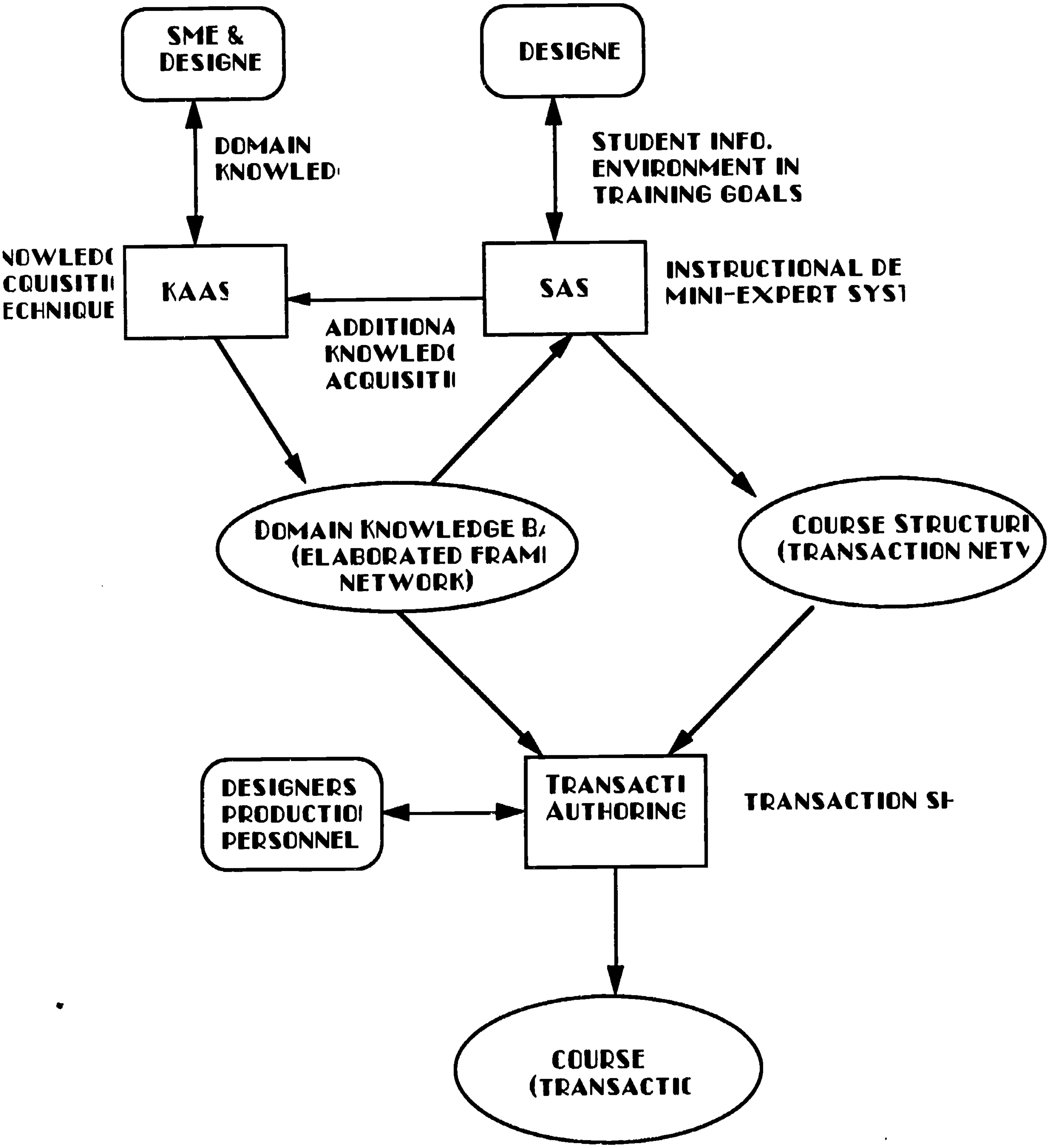
The focus of this paper is the application of ID2 in the Courseware Development Laboratory.

A corporate client contracted with Utah State University for the development and production of some internal training materials using the ID2 theory. The project was to focus on two specific instructional packages that had been developed by the clients internal training personnel. The client has an extensive corporate education organization which employs numerous instructional designers, subject matter experts, and trainers. The materials under consideration were in use within the corporate education system. One of the significant goals of the project was to study the ISD process under ID2 theory.

**Goals of the Project**

It was decided to integrate the corporate project with the Courseware Development Lab at Utah State University. The following goals or outcomes have been identified:

THE ID2 INSTRUCTIONAL DEVELOPMENT PROCESS




FIGURE

First, this will be the first practical application of the second generation instructional design theory (ID2) in developing a real piece of instruction. Observations will be made in order to learn how ID2 might change the traditional ISD process.

Second, we will collect data on how beginner (novice) instructional designers interact with the KAAS tool. Also we will test the completeness of the knowledge representation model underlying KAAS. Both of these evaluations will contribute to the novice version of the KAAS tool.

Third, we will focus on the development of up to five hours of instruction that can be directly used in training by the corporate client. We will also evaluate the instruction and the efficiency of developing such instruction, both which will be an extra benefit to the corporate client.

Fourth, the project will give the selected graduate students practical experience in applying ID2 theory. Students will also gain first hand experience in a "corporate design atmosphere".

Fifth, this joint Utah State University/Corporate project will be examined as a model for corporate partnership with higher education.

**Expectations and Results**

In order to meet the first goal, developing a real piece of instruction using ID2 theory, it was necessary to obtain samples of the corporate training materials including written documentation. After a period of initial orientation and up front analysis with this documentation, three specialists from the education division of the corporation made an on-site visit to the university and spent three days with the CDL team. Work sessions were scheduled between the corporate team and the graduate students. The purpose of these meetings was to review the knowledge base behind the training materials under study. The corporate team acted as Subject Matter Experts (SME's) and the CDL team members interviewed them concerning the training content and all aspects of the organization of the training materials. The three day visit provided a number of separate opportunities for the groups to interact, record data, ponder and analyze what had been discussed, formulate new questions, and interact again. This process produced excellent results and the CDL development team came away with a much clearer understanding of the training materials.

The second goal was directed toward the KAAS tool. The students in the CDL team were trained in the use of the KAAS tool. Following the analysis of the corporate training materials the students will be required to enter the data into KASS. Observations will be made as the novice student designers work with KAAS and data will be collected about their experiences. Also, careful evaluation will be conducted with the knowledge representation model underlying KAAS to see how it handles the specific domain knowledge of the corporate training materials.

( Note - the results of the interaction between the novice designers and KAAS, and the examination of the knowledge representation model will be completed and documented later in the study.)

The third goal, the development of up to five hours of instruction for the corporate client, will be implemented during the second phase of the project, the Product Development and Documentation phase.

The intent of this phase of the program is for the graduate students, in consultation with the ID2 theorists, to produce the specifications for the required transaction shells and have these specifications programmed as functional shells by the software engineers who are assigned to the project. Following the actual production of the working shells the CDL team will then undertake a formative evaluation of the first prototype and make revisions as necessary. This goal also requires an evaluation of the instruction and the efficiency of developing such instruction. This will take place during the third phase of the project, the Product Implementation and Evaluation phase.

(Results and documentation of this phase will be available following the completion of the project in the summer of 1991.)

The fourth goal of the project, giving the graduate students practical experience in applying ID2 theory, will be significant to their education as instructional technologists and will better prepare them to move into education or the corporate world as well trained designers of instruction.

The fifth outcome of the project, the model for corporate partnership with higher education, is especially significant to the continuation of the development of new instructional design theory and the implementation of new and better instructional design techniques.

**Summary and Conclusion**

The theory and underlying principles of ID2 have important application for any instructional design process, especially instruction that is computer-based. The development of computer-based transaction shells and a knowledge representation system can be a very complex task, but once developed, will be tremendous tools for the instructional design and development process. Specifically, ID2 provides the instructional designer with powerful tools for analyzing the knowledge that needs to be taught, the strategies and transactions that would most effectively teach a given subject and audience, and a systematic and easier way to author a course. (Li and Merrill, 1990)

The Courseware Development Laboratory at Utah State University provides a unique opportunity for advanced graduate students to interact with some of the leading instructional design theorerists as they expand the boundaries of Second Generation Instructional Design. The ultimate reward comes as the CDL team has the opportunity to effect one of the first practical implementations of ID2 theory for a corporate client in the real world of design, development, and utilization.

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# META-CBT A SUCCESSFUL MODEL FOR ALTERNATIVE CBT STRATEGIES?

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**Abstract**

This paper presents an alternative approach for the design, development and implementation of Computer Based Training (CBT) applications, based on concepts developed in the production of courseware to teach the principles of CBT (**meta-CBT**). During the design phase, it became evident that the traditional approach to information presentation based directly on instructional objectives was inadequate, giving rise to the notion of **transformational** Instructional Systems Development, in which the courseware structure is based on discrete performance events rather than content or task hierarchies. A presentation strategy was implemented in which the learner was an integral component of the instructional interactions, playing an active role in the selection and manipulation of content. This strategy formed the framework for a new presentation model, the **Learner Integrated Training Environment (LITE)**, which provides courseware developers with alternative options for structuring and delivering courseware. Given the demand for courseware implementations using this model, the **LITE** demonstrates a new paradigm for courseware presentation, especially in the work environment, where effective performance is a vital factor for success.

**Towards Alternatives for CBT**

Much of past, present (and perhaps future) education has been based on the instructor's perception of content and discipline. The traditional lecture and tutorial have provided a framework and environment for the teacher to emphasise their particular understanding in the context of the unit of instruction being presented. This approach has also frequently been reflected in many of the commercial computer-based educational applications, with the underlying structure resulting from the production techniques of Instructional Systems Development (ISD) methodologies (Reigeluth, 1983; Dick & Carey, 1985; Gagn•, Briggs & Wager, 1988; Romiszowski, 1988).

With frequent debate as to the effectiveness of CBT and the current emphasis on productivity and performance, it is appropriate to question the traditional models of computer-based training, and the instructional design systems which created them. A typical norm for courseware is one in which students are guided through a content domain using instructor-initiated prompts and cues. This content-question-feedback model is illustrated in Figure 1 (based on Alessi & Trollip, 1991). While this approach has become accepted practice, it is evident from the development of many different courseware applications that the resulting interactions are often unsatisfactory as learning events, and the cause of the frequent critical reports of CBT courseware (Sims, 1986a, 1986b, 1991a).

In contrast, recent emphasis has been placed on the learner and their performance in the work environment (Sims, 1991a). This is consistent with the directions of Performance Support Systems (Gery, 1987) and Embedded CBT (Bentley, 1990), which focus more on the learner's effective performance in the work environment, rather than their demonstration of content mastery in off-the-job training sessions.

Using the Australian work environment as an illustration, there have been significant developments in job restructuring and multi-skilling, leading to extensive definitions of performance levels and competency-based training. However, it is apparent from materials produced by industry groups that the focus is on content knowledge, rather than workplace performance. For example, in the hospitality industry, one of the defined competencies is to identify different types of service providers (restaurant, hotel, bar etc), although there is no clear context or purpose for this knowledge. While comprehensive, it is predictable that this framework for Australian industry training may generate similar problems to that of computer education: over emphasis. Solutions such as those proposed by Carroll (1984, 1990), in conjunction with those presented in the current discussion, are relevant to the effective implementation of new training and performance standards.

Extending the argument to courseware development specifically leads to the

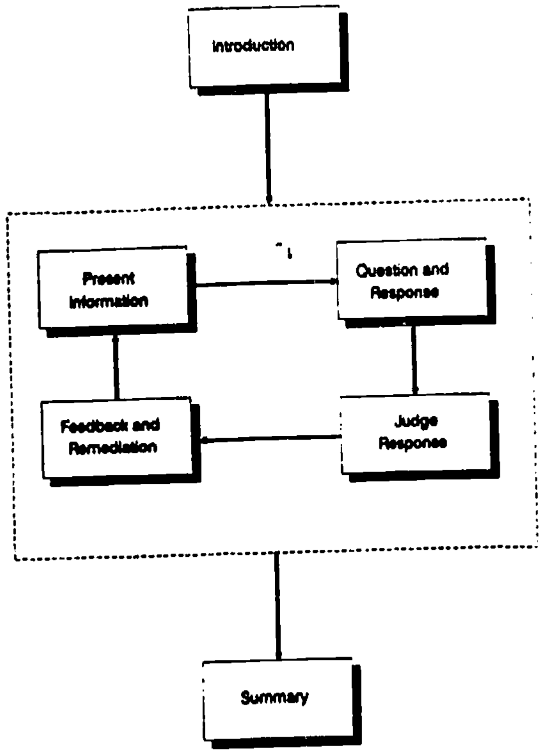


Figure 1 Traditional Tutorial Model

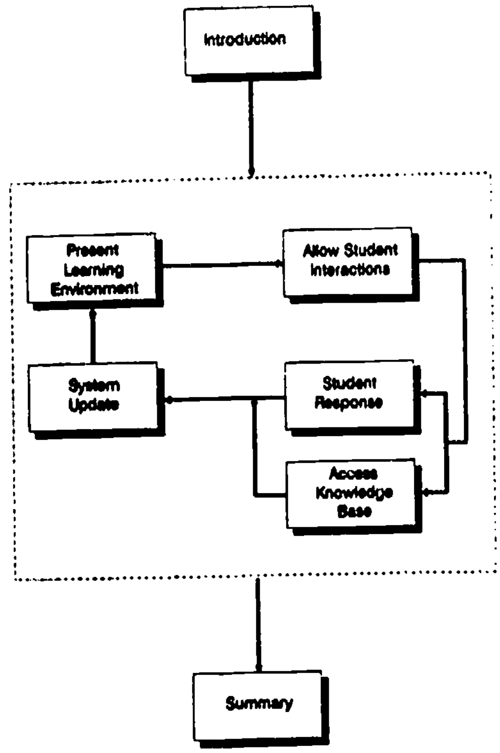


Figure 2 Integreated Tutorial Model

prediction that flaws in courseware modules may be due to an exaggerated emphasis on instructional objectives and hierarchical task structures. The suggestion is that a solution is to present the content in such a way that it will maximise opportunities for learning, exploration and discovery in the context of job performance.

To support this idea, Figure 2 illustrates an integrated presentation strategy whereby students have greater flexibility in selecting options for working through instructional content (Sims, 1991b). This strategy includes elements of Artificial Intelligence through the implementation of a microworld and knowledge-base to reflect a particular work environment (Kearsley, 1987). In essence, the student experiences a simulated work environment, and learns by problem-solving and decision-making through typical work scenarios. While similar to the simulation models proposed by Alessi & Trollip (1991), the approach suggested is one in which the student is the focus, in the same way as the employee is the focus in the work environment.

This integrated model emphasis a move from an instructor-led approach to one which is student-centred and student-controlled: a paradigm shift from the traditional behavioural models to cognitive operations.

Although traditional approaches to courseware development have identified specific presentation formats for different training requirements (tutorial, drill, simulation etc), this discussion argues that content material may be presented more effectively using different and new techniques. More importantly, it questions the requirement for content presentations to require specific prior knowledge for interpretation and manipulation, as the students will often be mature, literate and capable adults. While students do require specific guidance, there is increasing evidence and thought that learning will be more effective when knowledge is gained through individual pursuit and endeavour (Schank & Farrell, 1988).

**The Meta-CBT Project**

An opportunity to apply these concepts arose with the need to develop a course about Computer-Based Training (CBT) using courseware as the delivery medium (**meta-CBT**). The demand for the course came partly from training departments who needed to convince management of the value, features and processes of CBT, and partly as a result of the various tertiary courses which are now teaching CBT. In both cases, few suitable materials were available to present the fundamental concepts.

In fact, the major techniques for presenting CBT as a concept have tended to focus on authoring tools and exemplary courseware rather than the significant factors of the CBT development process. In brief, the major options for presenting CBT have been:

**Demonstrating Authoring Tools**
While of interest, an authoring tool is not a training resource, and the demonstration software is likely to overwhelm all but the most experienced authors as it will go beyond the scope of the project and the ability of the development team.

**emonstrating Samples of CBT Courseware**
ompleted products can be impressive, but they are all too frequently irrelevant to the current corporate need. It is vital to impress upon any decision makers the benefits and commitments CBT will bring to the organisation.

**Training Sessions on CBT**
While practical, there is the risk that material presented will be too general and not enable the major issues and factors associated with CBT development to be explored.

One of the items not listed is CBT courseware, and it appears there has been little application of CBT as the medium of explanation for CBT! In an attempt to provide a viable and contextual environment for the potential student (senior executives, trainers, students of CBT), the current technology was assessed to determine how it could be used. The most obvious features considered were:

**Multi-media and Graphics**
This provides a variety of presentation options such as animation, video images and audio. One major advantage of these options was that they could minimise the amount of text displayed to the student during instruction as well as enhance the graphic display.

**Organisational metaphors**
With significant emphasis on screen design, there has been little use of the technique which presents courseware using a context with which the student is familiar, such as an office, workshop or personal work area. The perceived benefit of the metaphor was that it would enhance courseware realism or fidelity.

**Interactive environments**
This has always been **the** feature of CBT, and yet the medium has most frequently been criticised for electronic page-turning. The principle adopted for the project was that students would be involved in some activity or decision-making process throughout the courseware.

However, apart from the technologies available, a major consideration of the development process concerned **relevance**, in terms of the factors of CBT which should be understood by either management or prospective users. This technique is used by information retrieval specialists, who also work with the additional dimension of precision (Lowry, 1990). In transferring this approach to courseware development, it was vital that the material presented to students was both precise and relevant.

In assessing the relevant factors for CBT, the traditional approach has been to focus on the features: colour, interaction, response judging etc (Sims, 1990). But this is only part of the finished product. What has to be understood, especially by organisations and students, is the actual process of courseware production, from initial concept to final installed product. Therefore, it was necessary to re-assess CBT to determine how and what should be included, based on the understanding that CBT, as a topic, is not just courseware but the complete development process. After careful consideration, it was decided that rather than implement a tutorial model to cover the basic topics of CBT, the courseware would be developed to integrate students into the CBT development process. The major constructs of the courseware were as follows:

**Integration**
The courseware would not be tutorial (didactic) in nature, but designed so that the student would be integrated into the CBT development process and environment.

**Strategy**
Instead of telling the student about CBT, the strategy adopted was based on a discovery approach, in which the student became involved in the actual design, development and use of a module of courseware.

**Data Base**
The courseware was designed to contain a database of screen displays and interactions relevant to an organisational training course in product training. Throughout the courseware, the student would "assist" with the development of these courseware objects.

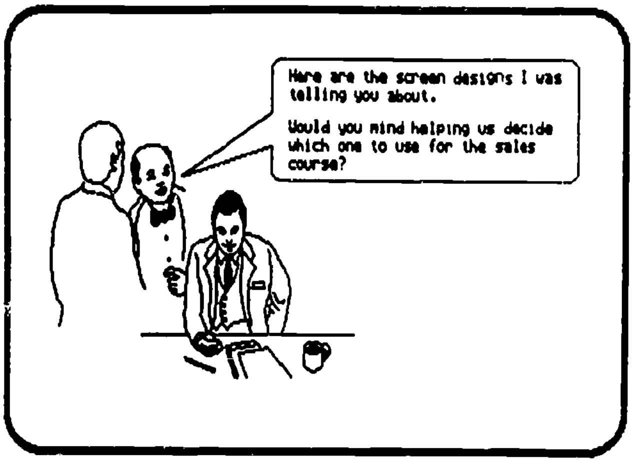


**Figure 3a Learner Integration**

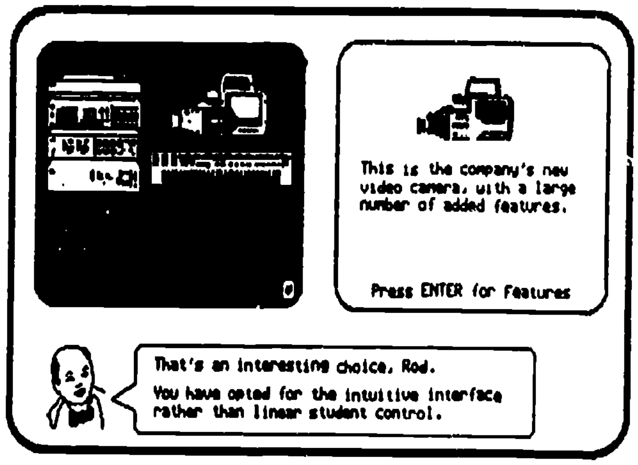


**Figure 3b Results of Action**

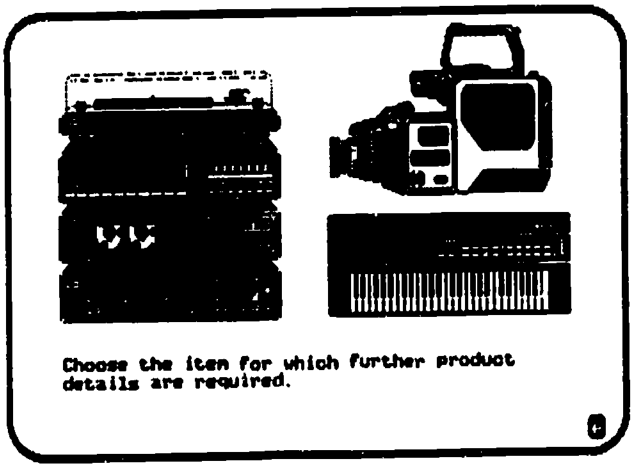


**Figure 3c Finished Product**

```
IF VISITING-DEVELOPMENT
    IF ANALYSIS-VISITED
        IF DESIGN-VISITED
            BEGIN-DESIGN-ACTIVITY
        ELSE
            SUGGEST-VISIT-DESIGN
        ENDIF
    ELSE
        SUGGEST-VISIT-ANALYSIS
    ENDIF
ENDIF
```

**Figure 4 Sample of Control Logic**

**Organisational Metaphor**
The student was "introduced" to members of the courseware development team, and assisted them in their various tasks (such as instructional design; specifying objectives, selecting screen designs, designing the learner-computer interface). Figure 3(a) illustrates a display in which the student is about to make a decision on screen design.

**Control**
If the student moved out of sequence (that is, required additional information to complete a task), it would be suggested that they discuss the project with another team member's work; in other words, the team member would indicate they could not continue with the production of courseware without additional details.

**Interaction**
The student was shown what a team member was doing, and asked to make a selection or decision on their preferred option (objective, screen design, interaction, animation, multimedia display etc). Figure 3(b) illustrates possible feedback resulting from such a choice.

**Creativity**
After making a selection, the courseware object (such as a specific screen) would be identified for inclusion in the finished product, and integrated into the sample course.

**Involvement**
On completion of the meta-CBT courseware, the student had contributed to all facets of the courseware development process and in doing so, created a lesson which could be viewed. Figure 3(c) illustrates a screen from the completed product.

The principle of this meta-CBT was to integrate the student into the actual process in order that they may experience first hand the nature of CBT design, development and production. In addition, the course focused on aspects such as cost justification and the resolution of training problems in terms of the application of CBT rather than other training resources.

One important factor is that the meta-CBT implementation does not imply that the design and structure of the interactions is free from standards and instructional integrity;

however, it is necessary to differentiate the role of the learner and the operation of the courseware. One the one hand, the learner must have access to courseware which enables them to move freely within the content area, and to simply work with the interactions presented. On the other hand, the courseware must record the information presented, depending on which items the student has completed, so that the interactions are relevant to the student's progress through the material.

In this particular course, the courseware allowed the student to interact with the CBT production team at any of the 5 major production stages (analysis, design, development, implementation and evaluation). However, it was also integral to the structure that the student could not view the completed module until each of the stages had been considered and in the correct sequence. To achieve this, a high-degree of logic control (i.e. programming) was necessary to ensure that certain conditions were met, and to ensure the processes of CBT development were emphasised.

For example, if the student were to work with development tasks before completing the design activities, the importance of the design function would be lost. The courseware therefore had to maintain a record of the courseware development tasks completed by the student. The basic logic for this particular case is shown in Figure 4.

While this is only illustrative, and does not cover all of the many options available to the student, it does emphasise that to develop a more effective courseware environment requires considerable expertise in courseware development and authoring. In this case, the meta-CBT courseware covered new concepts in the presentation of instructional interactions, but to achieve this required the use of complex presentation logic.

**Transformational ISD**
One outcome from the work with the meta-CBT courseware was the concept of **transformational** Instructional Systems Development (ISD), which extends the traditional task analysis and statement of objectives to a process whereby the content is expressed as a work event, and objectives linked to that event addressed by the courseware. This varies from the more traditional and accepted approaches to ISD, which break down the content material into manageable units or tasks, and objectives (both enabling and terminal) are generated to provide a measure of performance on those tasks.

The mistake made by many courseware developers is to use those objectives as the focus and structure for the design process, wih the result that the instructional sequences developed reflect the content its associated objectives rather than the context of the content and its relevance to work activities. In terms of courseware presentation, there is the potential that the material will be too content oriented and lack any specific continuity in terms of job performance. Figure 5 illustrates a traditional lesson structure with a number of objectives, and the way in which those objectives may be extracted and integrated into an instructional event which is based on a specific performance activity.

The importance of the notion of transformational ISD is that additional consideration must be made after completing the traditional task analysis phases (Sims, 1991b). The content and objectives will then be grouped in terms of job performance rather than content hierarchy, which will provide an environment in which the student can work with the material as it would be found on-the-job.

**The Learner Integrated Training Environment (LITE)**
In practical terms, the development of alternate courseware strategies reflects a paradigm shift (from behavioural to cognitive), and illustrates a movement towards focusing on the learner rather than the instructor/content (Sims, 1991a). As shown in the previous discussion, this will result in a change in courseware structure and appearance. In many ways, this "new" courseware will be similar to some of the original exemplary models of CAL which were geared towards individual analysis and problem solving, and which mainframe PLATO users may remember. It is possible that the approach suggested in this discussion has been neglected because it requires additional effort and extensive programming skills rather than for pedagogical reasons.

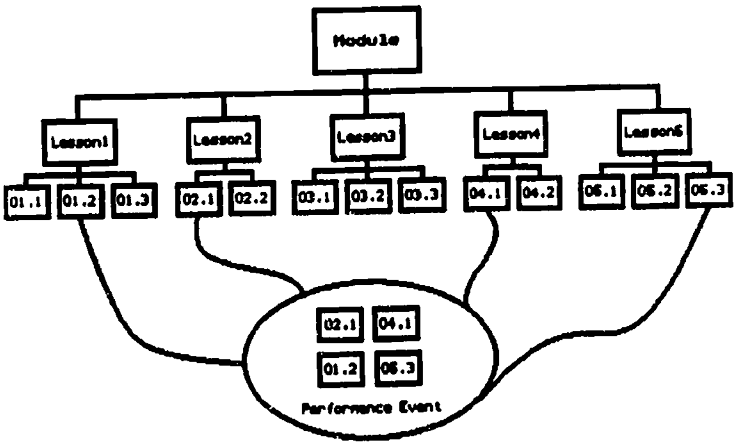


Figure 5 Transformational ISD

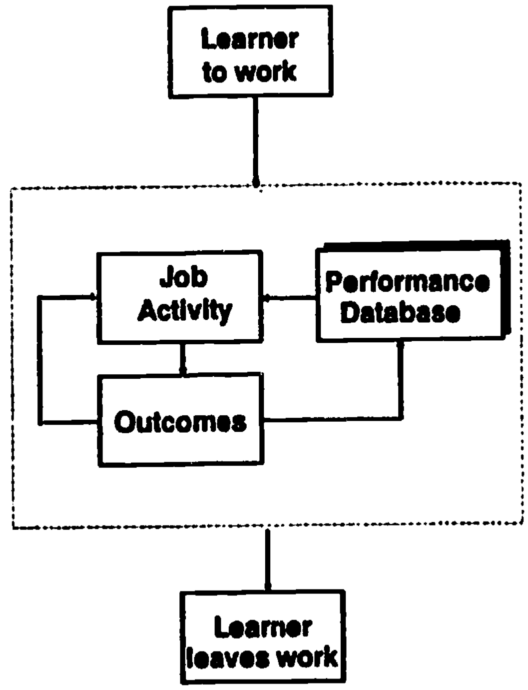


Figure 6 Learner Integrated Training Environment

However, based on the meta-CBT development, it is anticipated that this courseware format will become the standard, and will focus on different instructional parameters, where the emphasis is on the activities the learner will be required to complete to demonstrate successful performance. This will be accomplished by placing the learner into the subject or work environment where they will be required to act upon activities (both planned and random) which occur naturally in that environment. This **Learner Integrated Training Environment (LITE)** is designed to provide a true fidelity simulated environment where the focus of the interactions is the student and the outcomes of their actions. The basic structure of the LITE is illustrated in Figure 6.

While this is a development and modification of the simulation format of CBT, it is also an attempt to address the fact that CBT has not been successful. The LITE environment is suggested as a way to re-think the way CBT (and other instructional resources) are designed and implemented.

Based on these concepts of learner integration, one of Australia's banks has adopted the model to address a training situation which had been treated with traditional CBT. The courseware had been designed to train branch supervisors in their roles as training coordinators; however, it became evident that they were not managing the training process as required. To address the situation, the LITE model was implemented whereby the courseware placed the supervisor directly into the work situation and allowed them to experience the responsibilities and outcomes of their actions.

In another example of this process, a recent courseware development project concerning proprietary electronic-mail software was developed using the LITE principles. While the content was based on the software manual, the presentation sequences had little relation to the sequence of the manual. The structure of the courseware was based on students reacting to communication tasks resulting from work situations, and the electronic mail software was accessed to solve the problem. One of the outcomes of the design of this application was the presentation metaphor illustrated in Figure 7.

In addition, the actual purpose of the course received considerable scrutiny to determine the exact purpose of the courseware. In the case of the electronic mail training, one of the major objectives was to change attitudes by demonstrating the effectiveness of electronic communications. Thus the course was titled "Have you checked your mail today" (with the corporate logo) rather than using the traditional "An Introduction to Electronic Mail".

In summary, the electronic mail courseware focused on using the software to achieve particular work requests, rather than how to use the software, which was treated as subsidiary to the communication task to be completed. In addition, the material was presented in a realistic manner, without significant assistance, which is what would occur in the real work environment.

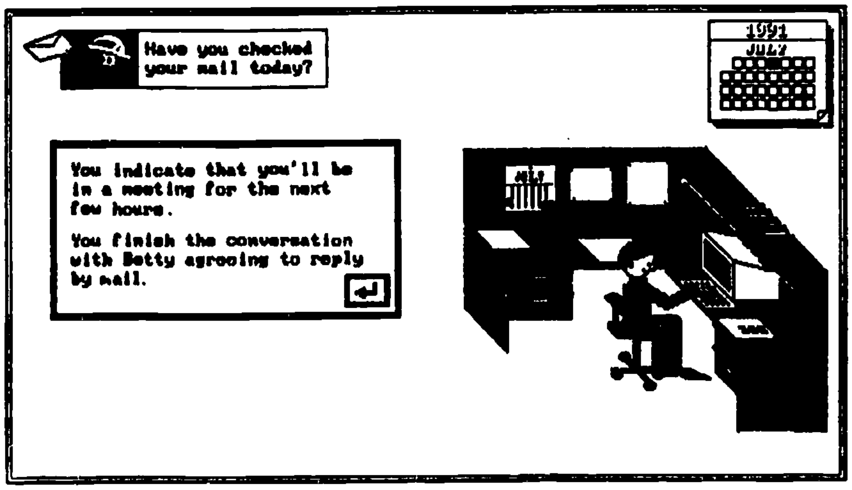


Figure 7 LITE Example

This use of a question as a title for courseware applications can assist in determining strategy and direction. For example, in the banking industry, a trainee teller will receive a unit of instruction on the **withdrawal** slip. Traditionally, this will be a series of examples describing each of the sections on the slip (name, account number, signature etc). However, when trainers are questioned as to "why" they conduct this training, there is often no answer. (Interestingly, this is one of the most difficult aspects of the courseware development process: identifying the instructional discrepancy which initiated the original demand for the courseware). Therefore, to implement a LITE, the course could be transformed such that the content was expressed in terms of "Will the customer receive their money" rather than Teller Training Module 75:

**The Withdrawal Slip**

This technique of expressing the content in terms of a question is integral to the LITE model, as it allows the designer to focus on the performance required by the student. In addition, this approach will typically result in different combinations of content as well as emphasising the relevance and purpose of the training.

**Future Directions**

The next stage in the application of instructional technology is the successful integration of multi-media components. It is likely that future courseware applications will see a significant reduction in displayed text, replaced by digitised audio, with graphics and interactions incorporating DVI or similar technologies. With respect to presentation strategies, models such as LITE will continue to be enhanced, applying techniques such as those used in the popular adventure game. It is important to highlight the observation that game players can spend many hours trying to solve problems, and in doing so, learn the tasks required to solve particular problems within the game. There is no reason why this strategy should not be applied to courseware applications.

Given these developments in courseware production and presentation, the task for trainers is therefore to assess the desired outcomes of the training in terms of student performance, rather than a focusing on a direct demonstration of knowledge. The introduction of new instructional strategies for CBT is therefore essential, especially with the developments in presentation technology and the increased demand for effective training and performance. The meta-CBT project, the resulting concept of transformational ISD and the development of the Learner Integrated Training Environment model emphasise the advantages of using alternative options as a means for enabling students to work with new concepts and tasks.

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

# PRESCRIPTIONS IN READING COMPUTER-ASSISTED INSTRUCTION: READING VERSUS WRITING

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**Abstract**
This study was designed to answer specific questions regarding the use of extensive computer curriculum products in computer laboratory settings in the upper elementary school. Should a "variety" of curricula be provided? And, does a computer laboratory setting impact girls and boys differently? Fifth- and sixth-grade students (n=115) were randomly assigned to either a reading only treatment (RO) or a reading and writing treatment (RW). The RO group received the WICAT Reading Comprehension product twice weekly throughout the study. The RW group received the same reading product once per week and the WICAT Writing 3-6 product once per week. The literal and inferential subtests of the Stanford Reading Test were used as pre- and post-treatment dependent measures. The factors analyzed by mixed ANOVA included two between factors, treatment (RO, RW) and gender (female, male); and two within factors, test (pretest, posttest) and subtest (literal, inferential). The main effects and most of the interactions were non-significant. However, the two factors test, $F(1, 100) = 5.926$, $p = 0.017$, and subtest, $F(1, 100) = 7.107$, $p = 0.009$, and the interaction of gender and test, $F(1, 100) = 6.072$, $p = 0.015$, were all significant at the $p < .05$ level. The first follow-up analysis examined males and females separately using a mixed ANOVA which included treatment, test, and subtest. The female group obtained no significant results for any factor or interaction, indicating that the females were not differentially affected by the treatments, nor did they experience pretest to posttest gains for the test as a whole nor for the literal and inferential subtests. The male group obtained significant differences at the $p < .05$ level for the factors test, $F(1, 53) = 16.114$, $p = 0.000$, and subtest, $F(1, 53) = 6.666$, $p = 0.013$. The RO and WR treatments were both effective in improving the boys' reading scores from the pretest to the posttest, especially for the literal portion of the test. In summary, males made substantial pre- to post-test gains on both the literal (e.s. = 0.43) and inferential (e.s. = 0.26) subtests of the Stanford Reading Test, while the females did not (literal e.s. = 0.01; inferential e.s. = -0.02). The paper concludes with a discussion of this troubling finding.

**Introduction**
Extensive computer curricula delivered in computer laboratory settings are now available. Companies like WICAT Systems, Jostens, and the Computer Curriculum Corporation are providing thousands of hours of systematic courseware products to our schools. WICAT Systems alone estimates that at least 250,000 students attend WICAT instruction each school day. More and more students will receive instruction in computer laboratory settings.

The research base required for making instructional decisions relating to this type of extensive computer-assisted instruction (CAI) environments is now being developed, but at this time, it is unclear even what questions should be asked. For example, what is the optimum amount of computer instruction time per period and per week? Does this vary by ability, interest, gender, or other individual variable? What is the best mix of computer delivered subjects? Should computer instruction be in lock-step with class instruction, or can each progress individually? What role(s) should the teacher play in the computer lab? Does the teacher even need to come to the computer lab? What sort of reports should be generated by these systems? Who should receive these reports? Teachers? Administrators? The student? Their parents? Do these extensive computer environments deliver a hidden agenda (Streibel, 1986, 1988)?

This study addressed a question posed by an area principal. Specifically, given that the students will attend computer class twice per week for twenty minute periods, and given that the intent is to increase the students' standardized reading scores, then should these students receive reading CAI only, or would a combination of reading and writing CAI be most effective? This study simplistically assumes that more is better in CAI, thus the reading-only group should outperform the reading-and-writing group on the reading posttest measure.

The possibility of gender difference was also considered because of findings from earlier research involving WICAT curicula. For example, in a study involving third grade students utilizing the WICAT Systems Primary Reading Product, Clariana (1990) reported that boys worked significantly faster than girls, e.s. = 0.86, thus completing considerably more activities over the course of the study. This difference occurred even though the girls were better readers (e.g., higher standardized reading scores). Completing more lessons may ultimately translate into higher achievement scores.

A recent review of gender difference in computer learning environments determined that boys usually do better than girls when the computer delivered content is either math or science (Signer, 1991). This may be due in part to the individualized delivery format of most CAI. Differences in girls' and boys' attitudes and preferences for working alone or in groups has been shown. In a study considering individual, cooperative, and competitive CAI, Johnson, Johnson, and Stanne (1985) reported that girls attitudes compared to the boys were adversely affected within the competitive condition. Other studies also show that boys prefer to work alone while girls prefer to work with others (Allen, 1987; Tobin & Garnett, 1987). This difference may be most evident in subjects like math and science, which girls traditionally tend to dislike (Esquivel & Brenes, 1988; Tamir, 1988; Tobin & Garnett, 1987).

When learning alone on microcomputers is combined with math or science subject matter, this combination of non-preferred delivery method and non-preferred content may be to much for some students, especially those with low-ability, to overcome. For example, Schultz and Clariana (1990) examined the gender-related learning differences of at-risk eighth grade students utilizing WICAT Systems Math Products. The students attended computer lab for six weeks in groups of twenty-five, Monday through Thursday, for two, forty-five minute CAI lessons. Two professional teachers (both male) were constantly available in the lab to assist the students. Extensive progress reports were produced and examined each day, and the teachers reviewed this with each student individually a minimum of twice per week. If a student's report revealed a problem, the student was given direct help that day. A significant gender and ability (i.e., pretest, median split of the group) difference was reported. Both below- and above-median boys, and also the above-the-median girls made significant pre to posttest gains on the math achievement dependent measure, however the below-the-median girls did not. The authors concluded that the combination of WICAT CAI and intensive teacher-student intervention/interaction was particularly beneficial for these at-risk students. However, even with such close monitoring of students' work, the low-ability girls were not successful. Post experiment interviews with the two male teachers suggests that the low-ability females were considerably less vocal than their peers, and seemed to "hide-out" by doing just enough work to avoid teacher intervention. Most of the boys were unusually vocal, and demanded most of the teachers' time.

Though upper-elementary boys generally out perform girls in mathematics (Fennema & Carpenter, 1981; NAEP, 1983), girls are usually better readers than boys. Though girls might not prefer the traditional individual, non-social aspects of CAI, their generally better reading ability may overcome this non-preference. In other words, it may require a preference mismatch of both the content and the delivery of instruction before a significant negative impact on learning occurs. This study assumes that when the CAI content is reading, there should be no posttest performance difference between groups of girls and boys.

In summary, the individual learning environment (or lonely learning) associated with most extensive computer delivery systems may differentially impact girls and boys. Girls may be more successful in group learning situations, which is generally impractical in computer laboratory environments. Thus it is not computers necessarily, but the way computers are used, that could exacerbate gender differences to the detriment of girls.

This study considered two pragmatic assumptions related to instruction in computer labs with extensive amounts of courseware. First, doubling the amount of time that students spend in a CAI reading curriculum will substantially improve their standardized reading scores. Second, because the CAI content is reading (Signer, 1991), no difference is expected between the girls and boys posttest performances.

**Method**

Subjects and Design.

The subjects involved in this study were fifth and sixth grade students from an elementary school associated with a large southern university. The school is a public school with a charter to enroll students from the families of university employees first. Additional vacancies are filled based on residential location. Students living near the school receive a higher priority. Additionally, the school intentionally enrolls a diverse student population which includes many different race and ethnic groups and also students from varied socio-economic backgrounds. More detailed descriptions of the school population are available in a dissertation by Jordan (1990).

Pretest data were collected for an initial pool of 115 students, which includes most of the fifth and sixth grade students in the school. Since the lab had only eight stations, students were assigned to come to the computer lab in groups of eight. The groups were randomly assigned to either the "reading only" treatment or to the "reading and writing" treatment. The students in any group of eight received the same treatment. This was necessary so that students would not be distracted or upset when they saw their peers working on a different curriculum.

The WICAT curriculum was extensively demonstrated to the student's teachers before the study began. The teachers were pleased at the chance to send their students to the computer lab. During the study, the teachers were invited to come observe their students, but none came. Computer progress reports were sent to the teachers at each six-weeks period, however the teachers never commented to the researchers or the coordinator about either the reports or their students' progress in the computer lab.

Students attended computer lab twice per week for twenty-minute periods and were accompanied by a parent volunteer, by a teachers aid, or by a graduate student intern. Occasionally, students would be unruly and were sent back to their classroom. Though the volunteer parents and the interns were present in the lab, they lacked the skills necessary to maintain the learning environment or give positive affective feedback to these elementary children. However, most students liked to come to the lab and were busy during most of the sessions. After 10 weeks, posttest data were collected. Students continued to work in the lab but no further data were collected.

Lesson Descriptions.

The reading only treatment received the WICAT Reading Comprehension product only. These lessons are designed to enhance reading skills like: identifying key ideas in passages, identifying fact from opinion, reading and interpreting charts and graphs, making inferences, and recognizing and deleting statements that do not relate to reading passages. The WICAT reading curriculum consists of several hundred stories ranging in grade level from 2nd grade through 10th grade, which are grouped into three major categories called protocols. The three protocols used during this study were inference, deletion, and graphing. The students received a mix of all three protocols during the course of the study.

The inference protocol required the student to read a story from 10 to 20 screens long. Previous pages could be viewed by a simple backpage command at any time. A series of inferential questions were asked with each story portion. The student responded to the question and then underlined key words in the text that supports their answer. Feedback was given after each episode of responding. Feedback included knowledge of the correct response and also the highlighting of the important words in context by using inverse shading of the words and the correct multiple choice response. Students were awarded points both for answering the question correctly and also for underlining the correct words.

The deletion protocol required the student to read a story from 6 to 10 screens long. The students were required to select the sentences that did not belong. These sentences were crossed out by use of the space bar and the "x" key. Feedback included knowledge of correct response as well as explanatory feedback after each student response. Students were awarded points for deleting all the unnecessary sentences, however there was a penalty for removing correct sentences.

The graphing protocol required the student to view a visual and answer questions about the visual. Students were presented with a picture, line drawing, chart, or table. About six highly specific questions about the visual were asked. Students responded to each question by moving the cursor icon to the correct location on the visual. The correct response was highlighted with inverse color. When the student was incorrect, the same question would be rephrased and a hint would be given. The correct answer was given after the second try regardless of the student's response. Students were awarded points for correct responses on their first attempt and partial credit for correct responses on their second attempt.

These reading passages covered a range of student reading grade and interest levels from about grade two through grade eight. Students were evaluated by the online WICAT Cloze test and placed into the computer curriculum at their appropriate level. Clariana (1991), in a study involving 101 upper-elementary school students, reported the relationship between this WICAT Cloze test battery and a well known national standardized reading test, the Iowa Test of Basic Skills, as $r = 0.83$. He concluded that the WICAT Cloze test was doing a good job of placing students into the WICAT Reading Comprehension curriculum.

The WICAT system monitors student progress and assigns students up or down in the curriculum based upon the student's accumulated performance. The ability of the WICAT system to monitor continuing student progress and automatically move a student to the correct lesson sequence has also been investigated. Bond and Clariana (1989) compared the WICAT computer-adaptive placement to manual controlled placement, where the experimenters monitored student progress biweekly and moved students to different lessons based on a predetermined algorithm. No significant differences were shown, which may suggest that the computer-adaptive system is, at least, no worse than the manual process used in their study.

The WICAT Writing product provides four different forms of activities that allows the students to compose stories that are either informational, humorous, creative, or descriptive of a visual that the students compose from a menu of "parts". These activities are very popular with students of this age, and students often request that they be allowed to do the writing activities. During the writing activities, the students were given information as text and questions, were shown pictures, figures, and animations, and were asked to write a story about what they had seen and read. The stories were composed on the word processor and were printed on paper and given to the student.

Instrumentation and Analysis.
Alternate versions of the Stanford Reading Test were used to obtain pretest and posttest data. The tests were administered under controlled conditions in the students' classroom by a graduate student and by the students' homeroom teacher. The importance of doing well on the test was emphasized. The tests were composed of literal and inferential subtests. The major analysis consisted of a 2 (treatment: reading only versus reading and writing) x 2 (gender) x 2 (test: pretest and posttest) x 2 (subtest: literal and inferential) mixed ANOVA on Stanford Reading Test scores.

**Results**
The means and standard deviations for each treatment group are shown in Table 1. The analysis of variance summary information is shown in Table 2. The two factors test, $F(1, 100) = 5.926$, $p = 0.017$, and subtest, $F(1, 100) = 7.107$, $p = 0.009$, and the interaction of gender and test, $F(1, 100) = 6.072$, $p = 0.015$, were shown to be significant at the $p < .05$ level. Because of the gender interaction, the first follow-up analysis examined males and females separately using a mixed ANOVA which included treatment, test, and subtest. The female group obtained no significant results for any of the main effects or interactions, indicating that the females were not differentially affected by the treatments, nor did they experience pre to post test gains for the test as a whole, nor for the literal and inferential subtests. The male group obtained significant differences at the $p < .05$ level for the factors test, $F(1, 53) = 16.114$, $p = 0.000$, and subtest, $F(1, 53) = 6.666$, $p = 0.013$. Figure 1 attempts to display the significant interactions noted above. Examination of means revealed that the boys made substantial pre- to post-test gains on both the literal (e.s. = 0.43) and inferential (e.s. = 0.26) subtests of the Stanford Reading Test, while the girls did not (literal e.s. = 0.01; inferential e.s. = -0.02).

**Discussion**
The assumption that "more reading CAI is better" was not confirmed. The posttest scores of the reading and writing group (mean = 658.5) compared to the reading only group (mean = 657.5) were not significantly different. Clariana (1991) noted that, "At this time, computer-assisted instruction means reading. The lesson content may be math, science, social studies and so on, but no matter what, reading, specifically, reading computer frames that have generally low resolution and limited surface area, is critical for instruction."(p.107)

In this study, the students that received the CAI writing curriculum were required to read, follow directions, and understand in order to be able to do the "fun" writing activities. Though the curriculum involved writing, it may have affected the students' reading skills. If so, it is possible that any type of CAI content may positively impact reading skills.

The assumption that there would be no gender-related differences in this CAI reading curriculum was also not confirmed.

TABLE 1
Means and standard deviations.

| | pre Literal | pre Inferential | post Literal | post Inferential |
|---|---|---|---|---|
| Females | | | | |
| Reading only (n=23) | 648.3 sd 64.5 | 648.9 sd 69.4 | 661.5 sd 80.2 | 647.2 sd 78.2 |
| Reading + writing (n=26) | 665.1 sd 79.2 | 654.7 sd 80.3 | 653.9 sd 83.9 | 653.8 sd 79.7 |
| Males | | | | |
| Reading only (n=26) | 627.5 sd 58.0 | 629.7 sd 66.7 | 665.8 sd 70.2 | 654.6 sd 58.3 |
| Reading + writing (n=29) | 649.2 sd 74.5 | 641.9 sd 77.8 | 669.5 sd 68.8 | 655.5 sd 56.1 |

TABLE 2
ANOVA summary table.

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| e | ss | df | ms | F | p |
|---|---|---|---|---|---|
| Between Subjects Effects | | | | | |
| Treatment (A) | 5815.846 | 1 | 5815.846 | 0.353 | 0.554 |
| Gender (B) | 2539.659 | 1 | 2539.659 | 0.154 | 0.695 |
| A x B | 473.810 | 1 | 473.810 | 0.029 | 0.866 |
| error | 1647215.569 | 100 | 16472.156 | | |
| Within Subjects Effects | | | | | |
| Pre/post tests (C) | 15050.998 | 1 | 15050.998 | 5.926 | 0.017 * |
| A x C | 4510.782 | 1 | 4510.782 | 1.776 | 0.186 |
| B x C | 15423.388 | 1 | 15423.388 | 6.072 | 0.015 * |
| A x B x C | 50.432 | 1 | 50.432 | 0.020 | 0.888 |
| error | 253992.349 | 100 | 2539.923 | | |
| Lit/Inf subtests (D) | 4770.428 | 1 | 4770.428 | 7.107 | 0.009 ** |
| A x D | 132.191 | 1 | 132.191 | 0.197 | 0.658 |
| B x D | 57.582 | 1 | 57.582 | 0.086 | 0.770 |
| A x B x D | 384.844 | 1 | 384.844 | 0.573 | 0.451 |
| error | 67127.272 | 100 | 671.273 | | |
| Interaction (C x D) | 985.877 | 1 | 985.877 | 0.895 | 0.346 |
| A x C x D | 1632.693 | 1 | 1632.693 | 1.483 | 0.226 |
| B x C x D | 384.120 | 1 | 384.120 | 0.349 | 0.556 |
| A x B x C x D | 556.034 | 1 | 556.034 | 0.505 | 0.479 |
| error | 110124.155 | 100 | 1101.242 | | |

Figure 1.Line graph of the pretest to postest changes for males (dashed lines) compared to females (solid line) broken out by literal and inferential subtests.

Examination of means revealed that the males made substantial pretest to posttest gains on both the literal (e.s. = 0.43) and inferential (e.s. = 0.26) subtests, while the females did not (literal e.s. = 0.01; inferential e.s. = -0.02).

Are there gender-related learning differences in computer lab environments? Schimmel (1986) stated "If feedback operates as a kind of assistance, then feedback may be more frequently sought and more effectively used by females than males" (p. 113). Perhaps girls take more advantage of help screens and other aspects of "good" computer lessons than boys, thus girls may actually read more information than boys during a lesson, and take longer to complete the lesson. At the same time, the chunk size of CAI tends to be small. There may be little advantage in using the extra available information provided by help screens. It seems that computer lab work will tend to favor learners that are aggressive or hurried (Clariana & Smith, 1988) and may punish careful or thoughtful learners. This has been referred to as a "production mentality" (Streibel, 1986, 1988), since students are rewarded for completing more activities. Quantity wins over quality. Such an environment may favor boys over girls.

Importantly in this study, teachers were not available to give praise or note student's good work. This may be a critical aspect of CAI work, especially with young children. Peterson and Fennema (1985) found that the mathematics achievement of fourth grade females was positively correlated with the amount of personal assistance they obtained and the opposite was true for males. Clariana (1990b) investigated the effects of teacher style on rate of CAI reading lesson completion by first grade students. An authorative teacher style resulted in significantly faster lesson completion compared to a laissez-faire teacher style. Teachers' style is an often overlooked variable in CAI research.

Teachers' presence may impact students' motivation to work. In this study, perhaps the boys received intrinsic motivation when working on the computer while the girls did not. If the teacher had been present, the girls motivation, which may focus on their teacher, would have been higher. This begs some important pragmatic questions, "Should teachers be present in computer labs?" and "What sort of role should the teacher assume in the computer lab"?

In summary, good instructional practice in computer labs with extensive curricula depends upon an adequate research base. The simplistic model that "more is better" is not adequate. Apparently, a computer lab is a complex learning environment that requires considerable examination, both qualitative and quantitative. More research and better models are required concerning the learning environment associated with CAI labs.

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# AN INSTRUCTIONAL MERGER: HYPERCARD AND THE INTEGRATIVE TEACHING MODEL

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**Abstract**
This paper will explain how one information processing model of teaching can merge with computer technology to create a more effective data retrieval process. The hypermedia program on the Macintosh computer, HyperCard, will be used to help focus students' attention on the material being presented in the lesson. In addition to the hypermedia program being able to isolate specific data display information, using animation and speech can also increase students' on-task behavior.

The Integrative Teaching Model combines content information with inductive and deductive reasoning to help develop students' thinking skills by having students progress through five instructional phases. This paper will summarize the theory behind the model, give reasons for using an information processing model, and will point out the advantages of using HyperCard for the data display and retrieval. The Integrative Model's five phases are described within a sample lesson plan. References will be included which would enable an educator to design hypermedia stacks on HyperCard.

An Instructional Merger:
One of the major criticisms voiced against our educational systems has been the low level of thinking that teachers have required from students. Too frequently, our classroom requirements have not extended beyond memorization and recall of facts and/or figures. This mere accumulation of descriptive knowledge does not prepare our students to critically interpret data.

Some instructional strategies have been developed and tested during the past few decades which encourage students to process information. Using information processing teaching strategies have been found to develop students' thinking skills (Steinberg, 1985; Rosenshine & Stevens, 1986). The information processing teaching model discussed here was first conceptualized by Hilda Taba (1965, 1967) and later described by Eggen and Kauchak (1988) as the Integrative Model. Eggen and Kauchak's conceptualization of the model includes five phases which combine inductive and deductive skills with content.

As computer applications become more powerful and more available to teachers, educators who feel comfortable experimenting with computer programs will discover ever increasing ways of using computer technology which will complement instruction. One such modification will be described in this paper. The hypermedia application, HyperCard, found on the Macintosh can be used in conjunction with the Integrative Teaching Model to make better data displays. Being able to reveal only that data which the teacher wants the students to respond to can increase on-task behavior during the lesson. Instead of students looking at immobile text or pictures, a HyperCard stack can be designed with objects which move, pictures which talk, and music. Other advantages of using a HyperCard stack with the model will be explored.

In order to ensure that the reader will be able to understand the theory behind the model's development, background for the Integrative Model will be given in this paper although the conference session only touched on it briefly. This paper will also summarize the instructional benefits of using the Macintosh HyperCard application for the data display and retrieval. The phases of the Integrative Model will be defined in a lesson plan which will lead the reader through both the five phases of the model and the merger of a HyperCard application.

**Hilda Taba's Strategy For Interpreting Data**
Several decades ago, Hilda Taba (1965) challenged the traditional method of teaching in the area of social sciences. The traditional approach was to have students memorize vast amounts of descriptive data for recall on objective tests. Taba noted that the twentieth century knowledge explosion has caused many facts to be obsolete by the time students have mastered them. Rather than burdening the memory with volumes of descriptive knowledge, Taba felt that teachers should instead help students develop organizing

conceptual schemes.

Taba built a whole social studies curriculum around these theories in the Contra Costra School District and popularized the terminology, teaching strategies (Joyce & Weil, 1986). She believed that certain cognitive tasks such as "concept formation, interpreting data and making inferences from them, and the tasks of applying learned generalizations and facts for purposes of hypothesizing, predicting possibilities, and explaining new phenomena could be taught at a fairly early age" (Taba, 1965, p. 468). In order for students to learn these skills, however, teaching strategies had to be used which were specifically designed for developing these cognitive tasks. Taba developed three teaching strategies which were designed to induce growth in these cognitive tasks.

The teaching strategy designed for "interpreting data" was built around three mental operations Taba referred to as interpreting, inferring, and generalizing (Joyce & Weil, 1986). The students' three mental rations were labeled "covert activities." The ble activities children engaged in were led "overt activities." The eliciting questions teachers were to ask formed an integral part of the information processing strategy; the teacher's questions were to help guide and stimulate the students' thinking ( covert activities) about the content found in the overt activities. Taba emphasized that teachers needed to organize instruction in two dimensions at once when they planned a lesson or unit: one level represented significant content, and the other level addressed the learner's cognitive skills for processing the content (Taba, 1965, 1967).

To help distinguish which content was significant, the social studies curriculum content was organized into hierarchial concepts. Taba's developmental learning curriculum was heavily based on Piaget's theory about thinking and Bruner's beliefs about the n ature of concepts (Taba, 1965; Joyce & Weil, 1986). Taba believed concepts should be presented through learning sequences which would gradually move the student from what is already known to more abstract and complex ideas. As students progressed through these sequences, engaged in interpretation, and saw relationships between concepts, they would be able to go beyond the given information to make inferences and eventually could make generalizations. Eggen and Kauchak (1988) used Taba's teaching strategy for interpreting data to form the basis for their Integrative Teaching Model.

**The Integrative Model**

The Integrative Teaching Model has five interrelated phases which encourage and expand students' thinking skills about the concept being taught. By (1) describing, (2) comparing and contrasting, (3) explaining, (4) making hypotheses, and (5) forming generalizations, the students move beyond just attaining factual knowledge (Eggen & Kauchak (1988). This model challenges students to bring together inductive skills, deductive skills, and content. The steps in this model will be more fully described in the lesson plan that follows later in this paper.

Content which matches this model well can usually be displayed graphically. Using visual organizers help students develop the cognitive organizational schema that Taba believed so important. In fact, Taba included various graphic examples which illustrated content organizational schema. These visual organizers included spirals, grids, and circles with radiating lines (Taba, 1965). These schema displayed data which could be used in the lesson's overt activities. The data displays became an indispensable part of Eggen and Kauchak's Integrative Model.

**Data Retrieval**

The data displays presented by Eggen and Kauchak (1988) include charts, maps, and graphs. The most frequently used method of display is the chart. Charts usually have a matrix which contains cells. The first step of the Integrative Model has students describe the information in an individual cell. Without the advantage that HyperCard can offer, students' attention cannot be focused as easily on the individual cell. Instead, the entire matrix is visible. Some teachers have tried to solve this problem by putting the data on the chalkboard as it is being presented. The disadvantages to this method are the management problems that can occur when the teacher turns around to enter the information and the interruption in the flow of verbal interaction that occurs when the data is being recorded. Using either the chalkboard or having an entire matrix displayed can prevent students from focusing solely on the data being discussed and can cause distinct problems for attention deficit children. Using the HyperCard application allows the teacher to "call up" information on the matrix as the lesson progresses. The Macintosh HyperCard computer application can enhance the Integrative Model's data display and retrieval process.

A HyperCard stack works much like transparency overlays for the overhead. Each "card" in the stack can build on the previous layer or cards. When the teacher uses HyperCard to present the matrix, the students see only those cells which have been discussed to that point in the lesson. This allows the teacher to be more confident that students are concentrating on the particular data being discussed. The students' attention is not "jumping ahead" to other cells on the chart. HyperCard also has the ability to go directly to any card in the stack that the teacher might choose to discuss next or to review.

HyperCard has the power to increase on-task behavior in another way. The stack can be animated, given sound, and can present material from a variety of sources such as textbooks, magazines, photographs, and records. All of these have the potential to capture the child's attention during the lesson and to make the data more meaningful.

The teacher can prepare the HyperCard stack ahead of time and can store it easily for future use. The storage room is minimal, and although the "chart" has been completed, it can be altered easily. This can be a real convenience if the teacher finds other material that could be included; or if after the lesson is taught once, the teacher finds it would be better to change some of the data.

A final reason to teach the Integrative Model with a HyperCard application concerns the reinforcement possibilities. After the lesson is finished, the teacher has the option of making a copy of the disk with additional directions or information that students can use independently for review of the concept. This independently used disk could also be beneficial if used with students who were absent during the classroom presentation.

The following sample lesson plan will demonstrate how teachers can use the Integrative Model with a Macintosh HyperCard stack. It will provide suggestions for merging HyperCard with content that is displayed on a matrix.

**Seasons: A Lesson Plan**
Grades: 1-2
Pre-Computer Activity

**Decisions:**
The first decision the teacher must make is whether the content matches the teaching strategy. If it does, during the lesson preparation, the teacher needs to decide what information needs to be included on the matrix. The most "processable" type of data is that which is factual; the next best type is a set of narrow generalizations or a mixture of facts and narrow generalizations (Eggen & Kauchak, 1988, p. 177). The teacher should then sketch or copy (from a reference book) a matrix data display which serves to help organize the lesson's content. This data display should be conceptually comparable to a set of index cards. Cards should be numbered so they can be linked to one another in the HyperCard stack. The teacher will then customize a duplication of the set of " index cards" on the Macintosh HyperCard program.

If possible, especially with young children, the data should be entered on the matrix so that the lesson begins by looking at the cell in the upper left hand corner. Simple directions should be given that alert the teacher or student how to progress through the stack.

The teacher should write the accompanying lesson plan either before the stack is designed or do it as the stack is being drawn on the rough draft index cards. The lesson plan should include all the five Integrative Model phases and should contain all the eliciting questions that the teacher plans to ask.

The matrix should then be entered on the HyperCard application. Two references are given in the materials section of this lesson plan which could help the teacher who is unfamiliar with the HyperCard application. When the lesson is taught, the teacher should use a data projection pad for students' easy viewing.

**Objectives:**
Students will be able to describe the four seasons, compare and contrast their similarities and differences, make an inference that goes beyond the data presented but is related to it, and make generalizations.

**Materials:**
Macintosh computer, monitor, data projection pad, screen, and lesson plan with a completed stack on a disk.

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**Computer Activity**
**Procedures:**

Anticipatory Set. Today we are going to learn something about each of the four seasons of the year. The names of the four seasons are listed on this side of the chart. (The teacher would call on a child to read the names of the four seasons that are displayed in the left column of the chart.) Across the top of this chart we will find the words that tell about what we are going to learn about the seasons (the teacher or a child will read the words, "weather, holidays, and food").

(The teacher will then click the mouse on the first cell in the matrix that the class will describe. Each cell will have not only a picture to be described on the top matrix layer, but after the mouse is clicked, additional cards will "pop up" with related data. For example, the top picture beside the word Winter is a group of snowflakes. Underneath is an animated group of cards that show a house with snow around it and a person who tries to ski. When the skier falls, he says, "Oh, dear me!")

1. Description. (Students are asked to describe the data in one cell on the matrix.) "There are some empty boxes on this chart; as we learn about seasons, different pictures are going to `pop up' for you to discuss." The teacher then points to the picture that is in the cell beside Winter and under Weather. The teacher might then say," Look at the weather in winter. What do you notice here?" Then the teacher would click the mouse to display the cell underneath the top cell's card. "What do you see in this picture? What is the man in the picture doing?" After completing the description of the information in the first cell, the teacher moves on and has students describe a second cell. "Now let's look at the picture beside the word Summer under Weather. What do you see?" (The teacher would let them describe the picture of the sun. Then the mouse would be clicked to reveal the card underneath the top cell's card which is a picture of a lady with a swimming suit on.) "What can you tell me about this picture?"

The teacher can make the decision about how quickly the students can move to Phase 2. The students might be asked to describe all the cells on the matrix before moving to Phase 2. The teacher may choose to have the students describe all the cells in one column or row, or they may begin to compare the two cells they have just described. Students may unconsciously move to higher level phases when they are asked to describe the data, and they should be allowed to do this if it happens naturally.

2. Comparing. (Students are asked to compare two or more cells. The teacher facilitates the student moving through this phase by asking probing questions.) Comparing helps students structure the information. This phase like the first one, is inductive. The teacher could ask, "How would you compare the weather in the winter to the weather in the summer?"

3. The third phase, Explanation, develops students' critical thinking skills. Students are asked to explain why the similarities or differences existed in Phase 2. Children can document their answers with information that can be found on the chart. Forming explanations in this manner is a deductive process.

Eggen and Kauchak (1988) noted that while summarizing and generalization can occur within a discussion about the data in one cell, children should be cautioned about overgeneralizing. They stated that overgeneralization is one form of conclusion assessment, a fundamental critical thinking skill (p. 192).

4. Hypothesizing is the fourth phase. Students are asked a hypothetical question which is directly related to the information they have been using in the first three phases. Students are asked to use information on the chart to support their reasoning. For instance, "If the weather suddenly became as hot in the middle of the winter as it is in the summer, what could happen?" The hypothetical question should be directly related to the information that has just been processed. Hypothesizing is another deductive thinking skill.

5. The final phase is Generalizing. Students summarize the content by formulating one or more generalizations. By the time this phase is reached, certain patterns in the matrix will have been discussed; the generalization will probably describe these patterns. Sometimes only one generalization is appropriate while

other lessons may support several generalizations. A child might make a generalization about the Weather column on the Seasons chart after all four cells have been discussed such as, "People do different things for fun when it's warm than when it's cold." As children disagree about each others' generalizations and expand on them, discussion in the classroom can become lively.

These five phases can be repeated several times during one lesson as the teacher leads the class through the different cells in the matrix. How much data the children describe before they move to the other phases may depend upon the information in the cell and the age of the children.

**Post-Computer Activity**

Independent Work. "Now, I am going to hand you a large piece of newsprint. I want you to fold it in half; then fold it in half again. I am going to put my folded piece of newsprint on the bulletin board so you can see what I am going to do next. I am g oing to number my boxes 1, 2, 3, and 4. (The teacher should let them number their quadrants and should circulate around the room to see if they have done this.) Next, I want you to draw something in your number 1 box that you learned about winter." (Proceed by giving directions for each numbered section and season.)

**Closure:**

"Today, children, we have discussed the four seasons of the year. Tomorrow you will work in small groups and will make dioramas for each season. Who can tell me what a diorama is? We will use large shoe boxes for our dioramas. I have collected some items that you could use in your dioramas, and you can bring in small things from home that can be used."

**Evaluation:**

During the lesson, the teacher will assess the children's responses (errors will be corrected through probing and giving clues). The teacher will informally check the students' drawings on the newsprint for accuracy. This summative evaluation will allow the teacher to correct any misconceptions the next day before the next seasonal activity progresses.

**Follow-Up:**

Reinforcement can be aided by leaving a copy of the disk, Seasons, available at the computer station. Extra narrative information may be added to this disk. Some of the children's own descriptive statements and generalizations might be very appropriate.

**Summary**

The Integrative Model of instruction can help develop students' thinking skills as they process information. By using the HyperCard application for the data display and retrieval, computer technology can enhance the instructional delivery of this teaching model. The main advantage HyperCard has to offer is related to the improved focus and attention of students during the data retrieval part of the lesson. The teacher can also appreciate the subsequent data modification capabilities that HyperCard affords and the easy material storage of the charts, maps, or graphs.

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# TWO DISTINCT CONCEPTS OF GROUPWARE

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**Abstract**
Research on team-study has produced the outlines of a theory of classroom qualitative structure. When these beginning ideas are further developed, it can be seen that there are two distinct concepts of groupware. The nature of groupware required to support centralized classrooms and team-study classrooms are developed by means of the qualitative theory.

**Introduction.**
The concept of groupware has emerged from the work of instructional designers and is now the focus of many discussions. One way to advance the development of this general notion is to place it within an appropriate theoretical context. In what follows, I will outline the features of a comprehensive theory of classroom organization, and then use this theory to investigate the nature of groupware and its place within instructional methodology. The following analysis reveals that there are two distinct concepts of groupware, and it is important for instructional designers to understand the nature of this distinction and its theoretical underpinnings.

**Classroom Qualitative Structure.** Every area of research requires a basic account of what there is to be studied. In geology, the theory of plate tectonics forms the blueprint or paradigm in terms of which observable events are to be described and explained. Some refer to such accounts as theories or laws of qualitative structure (Newell and Simon, 1990). Such theories serve as paradigms or blueprints that determine what kinds if things offer the best explanations of the phenomena under study (Popp 1978, and Popp 1980).

Within the research on teaching, there has emerged a qualitative theory that characterizes classrooms in terms of a three dimensional social structure. These three dimensions consist of the following: (i) rules of participation that define and govern activities of students and teachers, (ii) rules of benefit accrual that regulate how valuables are distributed, and (iii) management structures that determine the role of the teacher as the one who is in authority within the classroom. Every classroom can be characterized by how it regulates participation, benefits, and manager behavior.

Rules of participation can be divided into three subsets: there are rules that regulate competitive activities such as arm wrestling; there are rules that regulate cooperative activities such as the three-legged-race; and thirdly, there are individual activities that do not require other participants.

The rules of benefit accrual are also divided into three sub-forms. A familiar way to distribute rewards is to give them to the winners of competitive activities, eg., curve grading practices. In addition to competitive benefit rules there are collective distributions that give each participant an equal share of the benefits. An individually structured benefit distribution system is exemplified by the grading contract.

Following Ouchi (1984), one can view the management of classrooms as being of three types. Some organizations are managed by the "holding company" approach where each unit within the organization functions as an autonomous unit. In traditional classroom theory this would be referred to as "permissivism." In a highly "centralized" organization, all decisions are made or overseen by a central authority. In classrooms, we typically think of this management form as authoritarian. Finally, there is the management structure that many refer to as "participatory." In this form, the participants in the organization are constantly negotiating who will be the bearers of what kind of authority and responsibility.

From an investigation of the various combinations of how these three dimensions are instituted within a classroom, one finds that certain combinations are workable and some that are not. It turns out, according to this line of logic, there are three basic modes of instruction that are workable. Traditional teacher-centered instruction uses competitive rules of participation, a competitive benefit structure (curve grading), and a highly centralized-authoritarian management form. Individualized instruction is characterized by individual rules of participation and benefit distribution, and a laissez-faire management structure. Team study is based on cooperative participation, collective rewards, and a more participative management form, eg., the decision as to what will be studied can be shifted from the teachers to the students in many cases (Slavin 1983).

Each of these three approaches to classroom organization demands different behaviors from teachers and students. Of particular interest to instructional designers is the finding that the type of practice exercises and study activities used by each of the three are quite different from each other. For example, in team study, it is impossible to use the questions at the end of chapters as team practice. End of chapter questions seem to assume that the user is working alone, whereas practice for team study must be constructed so as to support group discussions. The exact nature of the best team-study practice-questions is as yet unclear, but it does seem that the questions must be more challenging than those questions effective for individual students working alone.

From my own investigations, it seems that when questions developed for individualized study are used in a team context, the quality of group discussion is very poor and students do not progress through the material as quickly as they do with group questions. On the other hand, if effective team-study questions are used for individualized instruction, then students quickly become frustrated (Popp unpublished a).

The questions required to support lively group discussions must be open-ended enough to induce an investigation of meanings and interpretations. Students are required to attempt to understand each other. I think that through these efforts at serious communication students develop the increased abilities to take the other person's point of view--a finding that Slavin (1983) is fond of pointing out. There is no doubt in any educational researcher's mind that the team-study classrooms do produce higher levels social interactional skills than do alternative designs.

For each of these three instructional forms, we can ask about the best or most effective use of the micro-electronic technology. Since these three instructional forms are theoretically different, one would expect that the role of computers within each form should be different, one from another. Moreover, as one evaluates the potential for computers in each of the instructional forms, one should note that the computer must be introduced in a fashion that does not undermine the social organizational pattern for that form. In other words, just as all mixtures of the various types of qualitative structure do not fit well together, all applications of computers in classrooms will not readily articulate with all classroom structures.

**Individualized Instruction.** In a sense we need not consider the case of individualized instruction because the notion of "individualized groupware" is an oxymoron. However, there is an important point that results as a kind of theorem deriving from the theory of classroom qualitative structure. The computer allowed for the development of a very sophisticated form of the earlier hard-copy-based "programmed learning." Teachers came to value a classroom that could provide a computer (or at least a terminal) for each student. In many cases, two or three students were seated at one computer or terminal; these students were said to be engaged in "programmed instruction."

Under the regime of the theory of qualitative structure characterized above, these students must be acting in accordance with certain rules of participation. It is clear that if it is not the case that two students are simply watching a third student who is actually the one engaged in the learning process, then the three students are a group and have a given pattern of rule-governed interaction.

Furthermore, it is a mistake to think in terms of "individualized programs" that allow more than one student to use the program at the same time. The fact that there are going to be student interactions involved in the very use of the program suggests that instructional designers must take this student interaction into account when constructing such programs. Individualized instruction with kibitzers (IIK) actually is no instructional design at all for the kibitzing students.

The following methodological conclusion can be dr. wn. If we are seeking to design academic "groupware" that is truly "designed" for group study, then the theory of classroom qualitative structure characterized requires instructional designers to decide for each case of groupware construction which type of groupware--teacher-centered groupware or team- centered groupware they seek to build.

**Teacher-Centered Groupware.** In the schoolhouse of old, there was a chalkboard upon which the teacher wrote, and there were individual slates for students. When students wrote on their slates, it was difficult for the teacher to monitor what each student was doing. When the teacher wrote on the chalkboard, it was often difficult for every student to see what was being written.

With a classroom LAN system this is no longer the case. The teacher can write on each student's slate. Any given student's "seat work" can also be readily monitored by the teacher. The hardware is, of course, already in use but the groupware driving it is not all that sophisticated. What would advance this area of research?

The distinction between automation and implementation is helpful. We could develop an intelligent LAN or teacher-centered expert system by automating what teachers do. There seems to be no limits to what is imaginable in this regard. For example, the Lincoln robot at Disney World could be further refined to become a lecturer on the Civil War. With appropriate sensing, the robot could respond to the attention level of students.

If on the other hand, we set out to develop an implemented system, then we do not have to enhance or automate what teachers do; we can directly pursue the learning of students by developing an appropriate expert system. Perhaps we should change our terminology from "teacher-centered classrooms" to "centralized classrooms." In any case, note that we seek a groupware solution to student learning. We want student learning to occur in a social context. Social skill development is always part of our objectives. Thus, we must avoid slipping back into thinking of a computer managed room filled with instances of individualized instruction.

As we pursue the question of the nature of teacher-centered or centralized groupware, it is important to understand that the traditional classroom practice of curved grading is a benefit structure that induces individual competition and undermines cooperation. Helping other students can decrease one's benefits, as every American student knows full well. What does this mean for us?

We could actually enhance the competitive nature of the classroom. For example, we might engage students in, say, math practice. As each student worked her or his problems, in a corner of the video presentation or "slate" there could be the current class mean for problems successfully solved, and a comparison with that individual student's progress. Each student would be aware at all times how he or she was doing in the competition.

Of course one can overdo competition; but the psychological question I want to raise is a different one. Our groupware should be psychologically consistent. Note that if we also established a system of student E-mail on the same LAN, we would be supporting cooperation in the sense of allowing students to work together. In the non-electronic classroom this was forbidden because student-to-student communication was said to cause disruptions of the classroom's academic activity. (Actually there is a more important reason to be mentioned shortly.) A student E-mail system would not have that effect, in all likelihood. Nevertheless, we still have the psychological and ethical question of establishing a competitive benefit structure in the classroom, and then also establishing an antagonistic system for students to cooperate.

An even more sinister dimension exists. Robert Slavin had described cases of students sabotaging each other in order to enhance their relative position in the competition of the classroom. Around the halls of chemistry on every campus, there abound stories of the brilliant methods of sabotage used by the pre-medical students. Do we want to create a system that allows unacceptable social devices to be created and used by students? Rapid informational transfers may greatly increase the potency of disinformation. E-mail type communications within a competitive classroom seem, in many ways, abberrant.

My investigation of the classroom qualitative structure described above has led me to the thesis that a teacher-centered classroom must be based on a competitive benefit structure (Popp, unpublished paper b). The reason that student-to-student communication is typically proscribed in the conventional classroom is the fact that such communication undermines to some degree the competitive nature of these classroom qualitative structures. I do not want to argue this entire thesis here; however, it does seem that instructional designers cannot avoid the issues of how much competition the groupware will impose on students, and how much cooperative activity should be allowed or provided by the system. Moreover, arbitrary decisions in this regard may not always be compatible with what we know about the psychology of learning.

**Team-Study Groupware.** The team-study methodology is based on the notion that there should be no interpersonal competition within the classroom. In a feeble attempt to avoid using interpersonal competition, the older "group" methods of the late 1960s and early 1970s attempted to avoid the confines imposed by teacher-centered instruction. Such attempts did not work, in part, because they provided no individual accountability, and this led some students to simply sit out the lessons. The team study approach holds students individually accountable while at the same time making success and failure a group experience. Each student has a personal stake in the results of the work of all team members. This aspect of the methodology explains much of its success (Popp 1987, and Popp 1989).

Another reason why the earlier group approaches did not work stemmed from the fear of imposing on students. Students were encouraged to set their own goals and to pursue them. The immaturity of the students was discounted. The lack of academic structuring of these approaches led students to create the label, "the group grope." The team-study methods provide academic structuring of the material while still allowing students to make study methodology decisions.

How could the team methodology be enhanced by computer capabilities? As I discussed previously (Popp 1990), the Laboratory School created by John Dewey at the University of Chicago at the turn of the century attempted to develop academic learning around student selected activities. One of the problems that all such approaches face is that of information availability. If students are actively analyzing a problem, sooner or later their efforts are going to be stymied by a purely factual question. If the information required is not available to the students in their classroom, then students must ask the teacher--who may or may not have it; if the teacher's knowledge must be imported, then there is a loss of student autonomy that is directly felt by the students. The other alternative is to stop the inquiry, for example to go to the library. The difficulty here is that when immature scholars are delayed or inhibited in any way, they quickly lose their eagerness to solve the problem.

If there were available to each team, a database--or better still an expert system--to which students could appeal when purely informational questions were encountered, students could experience greater analytic powers; in fact, it may well be the case that many students have never experienced what it means to solve a difficult problem after considerable effort. Just as students have to learn the quaint ways of the libraries, they would have to learn how information is organized, stored, and recovered. One dimension of the curriculum would be coming to know one's way around the world's information.

One can imagine a developmental approach to learning about information and expert systems. In the primary grades, the databases and expert systems would be structured in ways appropriate to the students. In later grades, the complexity of the systems would increase, as would the amount and kind of "help" screens and tutorials. Instructional designers would create products to bridge the gap between the primary grades and the expert systems in use by the professions.

The instructional design of team study lessons in this case would require the integration of the topics studied and the form of the information in the database being used by the teams. The best organization for students could be explored as related to the various grade levels. In any case, by the high school years, all students should be using typical forms. What is interesting about this role of the computer is the fact that hardware, software, and hard copy must be integrated so as to produce a workable classroom system.

Groupware could enhance the team-study approach beyond the providing of improved informational and expert resources. In the current team-study classrooms, students are given hard copy lessons or modules. These lessons could be written in an electronic form. That is, the computer could present the expository material of the lessons. This poses an interesting problem. The team-study approach does not make use of lecture or teacher presentations to any great extent. If we computerize the lessons, are we not sliding back into a teacher-centered classroom?

With auditory input capability, the members of the team could interact with the electronic lesson the way they interact with each other. Only one person can talk at a time if anyone is to be understood. So, the rules of participation that involve interaction with a computer create a regime that is not all that different from the one currently in use by team-study classrooms.

But there is a danger of our writing groupware that allows the computer to become the source of all wisdom--in effect, a lecturer-questioner. We do not want the students to talk to the computer but to each other. To avoid the slipping back into teacher-centered thinking we must be clear that the students have and should retain the autonomy for the direction and method of study.

In the current paper-oriented system, lessons are structured around questions that are posed to students. Solutions to problems are provided, but students cannot ask the paper lessons questions or for further elaborations. With electronic lessons, they can. We must make sure that we understand the line that separates presenting expository material, asking practice questions and providing answers to practice, and becoming teacher-centered. Assuming this line can be and is clearly drawn, then a great new domain of opportunity opens before us.

We can begin to think of groupware that presents expository material and then provides practice for the concepts and relationships of which this material is composed, all the while using the best information available. Furthermore, as with earlier individualized systems, the kind of practice presented to the students can be continually updated to present the most challenging problems to the students without allowing them to become discouraged or stymied by the material being studied.

**The Role of Recall in Groupware.** Another very significant issue to be dealt with when thinking about the role of computers and expert systems in team study is the role of recall. I advocate down playing recall ability as an instructional objective. That is, the team study method excels in the achievement of skill or performance objectives. When students learn to solve problems, the examinations or quizzes they should be given are applicational. Recall is what information- processing software does much better than humans. I think groupware should emphasize problem-solving skills and not recall. The objectives for students of the new millennium should be on processing information not storing it.

The recent major review of the research on human memory (Schwartz and Reisberg 1991) suggests that we do not know all that much about it. We know that we remember what we use frequently. Everything else can be retrieved mechanically. Thus, is it not reasonable to expect students to recall how to use the information retrieval methods and let other recall objectives slide by the wayside?

Given the ubiquitous calculator and micro-computer, why do we even bother with arithmetic? There was a time when square roots had to be extracted long hand. Have we not come to that same place for fractions and the division algorithm? It is past time for us to be considering the nature of problem-solving and leaving behind the algorithms done so well by the machines. The mind is born free and everywhere it is chained to algorithms.

**Conclusion.** I think it is obvious that as we further refine the theory of the qualitative structure of classrooms, we will further clarify the defining characteristics of groupware. Moreover, it is already clear that there are two distinct concepts of groupware. Moreover, it is important to keep in mind that under the team-study approach the role of the computer cannot serve an executive or directional function on a level that is equal to or superior to that enjoyed by the students. The team-study classrooms place student autonomy has the highest level of directional authority within the pre-established structure of the lessons.

Dewey's (1916) famous tome on education argued that the reconstruction of experience that adds to the meaning of experience and that increases the ability to direct the course of subsequent experience is the central meaning of 'education'. Moreover, it is education in this sense that is the highest human value. As he put it, "education has no end beyond itself."

We can extend this point for our time by observing that anything that enhances the reconstruction of experience is of instrumental value. Some writers refer to computers as "power tools for the mind" (Feigenbaum, et. al. 1989, With computers we can do mind things that we could never do otherwise. Computers are power tools for the reconstruction of experience, and they can support our reconstructions of experience in ways never before possible.

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# METHOD AND FREQUENCY FOR USE OF A COMPUTER-BASED DRILL IN THE LEARNING OF VERBAL INFORMATION

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**Abstract**
The purpose of this study was to determine an effective schedule for the frequency and spacing of drill and practice in the learning of verbal information, and to investigate the number of times to review a missed item during a drill.

The study used a computer-based drill which incorporated in its structure the findings of past research. It involved 117 junior high and high school French I students who drilled 20 French words. Half practiced twice, and the other half practiced three times. One third reviewed missed items once, twice, or three times respectively. After two weeks of scheduled practices, a posttest was given, followed by a delayed posttest one week later.

Analysis showed that both treatments resulted in a significant difference between the delayed posttest means. That is, those who practiced three times scored significantly higher than those who practiced twice. Also there was a significant difference between repeating a missed item once and repeating it three times, but not between 1 and 2 times or 2 and 3 times. The verbal ability of the students, as measured by the Iowa Test of Basic Skills, did not have a significant effect on their success with the drill.

This study, conducted in a school setting, offers suggestions for ways to structure our drill and practice procedures in that setting so that their impact on learning is maximized.

**Introduction**
Drill and practice has gotten some negative publicity in recent years. One reason is that as we use and study the use of modern technology in education we are becoming more aware of the various levels of knowledge. In comparison to higher level skills such as problem solving, drill and practice can seem meaningless and unimportant. Drill and practice is considered by some a poor use of the computer, both because most drills do not use many of the capabilities of the machine and/or because many computer drill programs are of poor quality (Fuson, 1985; Salisbury, 1985; Yates, 1983). In spite of this fact, research in modern cognitive theory suggests the importance of drill and practice in the learning process (Merrill, 1984).

Since the microcomputer entered the classroom, many computer-based drills have been developed for use in schools. Such drills can be effective research tools because it is possible to control the structure of the drill as well as its use. After the introductory section of the drill, in which instructions and explanations are given, there is usually a cycle of steps which is repeated for each item: selection of the item, display of the item, the response of the learner, a judgement of the response, and feedback to the learner. Each of these steps can be designed by the researcher. Then, as the drill is used, the length, spacing, timing and number of drill sessions can be controlled (Rysavy, 1991).

Research has studied some of the aspects of drills in order to determine which qualities/methods are most effective. Using the results of this research, a study was conducted to determine an effective schedule for the frequency and spacing of drill and practice in the acquisition of declarative knowledge. It also investigated the number of times to review a missed item during a drill. Its purpose was to further refine what we already know about drill procedures so that we can maximize learning and minimize the number of practices needed for learning.

**Background for Study**
At the center of this study are the concepts of (1) verbal information and (2) drill and practice. The term "declarative knowledge" is usually considered to mean the same as "verbal information," but "verbal information" is more commonly used in the literature. The terms will be used interchangeably in this paper. After a short discussion of these concepts, previous research on various aspects of drill and practice will be summarized.

**Verbal Information**
We learn a great deal of verbal information throughout our lives, from the names of people, objects and concepts, to more highly organized information, such as events of history or

achievements of industry and science. Areas of specialty each involve a particular vocabulary; e.g. a botanist needs to know names and information about plants, and a chemist needs to know the chemical symbols. Rabinowitz & Glazer (1986) stated that "an expert in a given domain is thought to have a greater amount of declarative knowledge about that domain than does a novice" (p. 78).

At times, verbal information is critically important as a basis for other learning (Dick, 1985). Examples include knowing events of U.S. history and government in order to analyze the influence of political parties in the United States, and learning the vocabulary in a foreign language as a basis for a very complex set of communication skills. What enables a person to utilize such information as a base for the more complex tasks is an automaticity in its use (Dick, 1985; Gagn*, 1977; Merrill, 1984). To facilitate acquisition of automaticity, the development of effective methods for learning and rehearsing that declarative knowledge is important.

**Drill and Practice**

Drill is defined to be "the process of training or teaching by the continued repetition of an exercise," while practice is "to do repeatedly in order to learn or become proficient" (Guralnik, 1986, pp. 427, 1117). While both involve doing something over and over, drill is considered repetition of a skill in order to learn it, while practice is repeating it once it has been learned in order to become more proficient in it. This distinction is not important for this paper.

Drill and practice has traditionally been used for the learning of paired associates. During the last decade, research in cognitive learning theory has suggested that drill and practice may be more important than many realize, and can have a significant role in learning (Salisbury, 1984). Practice of verbal information, which provides review of the material, can result in additional and more elaborate encoding (Gagn*, 1977).

**Previous Research**

Previous research suggests procedures and methods for the development of computer drill programs. This research studied short-term memory, review of missed items, feedback, and spacing and length of practice sessions. A summary of these topics is followed by considerations regarding the learner.

**Short-term memory.**

According to modern views of learning, short-term memory is a kind of memory which stores limited amounts of information for a brief time interval (Gagn*, 1987). According to this view, information is encoded and enters long-term memory once it is processed into a meaningful context. Research has suggested that short-term memory is limited by the number of items it can handle at one time (Miller, 1956). This limitation suggests that for drills, items should be grouped, when this is appropriate. The number of items being drilled at one time can also be kept small by dividing the items into a working pool and a review pool (Salisbury, 1988). A limited number of words are used from the working pool at a time, and are dropped from that set only when they are learned.

**Review of missed items.**

When drilling verbal information, the learner can make errors. Those items should then be reviewed until they are learned correctly. Research has studied both how often and how soon a missed item should be reintroduced.

Regarding how soon a missed item should be reintroduced, Jacoby and Craik (1979) found that immediate repetition of a missed item results in no further useful encoding. Goldenberg (1987) found the best position to reintroduce a missed item before it is lost from short-term memory is after 2 intervening items. The next best position is after 3 intervening items. As to how often a missed item should be reintroduced, it has been suggested that missed items be reviewed up to 3 times (Salisbury, 1985). Siegel & Misselt (1984) concluded that increasing ratio review techniques (e.g. after 2 intervening items, again after 3 more intervening items, and once more after 5 more intervening items) are more effective than 1 later or no review at all.

**Feedback.**

For purposes of drill of verbal information, immediate feedback is most desirable (Cohen, 1985). It can be scheduled after both correct and incorrect responses, but it is more important after errors (Kulhavy, 1977).

Research has shown that feedback with discrimination training is effective (Siegel, 1984). A "discrimination" error occurs when the learner gives a response which is correct for another item in the drill list. The feedback given for this type of error includes informing the learner both of the correct response as well as of the item which matches the answer given.

Spacing and length of practice sessions.

Researchers have asked the question as to how much and how often a learner needs to practice. Much evidence has suggested that short, spaced practice periods yield better results than long concentrated practice periods (Anderson, 1980). Reynolds and Glaser (1964), for example, found that the practice of new material intact (massed) was relatively ineffective. Gay (1973) found that placement of a practice near the time of learning (early) and another near the retention measure (late) are most effective.

**The learner.**
For the learning of verbal information, as for any type of learning, the learner must be considered in the choice of instructional materials and methods. These considerations include the learners' preparation for the material to be learned (aptitude, motivation, prior knowledge, cognitive structure), and the method used (Ausubel, 1963, 1968, 1969; Bloom, 1976; Snow, 1980; Tobias, 1987). The learners should be informed about how the new material will fit into what they already know. The objectives should be clearly stated, specifying the desired learning outcome (Gagn*, 1977). If the student is involved in other learning activities at the same time, the effect of these activities should be considered (McGeoch, 1932).

**Implications of the literature and development of a pilot study.**
The issues discussed above (learning of verbal information, need for drill and practice, and short-term memory) provide the rationale for the material of this study: use of a drill for the learning of verbal information. The findings regarding review of missed items, feedback, and spacing and length of practice sessions, were used to create and implement a computer-based drill which would be as effective as possible. A pilot study, using that drill, was conducted to generate additional data regarding the question of how much practice was needed to effectively learn verbal information. That data was used to formulate the hypothesis for the main study. More complete details on both the pilot study and main study are found in Rysavy (1991).

**Pilot Study**
Subjects for the pilot study consisted of 28 male and 34 female 4th, 5th and 6th graders in an urban public elementary school. The students were given the task of learning the capitals of the 50 states. Using the suggestion of Tobias (1981) that research might be begun by observing what students of varying individual difference characteristics actually do and what instructional options they select, each student was given the task of learning the material, and made his/her own decision as to when and how long to practice. The drill was designed so that the student could stop at any time and then continue through the drill at the next practice session.

Each student had an individual disk which contained the drill program and files which stored details and data of each practice session. At the beginning of the study, students were given a written pretest. It was explained to them that they were going to help researchers better understand how students learn. They were urged to take seriously their task of learning the states and capitals within the 2-week period and to decide how much practice they needed to accomplish that task. At the end of two weeks a posttest was given.

In order to determine which variables which most affected the learning of the verbal material, as many aspects as could be quantified were studied. These included pretest and posttest scores, number of times the student practiced, when the student practiced, number of times through the entire drill, and length of practice sessions.

The percentage of items correct on the posttest after the various number of times of practice was calculated. Percentages were calculated on all items, as well as on those which were not known at the time of the pretest. These results are shown in Figure 1.

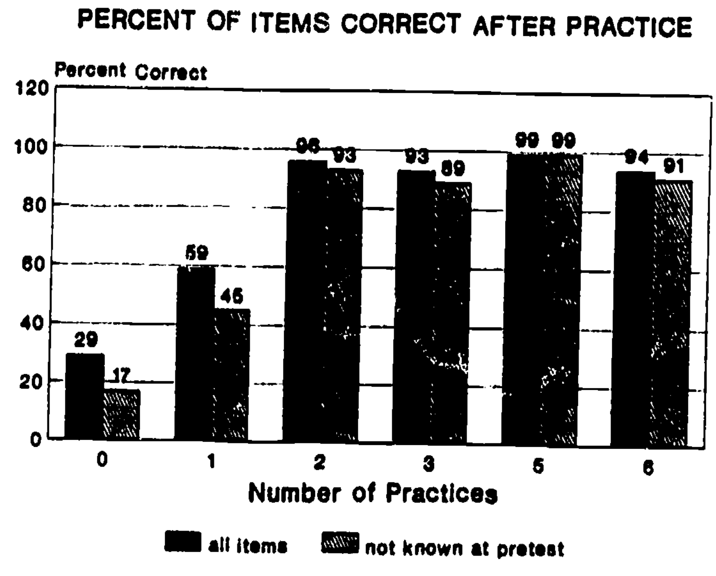



Figure 1 Percent of Times Correct After Practice

These results suggest that when an optimal drill format is used (discrimination training, increased ratio review of 3 positions for missed items) with placement of reviews early and late (as described above), then two times through the drill are sufficient for maximal learning of the verbal information being practiced. Regarding the number of times an item is reviewed once it is missed, the study showed that a review of 3 times is effective. Details of the other variables considered are found in Rysavy (1991).

## Main Study

### Hypothesis

Using the results given above, the study was based on a hypothesis as well as a question. They are as follows:

(a) Hypothesis: two times (placed early and late between initial learning and the retention measure) through a drill which utilizes discrimination training and the increased ratio review already described, is as effective as three times through the drill.

(b) Question: regarding the number of times a missed item is reviewed, are 2 times or 1 time as effective as 3 times?

### Study Procedures

One hundred seventeen junior high and high school French I students were divided into six groups stratified by grade level. Their teachers were consulted to determine a list of French words which the classes had not yet studied but which would build on their course work. A computer-based drill containing those 20 French words and their English equivalents was created. Half of the subjects practiced twice, and the other half practiced three times. One third reviewed missed items once, twice, or three times respectively. The drill used discrimination training for all subjects. After two weeks of scheduled practices, a posttest was given, followed by a delayed posttest one week later.

### Study Results

Pretest scores had a mean of .98 out of a maximum of 20. The mean of the posttest was 16.2, and that of the delayed posttest was 16.1. Some of the students were not able to practice all words during one or more practice sessions. These 40 words, along with the 108 words known before the study began, were removed, and the posttest scores were re-calculated as percent of unknown words learned. The resulting mean of the first posttest was .81, and of the delayed posttest was .80. The correlation coefficient between the first and delayed posttests (Prunkl, 1979) was 91.2%. Details of posttest scores for the treatment groups are given in Table 1.

| | No. of Times Missed Items Repeated | | | |
|---|---|---|---|---|
| Number of Practices | 1 | 2 | 3 | |
| 2 | 0.66 * <br> 0.258 ** | 0.73 <br> 0.247 | 0.87 <br> 0.170 | 0.75 <br> 0.241 |
| 3 | 0.78 <br> 0.245 | 0.87 <br> 0.140 | 0.90 <br> 0.143 | 0.85 <br> 0.187 |
| | 0.72 <br> 0.256 | 0.80 <br> 0.210 | 0.89 <br> 0.156 | |

* Mean

** Standard Deviaton

Table 1 Details of Posttest Scores f or Treatment Groups

Figures 2 and 3 show the comparison of two and three practices, and the comparisons between one, two, and three repetitions of missed items, respectively.

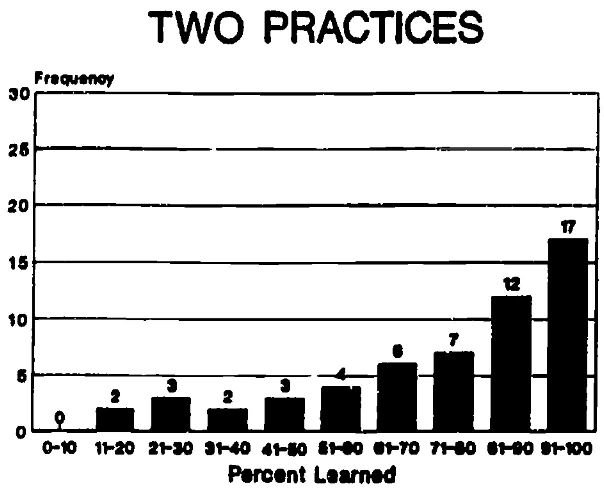
Analysis showed that both treatments resulted in a significant difference between the delayed posttest means ($p$ = .015 for number of practices, and $p$ = .003 for number of times a missed item is repeated.) That is, those who practiced three times scored significantly higher than those who practiced twice. Also, using Tukey's Studentized Range Test, a significant difference at the .05 level was found between repeating a missed item once and repeating it three times, but not between 1 and 2 times or 2 and 3 times. The verbal ability of the students, as measured by the Iowa Test of Basic Skills, did not have a significant effect on their success with the drill.

These results suggested the following regarding the hypothesis and question proposed by this study:

### Hypothesis.

The hypothesis, based on the pilot study, was that there would be no significant difference in posttest scores between those who practiced twice and those who practiced three times. The main study showed that there was a significant difference. At the same time, subjects whose drill procedure was identical to the pilot study (i.e. reviewing missed items three times) differed by only 3 percentage points in mean posttest scores, compared to 12 and 14 percentage points difference between the groups reviewing missed items 1 and 2 times respectively. This suggests that reviewing missed items 3 times may reduce the number of practices needed.

**Question.**
This study asked the question of whether reviewing a missed item 1 or 2 times would be as effective as reviewing it 3 times. The study data showed a significant difference between 1 and 3 times, but not between 1 and 2 times or 2 and 3 times. This suggests that once is not an effective number of times to review a missed item. The effectiveness of 2 reviews is not clear.



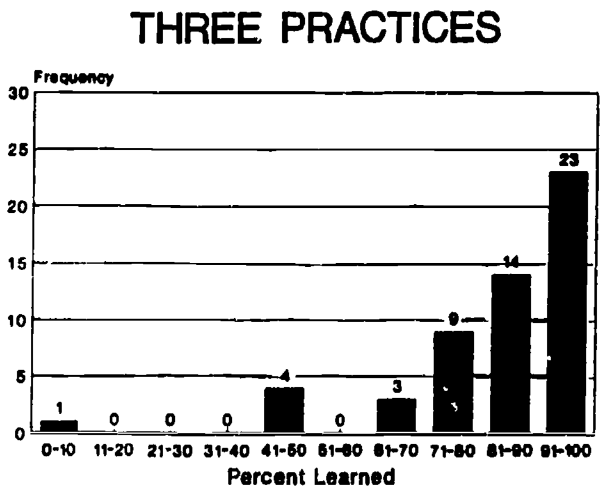




**Figure 2 Comparison of Two and Three Practices**

**Other Results**
The result of student choices during the pilot study concerning frequency and length of practice sessions supported the findings of Gay (1973) regarding the time of practice. Gay found that an early review and a late review are better than two early or two late reviews. In the pilot study, the average amount learned by students who practiced both weeks (both early and late) (M=.70, N=22) was twice the average amount learned by those who practiced only early or late (M=.35, N=27). The effectiveness of this schedule was further tested in the main study through the administration of a delayed posttest. This posttest showed that student retention did not decrease significantly after a week with no further practice.

**Recommendations for future research**
This study, along with those on which it is based, shows that when meaningful verbal information is to be learned, effective methods and timing of drill and practice can maximize learning and minimize the number of practices needed. The drill process, however, can be affected by other facets of learning both internal and external to the learner, as well as by the instructional process surrounding the drill. Several of these issues suggest questions for future research. Some of them are as follows (Rysavy, 1991):

(1) How do the instructional procedures used before and after the use of a drill affect the amount of practice needed? In this study, would the students have needed less practice if they had been guided through an initial learning of the words before the drill sessions?
(2) Are there ways in which a drill procedure can help learners group or chunk verbal material as they drill it? Would the grouping of similar items, or items which may be confused, help the learner to differentiate between them and thus learn them more quickly?
(3) Given a period longer than two weeks, will the number of times through the drill needed to learn the verbal information increase? If the period between initial learning and the retention measure was one or two months, for example, would additional practices be needed?
(4) Given a longer or shorter drill, will the amount of practice needed increase or decrease? Length of drill, which depends both on the number of items and on the number of mistakes made, can affect the attention, interest and retention levels of the student.

(5) How is the amount of practice needed for effective learning affected by the other learning activities in which the learner is involved during the same period? Do students in a school setting need more practice than those learning verbal information outside the school setting (when they are not involved in other learning activities)?

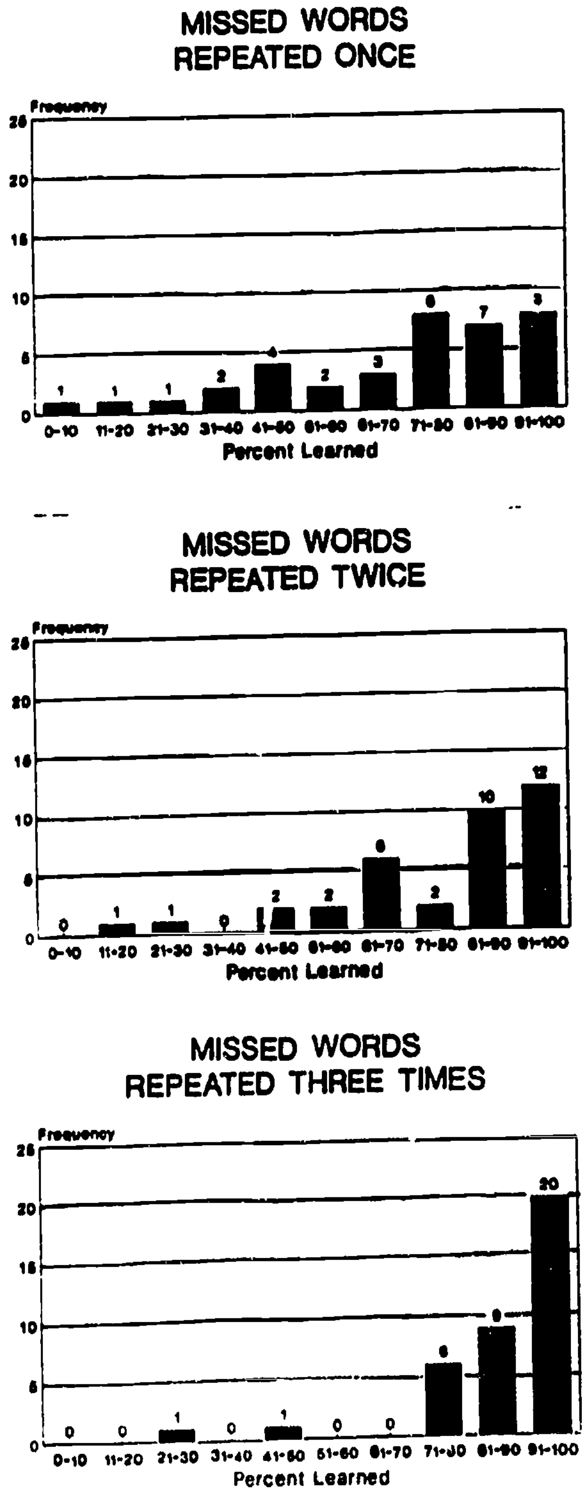



**Figure 3 Comparison of One, Two and Three Repeats of Missed Items**

**Conclusion**

When considering use of drill and practice, the first question is always whether it is appropriate for the material being studied. This question is best answered by experts in each field. (Note: Use of drill and practice for the material of this study is discussed in Rysavy (1991).) Given the appropriateness of drill and practice, this study, conducted in a school setting, offers suggestions for ways to structure drill and practice procedures in that setting so that their impact on learning is maximized. Some of these implications, along with others which are suggested by previous research, include the following:

(1) Feedback to student response should be chosen which is most appropriate to the material being learned. For matched pairs, feedback with discrimination training is effective.
(2) Shorter spaced drills are more effective than massed drills.
(3) Computer-based drills can keep track of student responses, thus repeating missed items at appropriate intervals and also allowing the student to stop at any time and finish the drill at another sitting.
(4) Items which are answered incorrectly should be repeated two or three times at increasing intervals.
(5) When possible, similar or related items can be grouped in order to help the learner distinguish between the items and learn them more effectively.
(6) Two times through the drill placed early and late between the time of learning and the retention measure are most effective.

Additional studies need to be conducted to learn more about ways to structure drill and practice so that their impact on learning is maximized. Some of these results can also help to improve our instructional methods for other types of learning situations.

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# A SYSTEMATIC EDUCATIONAL COURSEWARE DEVELOPMENT MODEL FOR DEVELOPING COUNTRIES

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**Introduction**

Today's state-of-the-art computer assisted instruction (CAI) systems have their roots in the IBM-1500 system, the PLATO system at the University of Illinois, the PDP-10 system at Stanford University, and other institutions in the 1960s. The effectiveness of CAI has been demonstrated and reported by numerous researchers during the last twenty years (cf., Kulik & Kulik, 1987). Although the high cost of CAI delivery systems developed in the early years restricted the extent of their dissemination, the development of inexpensive, powerful microcomputers in recent years has significantly reduced the cost of hardware required to support CAI.

There is no longer much debate regarding the inevitability of CAI being used for education and training throughout the industrialized world. As industrialized nations move rapidly towards computer-intensive classrooms, schools, and school systems, developing nations are beginning to feel the pressure of being left behind. Even if computer education in schools lives up to only a fraction of the potential claimed by CAI proponents, it will certainly widen the gap even more between the developed and developing countries. Therefore, it is necessary for educators of the third world to look into more feasible ways of introducing CAI into their school systems.

The integration of CAI into the schools of developing countries is not as simple as just accepting the inevitability of an increasingly computerized society. Marshall (1984) identified critical areas of discussion for decision makers concerned with the introduction of computers into the third world educational systems. These include financial considerations, language and cultural differences, preparation and training of trainers, hardware selection, software availability, and courseware compatibility with culturally and politically unique educational philosophies and settings. Jones, Harmon, & Reeves (1990) developed a ten component model for analysis of the feasibility of computer-based instruction in developing countries, including strategies for dealing with cultural sensitivity, technological appropriateness, and conviviality. However, each of these models is focused on a country-level analysis. They do not provide detailed guidance for actually implementing CAI in developing countries. The purpose of this paper, on the other hand, is to recommend a model for effective development and implementation of CAI in developing countries. A major assumption of this model is that software rather than hardware presents the major challenge in this effort.

**Educational Computing Implementation Problems**

The success of educational computing in any country is very much dependent on the availability of high quality software. Although there are numerous computers in schools in developing countries, good educational software relevant to local educational curriculum and setting is virtually nonexistent. One major reason for this scarcity is the lack of financial incentives for educational software development. There is little financial reward to be gained from developing such software since the market is small and most schools lack money to invest in software purchase. Another reason is the lack of computer programmers with relevant educational experience and expertise. As a result, the small amount of available commercial software lacks the pedagogical considerations to make it instructionally sound for classroom implementation.

Developing countries have jumped on the bandwagon of implementing some form of computer education program to ensure that the technological and educational gaps between them and the developed nations do not increase. In the excitement of being in-step with the developed nations in computer use in schools, these developing nations have repeated similar mistakes encountered by the developed nations during the infancy of their use of computers in education (Friend, 1985). Some of these countries have invested large sums of money in equipment that is now obsolete. The major challenge faced by nearly all the developing nations, however, is the availability of software that is compatible and relevant to their unique educational and environmental settings.

**The Lack of Educationally Sound Software in Developing Countries**

Nearly every developing country has decided to spend a major portion of their education budget towards implementing computer use in schools. These countries are now finding out that the availability of the appropriate hardware has automatically made their educational computing programs effective. Most of them are now facing the problem of obtaining software that is both relevant and culturally sound for their specific educational contexts.

In Taiwan, R.O.C., the Ministry of Education decided to launch a major effort in 1986 to develop CAI courseware for a wide range of subjects. This project produced a total of 417 courseware units for vocational high schools within four years. This experiment was cancelled after realizing the dearth of appropriate software available for use in schools (Hong, 1989). Many of the CAI lessons developed in Taiwan were unsatisfactory because they were just "page-turners" (Alessi & Shih, 1989). Computer educators in Taiwan have come to realize that good CAI does not come simply from placing computer hardware in schools. The presence of computer hardware provides a necessary, but insufficient basis for successful CAI. Teacher training and good software development are also necessary.

The Ministry of Education in Bahrain decided to carry out a pilot project in 1985 to introduce computer education into secondary schools, and they were faced with four major problem areas: hardware, software, Arabic language interface, and teacher training. The problems of hardware uniformity and compatibility as well as teacher training were resolved somewhat easily (Chaudhry & Fakhro, 1986). In addition, the Arabic interface problem was remedied when a company designed a computer system supporting Arabic characters. The most pressing problem encountered was the software problem. The Bahrain authorities decided to develop their own national software, but they have encountered many problems in designing software that is instructionally sound and relevant.

In the mid-1980s, the People's Republic of China conducted a study to find out the potential of implementing CAI in its educational system. Among the primary recommendations forwarded was that China should develop its own CAI material to ensure that it would be relevant to the Chinese school system. In their examination of existing software, they found an almost total lack of programs that could be easily used within their unique educational settings (Wu & Yu, 1987).

Although the Soviet Union is not a part of the Third World, the USSR is increasingly recognized as sharing many of the problems as those nations traditionally labeled as developing countries. Hoot (1987) estimated that even if the Soviet Union installed computers in every school, the computers would probably gather dust because of the lack of software. Major contributors to the software dilemma in the USSR are that programming languages are mostly in English and their uncompetitive economic system does not motivate programmers to invest time and effort in producing educational software.

Australia, Japan, India, Philippines, Sri Lanka, Thailand and Malaysia have all aired similar views concerning the major problems encountered in their attempts at implementing computer education in their respective countries. These views were voiced in the Third Asian Seminar on Educational Technology held at the Tokyo Gakugei University, Japan in 1984 (APEID, 1985). Australia and Japan, however, have moved ahead towards the solution of the software problem with the abundance of expertise available in their countries. The rest of the developing world is still struggling to find a solution that is both feasible and economical.

**Software Development in Developed Countries**

Considerable effort has been made by many countries to produce educational software of better quality. Different strategies have been used to support the software development and production process, examples of which are individual, team, and industrial or commercial approaches (Moonen, 1989). In general, the quality of software is improving and the quantity of educational software is increasing. However, this is mainly true for the already developed nations. The development and production costs of these approaches remain too high for many developing countries. Nonetheless, some lessons can be derived from the different strategies for software development employed in industrialized countries.

Reporting on the development of educational software in The Netherlands, Moonen and

Schoenmaker (1986) concluded that software development approaches which have been supported by an individual developer usually have to incorporate more people after a while, or fail as a result of the frustrations of insufficient recognition, insufficient compensation for investments, or insufficient perspectives with regard to the work carried out. Although the individual approach to courseware development might seem very appealing to developing countries, the lesson from Moonen and Schoenmaker's research should be heeded.

Another approach that is frequently used is the team approach. Developing computer-assisted learning materials requires a philosophy and strategy which places the technology and the curriculum on equal footing. This has long been recognized by serious developers of educational software. Watson (1983) maintained that CAI development should be a team activity, depending upon the interplay of different expertise representing hardware, software, curriculum and classroom. The Computers in the Curriculum (CIC) project, based at King's College (Chelsea), London, Great Britain, has developed CAI for pupils in secondary schools (11-18 years of age) since 1973.

The CIC project has published over 150 CAI units in various subject areas. Its development model reflects expertise in both the technology and the curriculum (Watson, 1987). According to Watson (1989), the success of the model depends upon a large development team in which several groups play different roles. Creative and energetic teachers provide practical understanding of their syllabus and situations; curriculum developers ensure that appropriate and current areas are tackled; professional programmers code good sound software; and CAI developers (or instructional designers) specialize in screen design, flow, and user interface aspects of the software. This combination of interlocking expertise and talents has resulted in effective and sound educational software for use in British schools.

The Netherlands used a similar approach where different teams are responsible for the pedagogical design, the system design, and the actual coding. Different approaches using the team concept have been tried out, but no satisfactory solution has been found for a completely effective development system. The main problem appeared to be communication between the developers and the target group (Moonen, 1989). Belgium, Denmark, France, Germany, Luxembourg and Spain have developed national software development bodies which mainly use different versions of the team approach (Plomp, Van Deursen & Moonen, 1987).

Schools in the U.S.A. on the other hand, usually obtain educational software by purchasing individual software packages from commercial publishers. More than 10,000 software products intended for instructional or educational use with computers in schools and home can be found on the U.S. market (Hunter, 1989). Commercial publishers in the U.S. have incorporated the team approach and combined it with their commercial/ industrial approach to churn out educational software. Many of these software packages have been sold to developing nations; however, for the most part, they were suited only to the U.S. curriculum, educational methods, and culture.

A major impetus for the team approach was the difficulty educators faced in developing software on their own due to complexities of coding or programming. Until recently, there was a lack of simple-to-learn authoring tools that were powerful enough to create the sophisticated instructional transactions that needed to be performed. All the design ideas had to be translated using high-level programming languages which educators found difficult to master. Many of those involved in team approaches to software development since the early 1980's have agreed that the advent of powerful authoring tools has changed their views about future approaches to educational software development (Moonen, 1989; Watson, 1989; Hunter, 1989; Plomp et al., 1987).

McLean (1989), in a paper about megatrends of educational development, suggested some sort of a return to the early approaches in software development, specifically the development of software by practicing educators themselves rather than commercial development. Watson (1989) noted that the rapid growth of software authoring tools is going to have a great impact on the future of software development in the United Kingdom. Although the proliferation of authoring systems requires modifications in the development process, it does not change the underlying team-based philosophy of how software should be developed. Instead of having four separate teams doing work in their own areas of expertise, the presence of new simple, powerful authoring tools has shifted the focus of development to a smaller centralized team consisting of a designer/author, subject matter expert, and programmer. This has important implications for developing nations lacking sufficient financial and expertise resources for commercial development of educational software.

**Educators as Courseware Developers**

In 1985, over sixty different authoring systems were reported (Locatis & Carr, 1985). This marks a growing trend to make authoring tools available to those who generally lack programming and courseware development experience. The availability and ease of use of authoring software such as HyperCard, Authorware Professional™, Icon Author, Scriptwriter, Linkway, Tutor Tech and many others have increased the interest and involvement of educators in educational courseware development (Hebenstreit, 1989). One factor inhibiting software development by teachers previously was the conflict between the need for attractive screen displays and easy navigation techniques in software to be used by students and the time and training necessary to develop those aspects. Most of the authoring tools mentioned above have made it feasible for teachers to design screens that are both attractive and functional.

In the early 1980's, there was much discussion as to whether teachers should be involved in developing educational computer courseware. The general consensus were that teachers should not generally be involved in courseware development since most teachers developed software that only met their own specific local needs and did not contribute to the overall improvement of education. Errors in teacher-developed courseware occurred in both the instructional design and programming characteristics (Roblyer, 1983). Opinions in recent years, however, have shifted due to the existence of more advanced authoring tools and the increase in the number of teachers with educational computing experience. Today's teachers may also be more aware of the principles of instructional design, especially as applied in educational software development.

Many administrators are again encouraging educators to be involved in developing instructional software for school use. Several models for the design of CAI software by teachers have been developed, and textbooks concerning the principles of CBI design for teachers or non-programmers have been published to encourage teachers in developing software (Tessmer & Jonassen, 1988; Bosler & Squires, 1989; Crossley & Green, 1985; Alessi & Trollip, 1987). These models emphasize the use of sound principles of instructional design methods to be incorporated together with the use of the authoring tools for courseware development. The consensus of opinion is that a key factor in the successful implementation of educational computing is educator involvement as courseware developers, certainly at the design stage, and even at the coding stage using authoring tools (Smith, 1987; Watson, 1989).

The existence of powerful authoring software has made training of educators as software developers more feasible (Bosler & Squires, 1989). This may benefit developing countries since hiring of programmers for software development is both very expensive and difficult due to the lack of programmers in these countries. Many developing countries have used educators as software developers by training them to program using high-level programming languages to overcome the shortage of programmers. However, the experience of Taiwanese educators indicates that programming courses or workshops are not sufficient for courseware development (Alessi & Shih, 1989).

Like Taiwan, many developing countries have implemented computer literacy training to encourage teachers to develop software. Similar problems appeared in these countries and very little educational software has been produced. Those programs produced were of low quality, especially in instructional design considerations (APEID, 1985). Trying to train teachers to program using high-level programming languages in a short duration of time, usually 1 week - 3 months, is ill-advised. Such an approach neither turns teachers into competent programmers nor helps them to be designers of good software.

Other factors that influence the quality of software developed by teachers are inadequate monetary support and the lack of a coordinated systematic plan for software development. Our review of the literature concerning methodology of software development in both developed and developing nations has revealed several important points that should be considered for the implementation of educational software development projects in developing countries:

1. a team approach is necessary to ensure a well-designed courseware products;
2. the use of teachers as designers and developers should be pursued due to financial and expertise constraints;

3.teachers must be trained in the principles of instructional design and implementation of instructional innovations;
4.simple-to-use but powerful authoring tools or authoring systems should be used;
5.a coordinated approach with a systematic monitoring and evaluation should be established at the national level; and
6.more financial support and involvement should be present from the educational agencies responsible for educational computing.

**Current Software Development Models**

A software development model that could be used by developing countries can be derived by combining the team approach carried out by Computers in the Curriculum (CIC) project of the U.K. and practices carried out in The Netherlands, albeit on a smaller scale (Watson, 1983; Moonen, 1986). The CIC model utilizes a large team reflecting a combination of expertise in hardware, software, curriculum, and pedagogy. The teams consisted of 1) classroom teachers in a variety of subjects; 2) curriculum developers; 3) professional programmers; 4) system analysts; and 5) CAL developers. The team was subdivided into a writing team and a central team. The writing team consisted of classroom teachers, curriculum developers, group coordinators, and programmers. This team was responsible for the main bulk of the development work. The central team consisted of a chief programmer, a systems analyst, a software support manager, CAL developers and programmers. Although a significant proportion of the work was carried out by the writing team, the central team took an active developmental role as well as a managerial one from its central base in Chelsea, London (Watson, 1987).

The Netherlands approach was similar to the CIC approach. The Dutch government created three development centers, each one specially aimed at one particular sector of education. These development centers were mainly involved in developing prototypes of software for commercialization. They also supported an agreed-upon methodological approach for software development by smaller groups in their vicinity. The development groups focused their activities mainly towards the coding aspects of the development process whilst the design process was the responsibility of the development centers.

**A Modified Courseware Development Model**

The rest of this paper outlines a system or methodology for developing instructionally sound educational courseware that is relevant to a developing country's unique educational setting. This is the beginning of a model for courseware development that is both economical and effective for small developing nations with little financial and expertise resources. It is hoped that this generic model will provide the guidance necessary for the successful diffusion and implementation of CAI in the educational systems of developing countries.

**The Team Approach.**

The basis of the modified software development model lies in a team approach that reflects a combination of expertise in instructional design, software, curriculum, and schools. Each team will consists of the following:

a)an instructional designer (as a coordinator and resource person);
b)a teacher (as a designer-developer);
c)a subject matter expert (as a curriculum resource person); and
d)an authoring software expert (as a software resource person).

It is important to realize that the team size is small due to the considerations of the financial and expertise constraints faced by developing countries. However, several small teams such as these spread out throughout the country would help increase the rate of implementation of the software developed.

*a) The instructional designer as a coordinator and resource person:* The inclusion of the instructional designer is to ensure that the software development follows the basic guidelines of sound instructional design, content integrity, and relevance to the local curriculum. The instructional designer should be a person with expertise in instructional design and computer-based instruction, preferably with experience in using the various authoring tools used for the software development. He/she will also train the other team members about the basic principles of instructional design and computer-based instruction.

The instructional designer should also act as a coordinator overseeing the management and administration aspects of the development team. He/she should establish a close relationship with the team members and act as both a catalyst for ideas and as a bridge between the two main types of work, i.e., the authoring and the educational. Establishing connections to other resources, including hardware and software expertise, will be a very important aspect of this work. He/she will usually be in charge of not one but several development teams involved in the development of software in similar areas of the curriculum. Another critical role for the instructional designer will be guiding formative and summative evaluation.

*b) The teacher as designer/developer:* Creative and energetic teachers are essential for the development of good software. A teacher of a given discipline can provide a practical understanding of his or her subject's structure of knowledge and methods of instruction. For example, a geography teacher is the best qualified developer of courseware for geography lessons since he/she instinctively knows a variety of ways a topic may be taught in the classroom and the areas of learning difficulty. This knowledge and the accompanying pedagogic skills can be tapped and transformed into sound software principles.

The teachers must be trained in the basic principles of instructional design and its application and relevance to the process of educational computer courseware development. In addition, they must be rigorously trained in the use of a type of authoring language/tool for software development for a duration of not less than three months. The teachers should be identified and selected based on their current knowledge, involvements, and initiatives in the area of computer education in their schools, district, state, or at the national level. The teachers should be handpicked through a process of recommendations, interviews and background research of opinions of their peers.

*c) The subject matter expert as a curriculum resource person:* The software development process must include the input of the people with the actual knowledge of the content to be developed. Subject matter experts are knowledgeable about the curricula requirements of the school system. They should act as advisors to the teacher-developers to ensure the software follows the curriculum guidelines and educational philosophy of the local school system.

The subject matter experts must also work closely with the instructional designer in planning in-service training courses for the implementation of the courseware in classrooms. They should work with the teacher-developers in the testing, evaluation and the development of classroom-use strategies for the courses. These courses should be conducted by the subject matter experts assisted by the teacher-developers.

*d) The authoring software expert as software resource person:* The in-depth training of the teacher-developers to use authoring tools should be the responsibility of the authoring software experts. They should work closely with the instructional designer/coordinator in planning and implementing the training program. They should also act as an advisor and resource person to the teacher-developers throughout the courseware development process to help fix problems encountered in using the authoring tools.

During the development process, the courseware created by the teacher-developers should be periodically reviewed in terms of efficiency in using the authoring language/tool capabilities to ensure that the software created is systematic and using the full capabilities of the authoring tool. The software expert should periodically meet with the teacher-developers to monitor their progress and generate further ideas and suggestions concerning the software being developed.

**The Development Process.** There are several critical components that must be coordinated to support a systematic development process. These factors include:

*a) hardware considerations:* Hardware must be chosen carefully with regards to its ease of use since teachers and students in diverse classrooms will be using the developed software. The hardware chosen should not require teachers to undergo comprehensive training courses to be comfortable using it. Since one of the major constraints of implementing CAI in a developing country is limited financial resources, the shorter user training time would minimize the budget necessary for training.

*b) authoring tools/systems:* Authoring tools/systems selected for the teachers to develop their courseware should be chosen for their powerful capabilities in designing and developing of courseware as well as for their hardware compatibility. The systems should be easy to learn so that teachers can develop courseware with their little or no programming experience. MacKnight and Balagopalan (1989) compared several authoring systems in terms of their power, ease of use, and productivity.

Some examples of authoring tools/systems are Authorware Professional™, IconAuthor, Quest, PCD3, HyperCard, and Linkway.

*c) training:* The teacher-developers and subject matter experts must be trained in the principles of instructional design with emphasis on CAI to ensure that the software developed will be instructionally sound. The teacher-developers must be rigorously trained by the authoring systems expert through a full-time in-service course that would require that they produce courseware to be used in the classroom.

*d) design/development teams:* The participants in a courseware development effort will be divided into development teams. Figure 1 shows the composition of such a team. In this model, each instructional designer/coordinator and the authoring systems expert would be overseeing five small teams consisting of a teacher-developer and a subject-matter expert. The teacher-developer of each small team, together with the subject matter expert, will develop a courseware module for a topic or sub-topic in the curriculum related to their specialities and/or interests. The module that they will develop will be between 15 to 30 minutes in length with an emphasis on helping teachers to deliver instruction in the particular subject area. The team members will meet to discuss any problems encountered as well as show the coordinators their current progress in their work at specified times every week. These sessions will be used as a peer group formative evaluation sessions to generate better ideas and techniques of developing courseware.

*e) pilot testing, evaluation and identification of teaching strategies:* At the end of a certain time length (e.g., three months), the teacher-developers should try out and conduct a pilot test of their products either in the classes that they are teaching or with the help of their colleagues. During this time, together with the subject matter experts, they will identify the strength and weaknesses of the courseware and the most effective strategies for

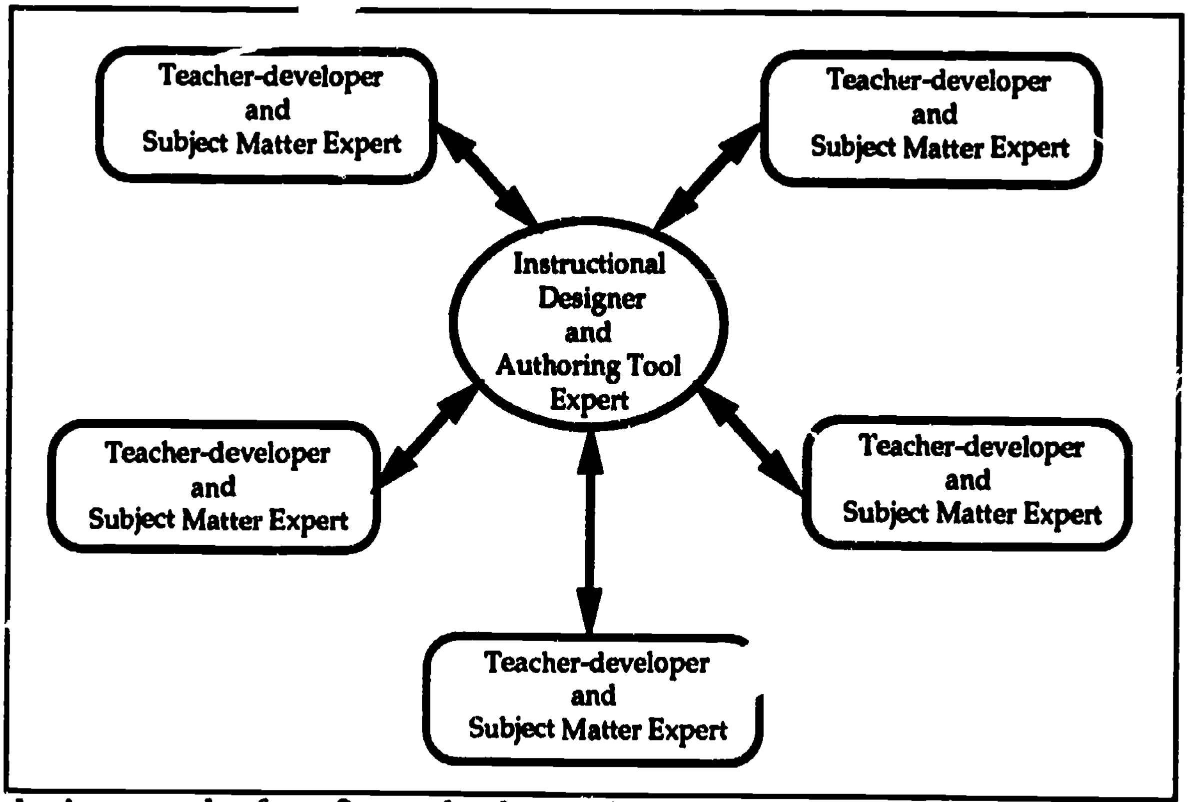


Figure 1. An example of a software development team.

teachers to use the software created. The evaluation would utilize qualitative and observational methods as well as traditional quantitative methods of evaluation.

f) *training other teachers to use the courseware:* After the major and obvious bugs or faults of the courseware have been identified and fixed, the teams must meet together to plan an in-service teacher training program to support the use of the developed courseware. The teachers will be trained by both the subject matter experts and the teacher-developers to use the developed courseware effectively.

The first group of teachers that will be trained should consist of the teachers teaching the relevant subject areas from the same schools as the teacher developers. This will ensure that there is back-up expertise in dealing with the computer or courseware if problems are encountered by the classroom teachers in the school.

Figure 2 shows the phases of the model's suggested development process. The development process has been divided into the development phase and the implementation or dissemination phase. In the development phase, the selection of the teachers, curriculum areas for courseware development, and software refinement should be planned, organized, and monitored by a central agency responsible for computer education in the country. The courseware development will actually take place at regional or local levels. This would instill within the teams a sense of ownership and personal investment which is crucial in nurturing and the acceptance of innovations in education (Rogers, 1983). The central planning and monitoring is important to ensure that development is guided towards the policies and aspirations of the educational system. It also helps to promote the sense of importance of the courseware developed and encourages its use by teachers at the school level.

The implementation and dissemination phase should be planned and organized at the local or regional level and monitored by the central agency. Locally developed dissemination and teacher training programs would be responsive to the particular interests and characteristics of the teachers involved as well as encourage innovations in the use of the courseware developed. Programs developed and taught by local staff will support professional growth and leadership at the local level. Local trainers would also be able to offer on-the-job support as teachers try to implement what they have learned in training experiences.

Figure 3 shows the set-up suggested by the model and the links between the central agency and the local/regional development teams. Collis and Oliveira (1990) described the advantages and limitations of different types of computer-related educational policies. They concluded that emphasis

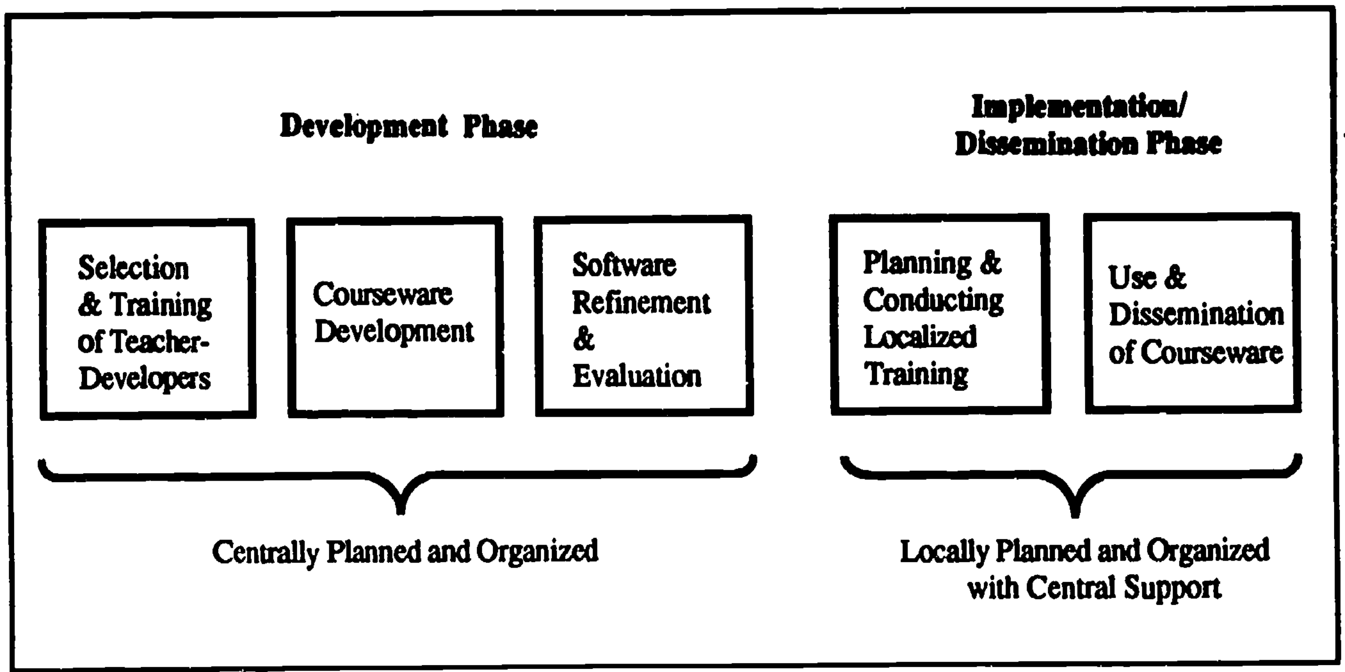


Figure 2. Phases of the development process.

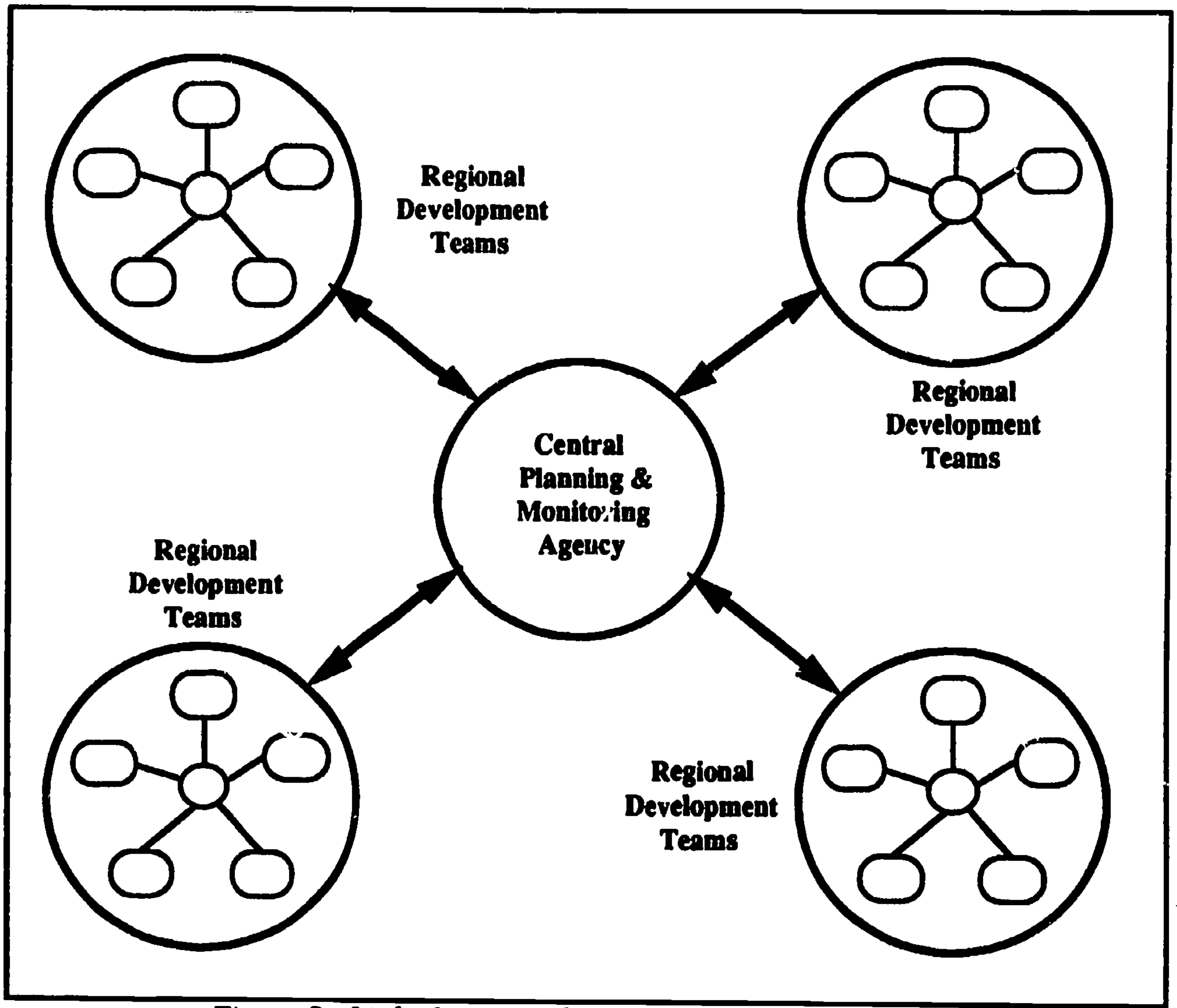


Figure 3. Links between the central monitoring agency and regional development teams.

should be placed on supporting a blend of centralized and localized policies to support the development and implementation of educational computing.

**Conclusion**

The importance of good software to support the diffusion process of computer technology in educational settings is beyond doubt. However, good software that works in a particular educational setting does not usually mean that it is also portable to other educational environments (Ely, 1990; Murray-Lasso 1990). Thus, developing nations have to find cost-effective ways of producing high quality, relevant software for their own education systems.

It is hoped that the systematic courseware development model described above will help in providing guidance and suggestions for educators in developing nat' s as they attempt to introduce CAI into th educational systems. Of course, this paper is only a brief overview of what will eventually be a more detailed generic model for use in developing countries. More detailed sequences of steps and considerations need to be specified to fully implement a systematic approach to courseware development in a specific developing country due to the unique cultural, political, and social features of each country.

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# THE ROLE OF THE COMPUTER IN SCIENCE FAIR PROJECTS: CURRENT STATUS AND POTENTIAL

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**ABSTRACT**
The need for more students to enter the field of science is acute in the nation, and science fair projects provide a motivational mechanism to entice students into pursuing scientific careers. Computers play a major role in science today. Because computers are a major source of entertainment for our children, one would expect them to play a significant role in many science fair projects. This study investigated current and potential uses of computers in science fair projects and incorporated an informal case study of scientists, teachers, and students involved in science fair projects from a highly scientific community. Interviews, a survey, and observations were conducted. Results indicated that most projects either do not use or inadequately use computers and that a significant potential for more effective use of computers for science fair projects exists.

**INTRODUCTION**
Science fair projects provide a mechanism to attract young people to enter science and engineering fields. Workforce projections reflect a drastic decline of available professionals in these fields; thus, science fair projects offer valuable resources for studying how to motivate and encourage potential scientists. In most elementary, junior high, and secondary schools, students receive encouragement and some help to prepare original projects. Computers now play a major role in science and engineering research, yet they do not seem to play a central role in science fair projects in spite of the fact that computer games are a primary source of entertainment for many students.

This paper explores the subject of the role of the computer in science fair projects. The specific research questions asked were the following:

How are computers being used by K-12 students for science fair projects?

How can students be helped to use computers more effectively for their projects?

The hypothesis being tested is that computers are inadequately used and, in some cases, misused in science fair projects. he methods used in this study were interview and observation. A small sample of students, teachers, school administrator, and scientists (science fair judges) were nonrandomly selected and systematically asked to provide information on how they feel computers could be used and have been used at science fairs. In addition, suggestions from the author regarding feasible potential application of computers to projects are provided.

This study is not intended to be an all-encompassing survey of science fair projects but rather is case study. The goal is for this study to prompt increased interest in the use of science fair projects to attract students into scientific careers and to promote the appropriate use of computers for science fair projects. In addition, vendors might consider the development of new softw are packages, tailored to assisting students with projects as an important market.

**BACKGROUND: SCIENCE FAIR PROJECTS**
A science fair project is an experiment or investigation designed and conducted by a K-12 student and then reported in a research paper and/or exhibit and presentation. One science fair project publication for students (Van deMan and McDonald, 1980) states, "All outstanding projects usually have one thing in common - They are the result of creative thought." The publication further elaborates with the following information:

- It is deciding if you are willing to make the commitment to see your project through from start to finish.

- It is choosing a topic that seems interesting to you and something that you would like to know more about. A good way to start is to ask a question that can be answered only by experimenting.

- It is formulating a purpose for your project and making hypotheses about the outcome of your experimentation.

- It is experimenting to test your hypotheses, making observations, recording your data.

- It is analyzing your findings, drawing conclusions, preparing your paper, exhibit, presentation, and presenting your project to an audience of judges, the public, and your classmates.

Kennison's handout (1990) provides a more flexible approach to problem selection, for it allows two types of projects:

- Investigation of a Problem. Construct a research question and then design an experiment.

- Construction of a kit or model, or putting together a collection.

The criteria listed for judging of the projects are (1) creative ability, (2) scientific thought, (3) thoroughness, (4) skill, (5) clarity, and (6) dramatic value.

The difference between true scientific research and science fair projects must be noted. To a great extent, science fair projects teach how to do such projects and not how to do research projects that scientists perform. In scientific research, much collaboration and study occur before selecting a research problem. Research problems also tend not to be selected in isolation, but rather as part of larger ongoing efforts resulting from years of concentrated study. In scientific research there is rarely strict adherence to the scientific method, as described in science fair publications (e.g. Van deMan and McDonald). The sequence of steps taken is not linear, for iterations occur within steps and steps are sometimes skipped and then revisited later. The time scale is rarely as predictable as necessary for a science fair project.

**BACKGROUND: THE ROLE OF COMPUTERS IN SCIENCE AND EDUCATION**

In the past few decades, computers have emerged as being tools central to scientific research. Thirty years ago, computers were often used for data analysis. Today, computers are used as tools during every stage of the research process and are used for literature searches at the beginning of the process. They are used for electronic communication and collaboration among researchers. Word processors, spreadsheets, project management, and graphics tools are used to prepare experimental designs and proposals. Computerized instruments or automated control systems are often involved in data collection. Statistics packages and other software tools are central to the compilation, analysis, and reporting of the research results. Aside from the role of computers in scientific research, computer science is a field itself. Computer languages, graphics, interface design, hardware, data structures, artificial intelligence, and algorithms are just of few of the computer science disciplines that can be delved into for science fair projects .

The role of computers in education is changing rapidly but still lags behind computer usage in science, which directly affects the role of computers in science fair projects. Most schools now have some type of computer laboratory and users courses. "At Cincinnati Country Day School two principles underlie the school's commitment to restructuring: First, that learning is best achieved by doing, and second, that technology - better than anything else so far - promotes principle number one." (See Pearlman, 1991.) Many teachers have a personal computer in their classrooms, but few are heavily used because of a lack of time in the teacher's busy schedule, lack of hardware or software support, or lack of adequate training on the part of the teacher. The bulk of computer use in the schools is in the computer labs during formal class time. In Los Alamos, the computer labs in both the middle and high schools are heavily booked with classes. Because of budgetary constraints, schools rarely have open computer labs where students can use the computers for projects during their free time.

Many schools envision that the application of computers to learning is limited to learning programming, applications package s (e.g., word processors, spreadsheets, databases), and computer-based instruction (CBI). CBI has existed as a field for over thirty years, yet few schools have state-of-the art CBI courses. The potential use of computers as tools for learning, however, is much greater than is commonly perceived (Andrews et al , 1988). The potential uses range from record keeping to class presentation and from gaming and simulation for individuals and groups to electronic communication with experts and students at other schools.

A very recent study of the California schools revealed some relevant data on computer usage (Main and Roberts, 1990). A written survey was administered to 1000 schools and 484 were returned. Some of the data highlights follow:

- An average of 40 computers are at each school site (slightly more than one per classroom or one per teacher).

- Computers outnumber TV monitors by more than five-to-one.

- The most common location for the computer is in the classroom, with the laboratory configuration a close second.

- The most commonly used computer applications are word processing and individual drill and practice or tutorial.

- Over half of the teachers are rated as being of limited proficiency or unskilled for both personal productivity and instruct ional use of computers.

- Ninety-one percent of the schools perceived that integrating technology into the curriculum was the greatest staff development need.

This data, from an educationally very progressive state . reveal that computer hardware is universally in place, but the use of the hardware and state-of-the-art applications is not optimal.

Computers are useful tools to facilitate learning, solving problems, organizing or retrieving information, doing simulation, etc. but they are only tools. A good education can be obtained without knowledge of computers, but computers have become instrumental in many jobs. As with science fair projects, computers can potentially help students organize and present their work more effectively and efficiently. Students need to obtain an accurate view of how computers are used in the workplace; science fair projects can help achieve this objective.

**METHODS**

This study involved interviewing and/or administering a survey to the following:

- two middle school science teachers, both heavily involved in helping students to conduct quality experiments

- one high school computer science teacher, who teaches a course on using computers in science fair projects

- one school principal, who chairs the Science Fair Committee,

- two scientists who had judged at several science fairs, and

- three students who had done at least two projects in the past (one each from elementary, middle school, and high school levels).

Subjects were chosen systematically, on the basis of heavy involvement with past science fairs. Subjects were not chosen, however, on the basis of computer expertise or experience. Interviews were conducted in an informal fashion, but a list of questions was use d as a guide (see Tables 1, 2, and 3). All interviewees were from Los Alamos, New Mexico, a unique small town with a very high percentage of resident scientists. Therefore, the interest in science fair projects is keen among students, parents, and teachers. Competent, motivated judges are readily available!

**RESULTS AND DISCUSSION**

The surveys and interviews revealed a range of experience and opinions regarding computer use in science fair projects (see Tables 4 to 8). To provide equal weighting of all opinions, the results are presented, without sorting the student's or instructor' s opinions from those of the scientists. Highlights of differences between categories are presented below. All of the collected data is not reported here because of space, but the tables contain the most representative feedback. Data on computer use in 1991 science fair projects is not yet available but will be provided at the time this paper is presented.

One teacher felt that motivating students to pursue scientific careers was only a minor goal of science fair projects. He saw the primary goal as giving them a long-term learning experience that requires dedication and follow through. Science fair projects need to be seen as an opportunity for all students (not just those interested in science as a career).

A high level of computer literacy prevailed among the subjects, for all of them had taken a computer course and used a computer fairly regularly, except for the elementary school subject. He had only used a computer for computer games, a little word processing, and math drill and practice, although he had been exposed to several different computer applications by observing his parents . To motivate more students to use computers and to represent the real world more accurately, the middle school and high school students both had taken computer science courses that had included using word processing packages and some programming. The middle school has recently moved from emphasizing programming to teaching applications. They help students use spreadsheet, graphics, and database packages. Drawing a box with a simple program in BASIC was a turnoff to some students, whereas drawing sophisticated graphics or seeing a spreadsheet accommodate changes instantly are more fun.

The Los Alamos Middle School, in an effort to encourage science fair projects, has recently enacted a new program in which the teacher for gifted students gives individual help to students doing science fair projects. Partially because there have recently been very few projects in the computer science category, the high school has added a self-paced, individualized computer science course for students working on science fair projects. The students who sign up for this course generally are working on computer science or mathematics projects, as opposed to the other sciences. Therefore, the chances for winning a prize are greater in computer science than they are in physics or chemistry.

One knowledgeable interviewee claimed that computers are used in approximately 50 to 60% of the science fair projects above the sixth grade level, Two other interviewees estimated computer involvement as much lower, 10% and 25%. Almost all of the uses of computers for these projects, however, is in the word processing or presentation graphics areas (see Table 5). Table 6 shows the potential uses of computers in science fair projects. It was interesting to note that the students interviewed perceived that they used the computer to its maximal potential in their projects, yet relative to the list on Table 6, they were far from fully exploiting the computer. In the elementary grade levels, the use of computers is less than that for the higher grades and again is used for presentation only and not for analysis.

In terms of the type of hardware used, an interviewee hypothesized that students who had a Macintosh computer at home were more likely to use it for their project because the interface is easier to use without parental help than that of other computers.

Many of the elementary school age children have their parents do the presentation graphics and text for them. The judges interviewed did not consider this as misuse, unless the parent edited the child's text while typing the presentation. Unfortunately, most parents are unable to resist editing their children's work and thus misuse does occur. The judges agreed that the way to identify the projects in which parents had too large a role in from those the child did independently, is through the interview. At the time the judges are going around examining the project displays, they talk with the children and ask for explanations. If the child cannot explain why the outcome was interesting or why the experiment was set up the way it was, then the misuse is readily perceived. The only type of misuse named by the judges interviewed was too heavy parental involvement.

Table 5 presents several examples of science fair projects in which the computer was used for something other than presentation graphics and/or word processing. Several of these same projects were mentioned by more than one interviewee, suggesting their uniqueness. One interviewee noted that role modelling played a big role in science fair projects. Many students started participating in projects in the elementary grades and each year would study other student's projects. When they saw a project they thoughts exceptional, then they tended to try to model parts of it the next year. This is one major way that students can learn about the range of possible uses of computers. This process, however, is currently an informal one done by just a few students and could be incorporated formally into the science curriculum.

How can a student's perception of how computer use in science become more accurate? Table 8 presents a list of methods that those interviewed cited as ways of increasing and improving computer usage in the projects. This list contains several significant areas of development for university education departments, schools, and vendors. The answer to the question, "Do you think that the use of computers in science fair projects should increase?" was yes from all the subjects. One teacher said, "How are kids going to get into the 21st century if they do not have more exposure to computers? This is only going to happen if our budgets for computers increase."

**SUMMARY AND IMPLICATIONS**

From the data collected in this informal study, we can conditionally accept the hypothesis: Computers are inadequately used and, in some cases, misused in science fair projects. The data did indicate that computers are inadequately used in science fair projects. The issue of misuse aroused some controversy, perhaps just because of the variable interpretation of the word misuse. The majority did not see examples of misuse of computers in terms of correct application of the technology in the projects they had observed. However, when asked about parental involvement, some interviewees saw misuse playing a role.

The underuse of computers in science fair projects fell into two categories: (1) The students whose project presentations could have been improved through the use of a computer and (2) The students whose project content could have been improved through the use of computers for analysis, control, or simulation. The interviewer's general impression of most interviewees is that the wide range of uses of computers for science is not known in the schools. If it is known (for example by the high school computer science teachers), often the range of possible uses cannot be shown to the student because of hardware (budget) or schedule constraints. The students who used computers for analysis or control (Table 5) were generally those whose parents were very computer literate and helped them and those who had a well-equipped computer system at home. Schools seem to be adequately informing students about the uses of computers for word processing, spreadsheets, and presentation graphics. Schools do not seem to be able to provide adequate hardware or software to students wishing to use computers in this way for their projects. In addition, schools seem unable to provide students the exposure to or opportunities for data analysis via computers not because of a lack of computer literacy among teachers, a commonly cited reason, rather because of a lack of an adequate computer budget. Students need the following:

- More free time on computers, therefore more computers, software, and computer-aids or teachers to advise individuals.

- More exposure to the range of uses of computers in science through examples.

- More software tools tailored for doing science fair projects. For example, a statistical package in which one can enter the data, obtain averages and standard deviations and basic plots.

- Computer-based instruction lessons that help in getting started. This instruction might include game-like packages to challenge the students into narrowing down their area of interest and then focusing on a problem.

- More computer networking at the schools. Such networking would provide the following types of opportunities not currently available: (1) electronic consultation with a remotely located expert in the field they are researching, (2) accessing information from databases that are not available locally, and (3) accessing mainframe computers that have much greater power than is locally available.

The computer is a tool that can enhance the quality of a science fair project. Computers are not seen as a central focus of science fairs but rather as aids. Increasing and enhancing the use of computers in science fair projects is, however, an opportunity to further prepare our children for the workplace of the future.

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NAME
AREAS OF EXPERTISE

1. What is your experience with science fair projects?
2. Have you judged science fair projects? If yes, discuss the experience briefly.
3. What do you believe is the main benefit of science fair projects?
4. Do you use a computer? YES NO If yes, for what and how often?
5. At your school, how many students receive computer training? Of what does that training usually consist?
6. At your school, is there any encouragement for students to use computers for their science fair projects? YES NO If yes, describe:
7. Do you see it as beneficial for students to use computers in science fair projects? YES NO If yes, how?
8. In the science fair projects that you have been in contact with in the past year, what percentage used computers? _____Give some examples, if you can, of specific projects that did use computers:
9. Can you give some examples of projects where computers were misused?
10. Do you know of any learning resources for students to use to learn how to use a computer to aid them in their projects? YES NO If yes, what are they?
11. Do you think that the use of computers in science fair projects should increase? YES NO If yes, how?

TABLE 1 INTERVIEW QUESTIONS FOR TEACHERS, ADMINISTRATORS

NAME
GRADE LEVEL

1. How many science fair projects have you done?____________ What was/were the title(s)?
2. What do you think that you learned from doing your projects?
3. Do you use a computer? YES NO If yes, how and how often?
4. How do you think that a computer is used in doing science?
5. Have you ever had a computer course? YES NO If yes, what did you learn?
5. Did you use a computer in your science project (s)? YES NO If yes, please describe the software, hardware, and type of use :
6. Would you like to have used a computer more in your project(s)? YES NO If yes, for what? If no, why not?
7. Can you tell me examples of other students' projects where a computer was used very well and very poorly?
8. How do you feel that your parents and/or your school and/or software companies could help students use computers more effectively in science fair projects?

TABLE 2 INTERVIEW QUESTIONS FOR STUDENTS

NAME
FIELD

1. What is your experience with science fair projects?
2. What do you believe is the main benefit of science fair projects?
3. What was your responsibility as a science fair judge?
4. What guidelines were you given for your judging?
5. How did you judge? (What did you look for the most?)
6. Do you use a computer? YES NO If yes, for what and how often?
7. Do you see it as beneficial for students to use computers in science fair projects? YES NO If yes, how?
8. In the science fair projects that you have been in contact with in the past, what percentage used computers? _______ Give some examples, if you can, of specific projects that did use computers:
9. Can you give some examples of projects where computers were misused?
10. Do you think that the use of computers in science fair projects should increase? YES NO If yes, how best do you think this could be accomplished?

TABLE 3 INTERVIEW QUESTIONS FOR SCIENTISTS

•To develop a project from beginning to end; the satisfaction of completing a project

•To gain practice in presenting the project to judges and in so doing develop poise and confidence

•To learn the scientific method in the research of specific areas/problems of interest

•To allow students to delve into an area of their own interest, in contrast to the curriculum of the schools, which necessarily allows for little flexibility

•To enable students to see science more like it really is in real life, not like it is in the classroom

•To provide an opportunity for academically oriented students (as opposed to sports oriented students) to excel at something and be rewarded for it.

•To learn how to collect and organize data

TABLE 4 RESULTS: MAIN BENEFIT OF SCIENCE FAIR PROJECTS

•Word processing (report preparation)

•Spreadsheets

•Computer program for problem solving

•Presentation graphics

•Microcomputer control systems

TABLE 5 RESULTS: CURRENT COMPUTER USAGE IN PROJECTS

•Accessing databases

•CAD

•Electronic communication and collaboration

•Computer-based instruction on the scientific method

•Data analysis (statistical packages)

•Record keeping

•Outlining; organizing information that is collected

•Simulation

TABLE 6 RESULTS: ADDITIONAL USES OF COMPUTERS IN PROJECTS

•The position of the moons of Jupiter

•Experiments on hair strength and the effect of microwaves

•The concept of chaos

•Computer-controlled robotics

•Computer-controlled hand

•Computer imager

TABLE 7 RESULTS: EXAMPLES OF PROJECTS USING COMPUTERS FOR ANALYSIS AND/OR CONTROL

•Making more computer courses available

•Having open computer labs where students can use the computers during free time for their projects

•Having software packages tailored for science fair projects (e.g., for problem recognition and definition/narrowing, for var iables identification)

•Providing easy-to-use presentation graphics software

•Science teachers showing example applications of computers in science, from which students can learn about the broader potential for computers

•Modeling of possible solutions, varying of parameters

•Assigning computer-educated volunteers to children who need help with computers

•Computer teacher offering sessions to give children ideas on how to use computers for science fair projects

TABLE 8 RESULTS: EFFORTS THAT CAN IMPROVE/INCREASE COMPUTER USE IN PROJECTS

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Selected Formal Papers From the

# Special Interest Group for Emerging Technologies (ETSIG)

# CAI IN LEARNING ENGLISH AS A SECOND LANGUAGE (ESL)

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**Abstract**
The roles of computers in the field of teaching English as a second language (ESL) have been discussed from different language learning areas: reading, grammar, writing, and listening/speaking. As a role of tutor, the tutorial program provides different levels of linguistic knowledge. As a role of tutee, the programming language allows students to use knowledge of language to communicate with computers. In addition, the computer also works as an editor, an advisor, an idea generator, and an expert in various computer applications. Concerns of integrating technology in ESL learning within various learning areas are stressed in this study.

**Introduction**:
In many countries, English learning is considered as an important issue in school curriculum. Learning English not only introduces students to English speaking culture, heightens awareness and comprehension of one's native tongue, but also serves the nation's needs in commerce, diplomacy, defense and education. When introduced to English as a second language (ESL), the learners have the opportunities to explore a new system of thinking within the new cultural context. At an advanced level, it also provides the chance of exploring new literary and political perspectives (Savignon, Curtain & Pesola, 1988). With learning English for this purpose, the use of computers in the field can be either direct instruction, focusing on the form of message presentation, or indirect language instruction through various subject areas. The use of the computer as an instructional tool has drawn a lot of attention during recent years. Many curriculum specialists have been designing software for a variety of instructional purposes, such as learning writing skills, reading skills, listening comprehension, and grammar. The role of the teacher is also seen to change from an information provider to an organizer and classroom manager (Cheung, 1987). The purposes of this review are to: identify the role computer is playing in the field of teaching English as a second language, identify possible problems existing in this approach, and forecast the trend of computer learning in ESL in the future.

Major linguistic aspects that constitute language learning are basically vocabulary, spelling, and grammar, but there are also attempts on cultural awareness and sociolinguistic appropriateness, and discourse in most language learning. Dalgish (1990) suggested that the computer can be applied in various aspects of linguistic knowledge with focus on the linguistic nature of context. The linguistic concept described by Le (1989) contains three interacting factors: syntactic, semantic and discourse levels. Several computer programs were developed based on these factors to influence children's encoding task and to establish the learning context. Based on the different linguistic purposes that computer assisted instruction (CAI) is intended to achieve, various modes of presentation are discussed as followed.

**Tool for Teaching Reading /Language art:**
Reading is a multileveled, interactive, and hypothesis-generating process in which readers construct a meaningful representation of text by using their knowledge of the world and language (Mustapha, 1988). Results of various research studies on the reading process and on the view of reading comprehension have indicated that reading is an interactive process between the readers and the context (Mustapha, 1988, Preisinger, 1988; Hedley, 1985). With the notion of providing interaction as a way to facilitate students' thinking process, the computer has been used in many ways in reading and language arts (Balajthy, 1986). It provides the function of drill and practice of subskills , such as electronic flash card, vocabulary quizzer, crossword puzzle, sentence/phrase association. The purpose of computer drill and practice is to provide novice learners with the smooth continuity and automatic process important to performing a complete skill essential for reading (Dreyfus & Dreyfus, 1985; Balajthy, 1987, Nyns, 1988).

In teaching reading, the different reading speeds among learners can be considered as a major problem. Especially, for non-English speaking learners, it is necessary to employ some strategies to comprehend the meaning of new words. The strategies that are often used are inferring the meaning of new words in the mother tongue, deciding on the importance of certain words for the global comprehension of a text, and dealing with compound and affixed words (Palmberg, 1988). Due to individual differences in the ability of using these strategies, comprehension time for different students varies from one student to another. Consequently, among a class of students, reading speed might vary greatly. In order to conduct group classroom activities, faster readers sometimes spend time waiting resulting boredom. On the other hand, lower speed readers who are never allowed to read through a text, will always feel frustrated. To increase the reading speed of every individual student with various starting points, and without forcing either the faster reader or the slower reader to compromise with each other, the computer is the ideal medium which offers such control. In addition to reading speed, allowing the adaption of different modes of reading also stresses the flexibility feature of using computers.

Another important issue in teaching reading is the syntax and text structure. Grammatical structure can help in comprehending text materials. However, non-English speaking learners usually have problems interpreting pronouns, articles, and conjunctions or logical connectives correctly. The solution to this problem is to provide sufficient practice (Nuttal, 1982; Palmberg, 1988). Computers can advantageously supply this guided practice which is necessary for skill development. From another approach, in order to develop predictive reading by consciously using knowledge about the structure of the text that is being read to guide comprehension, the learner control and guided practice are both considered very important, and computer is the ideal tool to serve this purpose (Higgins, 1984; Palmberg, 1988).

Because computers can be easily programmed to recognize and respond appropriately to true-false, multiple choice, matching drills, they serve as an effective tool to diagnose, prescribe, present tutorial instruction, and drill reinforcement, and furthermore, to monitor student achievement. However, as concerned by Balajthy (1987), computers can be used or misused. Instead of considering CAI as an "end", one should consider it more as a "tool". For more advanced learning in reading, one needs to develop higher level reading comprehension skills (Kleinmann, 1987). When the purpose of monitoring the subskills is achieved by using CAI materials, students need to move on toward more complex human activities to achieve the heart of language function, meaningful communication.

Learning of a language starts with learner's interest in relating learning materials to the everyday needs of communication. As pointed out by Palmberg (1988), the issue of language needs is of the special importance to learners when it comes to beginners. His concern is more on the content itself to achieve the motivation purpose. A simulation model in computerized foreign language is suggested by Wu (1984) as an approach to increase the reality of learning materials and encourage active involvement in reading for understanding. Since the materials presented satisfy the criterion of language needs, relevant to young learner's real life activities, they promote vocabulary learning. The notion is that comprehensible input of the instructional material that is interesting, relevant, and at an appropriate level of complexity is crucial to second language development (Krashen & Terrell, 1983).

Described by Kleinmann's study (1987), in the CAI approach of reading achievement, the CAI environment can facilitate an informal intake process and formal learning process. As an informal intake environment, the CAI instruction allows input of reading material to be matched with the particular level of students. The materials can be chosen in different levels according to the individual needs. As a formal learning environment, the CAI instruction provides the necessary interaction and feedback which is equivalent to the classroom learning environment. Whether providing a formal learning environment, or providing a informal learning environment, the attention of developing CAI should be paid to creating meaningful communicative interaction with learners. Moreover, how to facilitate the development of self-monitoring skills through the provision of learning strategies within the learning materials is also necessary to be considered.

**Grammar Software:**
Knowing grammar is a metacognitive skill that allows people to integrate new knowledge with the complicated nature of the language they have mastered. Learning grammar is to relate different linguistic rules, and apply in different categories of situation. From an historical perspective, computer assisted instruction began in the 1960's during the time when theories of structural linguistics were giving way to those of transformational grammar (Jamieson & Chapelle, 1984). As described,

CALL (computer assisted language learning) grammar lessons were developed to use computerized grammar drills and to give students out-of-class practice. The content of those grammar lessons often focused on more mechanical aspects of language. The exercises were mainly mechanical, and few were meaningful or communicative. The same situation is found in the current approach of grammar software. Most ESL software claims to teach grammar is of a traditional prescriptive nature and is often in a drill and practice format with inadequate ability to judge student's response. There is great concern about the poor quality software flooding the market(Dalgish, 1985a,1985b, 1987). Among the problems noted are: inappropriate lesson content, poor documentation, errors in format and content, improper feedback, etc. (Dalgish, 1987).

This traditional approach to language teaching has been criticized by recent supporters of a totally communicative approach to language teaching. The computer should be seen as a useful tool for language study by providing the students with practice in communicative aspect of a language. Ideally software should be designed with consideration of judging student's answer, and analyzing student's answer in order to provide relevant feedback to help them learn (Hart, 1981; Jamieson & Chapelle 1984). Instead of simply providing feedback of "right" or "wrong", an intelligent computer program should be able to identify student's misconception that led to the production of a wrong answer, or a wrong type of answer. If well designed, good quality drill and practice may have a place after all in a fully integrated curriculum, as long as the computer allows students to use them functionally.

From one approach, grammar software of drill and practice sets rules as an essential requisite to grammar learning. In another approach, structured grammar can be acquired from a descriptive perspective in order to motivate an appreciation of the rules of grammar through a understanding of them. Freyd (1988) suggested the use of the whole language approach through logo activities. Programing languages with natural language manipulation can formulate rules of grammar based on the student's own knowledge of English. The nature of natural language and lexical categories in particular can be generated by these programming activities.

**Computer in Writing**:

Writing can be considered as a sequence of processes, including brainstorming, production, and revising. By viewing writing as a process instead of focusing on the products, a lot of researches addressed the importance of the writing process and use this approach to apply computer assisted instruction in writing (Burns,1980; Daiute,1985; Selfe & Wahlstrom, 1982; Shostak,1984; Wresch, 1983). The stages involved in writing can be categorized into: prewriting, composing, rewriting and editing. At the prewriting stage, the process is usually focused on invention, encouraging learners to concentrate on the topic. When students are guided to concentrate on the flow of a narrative example, they are much easier to develop higher-level thinking strategies, which means it is more able for them to organized their thoughts in an elaborated way. In cognitive psychology's investigation of children's writing and reading, studies have shown that children, when faced with high-level cognitive tasks, tend to focus on lower-level processes such as decoding in reading, or spelling and handwriting in composition (Shostak, 1984). Several kinds of computer software can be used in the prewriting stage to free learners from attending to low level processes and focus on higher-level thinking process. StoryMaker (elementary level) is a typical example for this purpose. In addition, software like Wordsworth II (Selfe, 1984), and MaxThink (Hershey, 1985) are designed to guide students' thinking through of structured concepts. Although this type of software is mostly used with native English speaking students, it could be a potential approach for non-English speakers in teaching writing in ESL class.

**Word processors**

In the composing stage, computerized word processing can be considered as the most convenient tool in writing. The main advantage of using a word processor is that it makes the mechanical aspects of the drafting and revising process simpler to attend to. Because of this advantage, it has become an important writing aid for almost any field at any level. A good, simple powerful word-processing package can foster a sense of student control over the computer (Dalgish, 1987). As a productive tool, the word processor can produce professional-looking final manuscripts. With a word processor, users can learn to mold and shape their writing and catch ideas as they flow. Due to this reason, a lot of learners are motivated not only to write and to revise but also welcome others to read and talk about the writing. Also, when using a word processor to write, users are frequently more open to the idea of change (Herrmann, 1986, 1985). Students tend to be highly involved in written context and gain new sensitivity to the flexibility of language. They also appear more receptive to feedback concerning the need for revision and editing, and improve their overall writing and language ability.

However, learning word processing varies greatly among students. The main disadvantage of using a word processor as described by Canale & Barker (1986) is that the software provides no means for the users to keep a record of the writing process, since people engaged in writing are not only interested in the product but also the process to produce the work. The use of computers also requires extra demands on students' mental processing by disrupting their accustomed methods of composing. And it usually requires a lot of out-of-class time for learning the skills (Baxter, 1988). Very often, learning how to do word processing is a frustrating experience, even through the program is supposedly easy to learn. Some students deal much less well with frustration than the others. Nevertheless, students try their best to learn, because they believe it can make their future lives better. With the anxiety to the computer among learners, it can motivate learners to learn better. Students learning word processing usually must balance a multitude of interrelated and self-motivated mental and physical activities. When the intent is to help users to quickly adapt the computer as their writing tool, the control issues of word processing softwares need to be carefully considered in its development and design.

**Database**

Although the use of databases is largely overlooked in ESL classes, databases are considered as a very convenient tool for more advanced ESL writers. Database management packages encourage learners and teachers to gather, organize, modify and use information about language. Most of the interest in database software is their potential as a personal learning resource. However, these packages can be used for administrative purposes as well. As described by Dalgish (1987, 1985c), it can help writers to maintain a personal writing inventory of current errors, difficult works and idiomatic phrases. It also can be used by the instructor to classify and determine common errors cross-linguistically as a way to correct different types of grammar errors in different non-English speakers' writing. By focusing on specific error types, and specific forms of errors within particular types, this approach can help users to gain control over their errors and focus on their problems in English grammar when learning English writing.

**Artificial intelligence**

Artificial intelligence (AI) can be used to help students diagnose and proofread composition exercises. Some AI programs can understand English fairly well when it is related to a specific, or limited domain, and they are relatively intelligent about the meaning of one particular paragraph or series of paragraph. Therefore, they are capable of helping students to proofread or make decisions about grammar, clarify meaning or help students to evaluate their own writing in a simulated human fashion (Parkhurst, 1984). ILIAD is one of the earliest examples of an AI system in language (Wilson, 1986). It can use its language generation capability to create both grammatical sentences and ungrammatical sentences with errors typically produced by language learners. With inclusion of a semantic component the program also can help to ensure that the sentences are reasonable and coherent. The AI approach to computer assisted instruction can be considered as potentially valuable way in language learning. Because of computers' capabilities of responding meaningfully to a wide variety of correct and incorrect answers, and their abilities of gaining use of information from users and making their own analysis of input, a meaningful communicative purpose between instruction and learners can be effectively achieved.

**Other use of CAI in ESL writing**

Other uses of CAI like dialogue journals, such as Dialog Maker, Computer Chronicles Newswire, and InterLearn, are interactive word processing software, which connect the word processing with writing tools locally, nation-wide, or even around the world (Sayers, 1986). These kinds of software, that provide written conversation on a daily or weekly basis, can help ESL students learn to read and write by bridging from communicative abilities to literacy skills. At the same time, through actual interaction with people, the computer can help bring people closer together without regards of time and space.

In many non-instructional settings, E-mail is a major use of the computer. As shown in Murray's study (1987), the use of computer-mediated communication within IBM, 86% of users spend more than 10% of their working week using the computer as a tool for communication while 28% spend more than 30% of their time on computer-mediated communication. This computer-mediated communication can also be applied in teaching ESL instruction to provide collaborative learning experiences that foster language development. The use of electronic mail provides three important factors necessary in communication: speed, low cost, and ease of storage for future reference, modification, or printing (Lunde, 1990). For any language learning, E-mail can significantly improve student's reading and composition skills in the target language. As an instructional tool and a communication tool as well, it can benefit ESL students by providing motivation to learn and allow students to communicate freely.

**Listening and Speaking**:
The integration of sound into computers can be considered as the most frequently inquired in listening lessons and has great potential in language learning. Advances in voice synthesis and voice recognition can make a valuable contribution in teaching speaking and listening comprehension, although their application is currently still limited. Many of the physically handicapped have already found important uses of voice recognition and voice synthesis for bypassing the need for keyboarding skills (Balajthy, 1987). Young ESL learners without learning keystrokes or not skilled in recognizing characters can also be benefit from this approach.

**Interactive technology**
Another CAI application in teaching listening and speaking is through the integration of computer and audio visual technology. There is a increasing interest in combining the use of audio cassette, video cassette, videodisk, and the digital voice synthesizer for the provision of speech, or both speech and visual presentation (Marty, 1981; Rogers, 1980; Schneider & Bennion, 1983; Sutherland, 1987). It is suggested by most language experts that only through real-life interactions in the target language can learners develop true communicative competence (Peppard, 1989). It is necessary to provide learners with context and control, and put learners in a real situation to let them interact and experience a different world. By this approach, the learners will be able to response and get feedback with their own learning pace and control. Moreover, learners might even more freely communicate because with this kind of interaction, learners are free from fear of ridicule, being rewarded for the content of what they say, rather than having teacher's recoil at their errors. Schulz and Bartz (1975) cited three conditions necessary for development of communicative competence: (1) meaningful life situations to practice the language; (2) the motivation to express; and (3) freedom to use and create linguistically. Interactive technology can provide those necessary condition for language skill development.

**Summary**
In ESL, computers can be applied in a variety of ways to facilitate the learning of language. The role that the computer is playing in ESL learning can be as a tutor, a tutee, an editor, an adviser, an idea generator, a partner, an expert, a facilitator, and an authentic communicator. As a tutor, various kinds of tutorial programs provide different level of grammatical and linguistic knowledge, different content information, reading and writing guidance, and information about the uses of strategies in language learning. As a tutee, some programming language allow students to use their knowledge of language to communicate with the computer. As an editor, the word processor is a convenient tool for writers to edit their writing materials, and revise their text with less effort and less time. The role of the computer as an advisor is best described in database programs and intelligent computer assisted instruction (ICAI), which present learning experiences from user's own database or from the system itself, to provide information or suggestions, and encourage expression along directed channels. As an idea generator, the prewriting software plays an important role in guiding student's thinking, and helping learners to generate idea in writing. In most word processing programs, intelligent systems, or some simulation programs, the computer can be considered as working partners to work with students and help students to solve given problems. In the intelligent tutoring system, the computer is an expert in certain subject area and it communicates with learners in a humanistic way. Due to the individualization and interaction characteristics provided by computer, in some ways, the students interest in learning are motivated, which is the key element of the success in language learning. Interactive technology provides another new dimension of language learning with provision of audio and visual, and the interactive characteristics, students are learning in a realistic environment and can communicate with the instruction in an authentic and meaningful way.

Although the computer has been applied in a variety of areas in ESL learning, the computer assisted instruction software is mainly used as remedial or supplementary materials. Computerized language learning has not yet reached its optimal application. Applying technology usually requires long-term planning to integrate CAI into school curriculum and existing delivery system/environment. More concern need to be focused on the structured differences among different countries and areas.

Use and design of CAI materials should take into account the whole array of language learning in creating an authentic environment in reading, writing, listening, and speaking. New possible exploration should be opened up on various aspects, such as issue of control, motivation design, the creation of real communicating opportunities, and the consideration of use in classroom activities as well as in individual learning. It is also important to know that language program is not designed or implemented just to show that the technology can be used in this discipline. More understanding about the relationship between technology and language or language learning is necessary to determine what technology can be integrated into this area, and optimize its application.

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# MAGNETO-OPTIICAL DISK AS A CD-ROM DEVELOPMENT TOOL

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**Abstract**
As computer-based training (CBT) becomes more sophisticated, the development of the programs become more complex. Today's CBT are large multi-media systems which incorporate computer-generated graphics and digital audio as well as text. The numerous computer-generated graphics, large audio files, and complex hyper-text structures place a great demand on the computer system's binary storage capacity (disk space). This makes a compact disk read-only memory (CD-ROM) a viable delivery system.

Because CD-ROM is a read-only system, the development and delivery systems must be different. There are several alternatives for the development system, including a very large hard-disk and a magneto-optical disk drive. Recently a CBT package for radiation protection workers (RPT's) that was developed at Los Alamos National Laboratory (LANL) was delivered on CD-ROM. A magneto-optical drive was used for the development system.

**Introduction**
Computer-based training (CBT) programs are becoming more sophisticated. They are no longer electronic papers, but are large multi-media systems which incorporate computer-generated graphics and digital audio as well as text. The numerous computer-generated graphics, large audio files, and complex hyper-text structures place a great demand on the computer system's binary storage capacity (disk space). If the use of interactive video is prohibitive because of cost or other restraints, a compact disk read-only memory (CD-ROM) delivery system is a viable delivery system.

Because CD-ROM is a read-only system, the development and delivery systems must be different. There are several alternatives for the development system, including a very large hard-disk and a magneto-optical disk drive. Recently a CBT package for radiation protection workers (RPT's) that was developed at Los Alamos National Laboratory (LANL) was delivered on CD-ROM. A magneto-optical drive was used for the development system.

This paper will discuss some reasons for selecting a CD-ROM delivery system and the use of magneto-optical disk drive as the development system.

**CD-ROM For Delivery of CBT**
While the laser videodisc is usually thought of as the vehicle for interactive multimedia, the CD-ROM is quickly beginning to be an option for multimedia delivery (Salpeter, 1991). While compact disk technology is probably best known for its impact on the music world, the same technology has been used to store information for computer programs since 1984 (Salpeter, 1991). There are many reasons why the CD-ROM should be considered as a delivery system for CBT. It has the advantage of a digital information storage which allows the easy transfer of data from one computer to another via a network or a modem. Furthermore, with a storage capacity of approximately 600 megabytes, it is equivalent to over 1,500 floppies (Bitter, 1988). The large storage capability of the CD-ROM makes it an ideal storage device for large reference files such as training manuals, glossaries, encyclopedias, etc., computer-generated graphics, and digital audio. The large capacity frees the instructional designer to be more creative in the use of varied instructional strategies and materials. The CD-ROM development is no more difficult than the development of any other CBT program and is priced to make more complex learning environments affordable.

**Selection of a CD-ROM Delivery System**
In the last five years the cost of a CD-ROM delivery system has substantially decreased, so that it is now within the reach of most training organizations. There are several considerations when estimating the cost of the delivery system. The selection of the delivery platform should be based on cost, availability, and performance considerations. A bare-bones 80386 PC system, which costs less than $1,200, was determined to be the appropriate platform for the RPT-Trainer. To allow the program to run as smoothly as possible, it is important to allow the CD-ROM to transfer data at its maximum capacity. The faster the data can be transferred from the MS-DOS buffers to the memory, the faster the data can be transferred

from the CD-ROM. When a machine less capable than the 80386 was used, the graphics and screen changes were jerky and disconnected.

At this time full motion video is not available on the CD-ROM; therefore, if the CBT is not a text only package, it is important to have the best color graphics display. With the cost/performance ratio between Video Graphics Array (VGA) and older color standards comparable, the use of VGA, which allows the use of both graphics and scanned images, is recommended.

To take advantage of the digital storage ability of the CD-ROM, digital audio should be used. A digital audio system includes the cost of the audio board and the speakers. The audio board which we used was about $400. Other boards and playback systems are advertised for less. Thus, the cost of digital audio boards is decreasing.

The selection of a CD-ROM player is dependent upon the system used. At this time, Apple, Commodore, and IBM have different platform standards. If the delivery system is IBM compatible based, the CD-ROM player selected should conform to the ISO 9960 standard which was adopted by the International Standards Organization (ISO) to define a CD-ROM directory structure. The actual cost of the player is between $400 and $800. Thus, if the CD-ROM player is added to the basic delivery system of a 80386 PC with a VGA monitor, mouse and audio board, the total cost ranges from $3,000 to $4,000. The addition of a CD-ROM player has minimal impact on the delivery cost.

**Selection of a CD-ROM Development System**

Of course, the selection of a development system depends on the delivery system selected. The development system specifications are those of the delivery system with the addition of a read/write medium. Because the development of a training package is often an iterative process incorporating many changes, the development system needs to easily accommodate the changes. Because CD-ROM is a read-only device, multiple masterings during CBT development would be prohibitively expensive (approximately $1,500 a master). Therefore, hardware with read/write capabilities which mimic the CD-ROM is required. There are several different types of hardware devices available, including removable hard disk, fixed hard disk and magneto-optical removal disk. Listed below is the cost per megabyte (Dataware, Inc., 1989):

| | |
|---|---|
| removable hard disk | $15 |
| fixed hard disk | $10 |
| magneto-optical removal disk | $10 |

Since the costs are virtually the same, the decision must be based on other considerations. The performance of the development system should mimic the performance of the delivery system as closely as possible.

**Performance Considerations**

When selecting a development system for CBT for CD-ROM delivery, the performance of the CD-ROM needs to be considered. The slower access time and the larger capacity are the two conditions which are unique for the CD-ROM.

**Slow Access Time**

The performance characteristics of the training package are defined in terms of the CD-ROM drive performance and the operational characteristics of the software driver interfacing to the CD-ROM drive.

The CD-ROM drive performance characteristics include the data transfer rates and access time. The data transfer rates of the CD-ROM are 150 KB/s sustained and 600 KB/s burst. Access time is 0.8 seconds for a full stroke seek. Seek time is the amount of time necessary to move the mirror of the laser beam to the correct position on the CD-ROM. An average stroke is one-third of a full stroke, thus requiring 0.5 seconds. The typical rotational speeds of CD-ROM are 530 rpm at the innermost track with a constant linear velocity of 1.4 m/s and 200 rpm at the outmost track with a constant linear velocity of 1.2 m/s (Sony Corporation, 1988).

In comparison, a typical hard disk has an access time of about 0.015 seconds, with a maximum track-to-track access time of 0.004 seconds. The data transfer rate from the buffers is up to 6 MB/s (Electronic Engineering Times, 1990). These rates are considerably faster than the CD-ROM. Thus, the hard disk is not a good simulator of the completed CD-ROM product.

With an average seek time of 0.0667 seconds (Relax Technology, 1988), the performance of a magneto-optical disk is closer to that of the CD-ROM than is the hard disk. The data transfer rate (about 690 KB/s) of the magneto-optical disk is faster than the CD-ROM.

**Other Considerations**
In addition to the performance of the hard disk and the magneto-optical disk, there are other considerations when selecting a CD-ROM simulator. The capacity of the magneto-optical disk is comparable to the CD-ROM. The magneto-optical disk has two sides; each side has half the capacity of the CD-ROM. Hard discs of comparable capacity are available for about $3,000.

Another important consideration is the media which is sent to the CD-ROM mastering company. The CD-ROM mastering company requires the input media to be a tape cartridge, a magneto-optical disk, a Macintosh compatible hard disk, or a CD-ROM. If a hard disk is used, the data would have to be transferred to magnetic tape before mastering a CD-ROM. This step incurs an added expense for the magnetic tape equipment. If a removable magneto-optical disk is used, the cartridge can be sent to the mastering company, eliminating transferring the system to magnetic tape. As a point of comparison, when we compared the cost of the magneto-optical disk with the cost of magnetic tape equipment, the cost was $5,000 versus $30,000. At $5,000 for the magneto-optical disk system, the simulation CD-ROM delivery is affordable.

**Limitations of the Magneto-optical Disk**
We used a magneto-optical disk drive to simulate the CD-ROM. While in many ways the magneto-optical disk drive was an excellent mimic of the CD-ROM, it did have some limitations. The primary limitation was the number of allowable DOS buffers. The magneto-optical disk drive increases the size of each buffer from 512 bytes to 8192 bytes. If the program requires a large number of buffers, there may not be enough memory left to load and execute the program. The RPT-Trainer did not require many buffers; we therefore, reduced the number of buffers in the config.sys file to five.

Another limitation is the inability to use drive assignment statements. The CD-ROM driver does not allow the use of the DOS "subst" and "assign" commands. Therefore, it is necessary to use the magneto-optical disk drive in a single partition mode. Another constraint is, of course, the magneto-optical disk drive must have the same drive letter as the CD-ROM in the delivery system.

**Conclusion**
The CD-ROM is a viable alternative for multimedia CBT delivery. Its large capacity allows the user to incorporate scanned images, large computer-generated graphics, and digital audio in a large CBT program. However, because it is a read-only device, there must be a separate delivery and development system. To allow testing, the development system must emulate the CD-ROM as closely as possible and yet be easy to use. The hard disk simulation of the CD-ROM is not recommended for two reasons. First, the performance characteristics of the hard disk and the CD-ROM are significantly different. The CD-ROM is much slower than the hard disk. This makes the package during development appear very different than the delivery package. Second, the data must be transferred to a tape cartridge before mastering. Because the magneto-optical disk drive and the CD-ROM have similar performance characteristics and storage capacity, the magneto-optical disk a good simulator of the CD-ROM. Furthermore, a tape does not have to be produced before the mastering of the CD-ROM.

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# COGNITIVE OUTCOMES OF BUILDING EXPERT SYSTEMS

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**Abstract**
Researchers and businesses are investigating the effects of having students and employees construct expert system rule bases. What is important are the cognitive effects of the construction process more than the resulting advisors. Expert systems can be thought of as cognitive tools engaging learners in cognitive and metacognitive learning outcomes. This project proposes to investigate the changes in critical thinking skills, cognitive learning strategies, and metacognitive skills that result from employees and students constructing rule bases. Changes in individuals' knowledge structures will also be investigated.

**Background**
Building expert system knowledge bases is a generative and constructivistic process that facilitates the acquisition of conceptual as well as procedural knowledge. The deeper understanding of the subject matter that results from the process represents a cognitive learning strategy. Cognitive learning strategies necessarily engage learners in higher order thinking. Just how high is the order of thinking that results from building knowledge bases? How do learners or employees intellectually benefit from assuming the role of knowledge engineer -- builders of expert system knowledge bases? Trollip and his colleagues (in press) believe that the development of expert systems results in deeper understanding because they provide an intellectual environment that 1) demands the refinement of domain knowledge, 2) supports problem solving, and 3) monitors the acquisition of knowledge. Several constructs from learning psychology support their belief. 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, Jost, Kenny & 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).

Clearly, building expert systems requires learners to synthesize knowledge by making explicit their own knowledge structures or the knowledge structures of experts. The improvement of retention, transfer and problem solving ability that results has been verified anecdotally by Trollip and others. This project seeks to provide empirical support for the hypothesis that building expert systems engages and improves cognitive and metacognitive processing.

This project seeks to analyze the information processing requirements of building expert system rule bases. An analysis of information processing requirements (Jonassen and Grabinger, in press) showed that building expert systems engages individuals in a variety of higher order thinking processing, including a number of cognitive learning strategies (see Table 1).

This study proposes to collect evidence of cognitive and metacognitive changes in individuals as a result of building expert system rule bases that reflect personal knowledge of content and/or processes. Changes in critical thinking, cognitive controls, and cognitive structure of students and employees engaged in building expert systems will be assessed.

Companies such as DuPont are training employees how to build rule bases that describe the decision making in their operations. They are finding that by providing operating departments with small rule- based shells, they are engaging employees in a very deep analysis of their operations. They are finding that the resulting rule bases are of marginal utility

Table 1

Levels of Processing in Building Expert Systems

| Step | Gagne | Bloom | Tessmer& Jonassen | Brezin |
|---|---|---|---|---|
| 1. Identifying problem | Higher rule | Analysis<br>Evaluation | | Testing<br>Judging |
| 2. Limiting problem | Concepts<br>Rules | Analysis | Organizing | Elaborating<br>Revising<br>Testing |
| 3. Specifying solutions | Rule<br>Higher rule | Analysis<br>(Synthesis)<br>(Evaluation) | (Elaboration) | Revising<br>Testing |
| 4. Specifying attributes | Concepts<br>Rules | Analysis<br>(Evaluation) | Organizing | Elaborating<br>Relating<br>Revising |
| 5. Solution matrix | (Concepts)<br>Rules | Synthesis | Elaboration | Revising |
| 6. Generating rules | Rule<br>Higher rule | Synthesis | Elaboration<br>Sequencing | Revising<br>Testing |

Note: Parentheses indicate a limited role.

(perhaps as a job aid for new employees), but the effects of the analysis of their operations necessary for representing them in a rule base are quite often dramatic. Improved efficiency and effectiveness often results from this analysis process. So, in addition to functioning as a cognitive tool, rule-based expert systems may also function as a systems analysis tool.

**Approach**

The first step will be to identify measures of thinking and systems outcomes. A review of the literature to identify tools or techniques that evaluate the effects of systems analysis will be conducted. A review of measures of higher order thinking will also be conducted.

University students from the University of Colorado and employees at Coors will be pretested with measures of critical thinking skills, metacognitive skills, cognitive controls, and cognitive structure. Critical thinking skills will be assessed by the use of tests such as the Watson-Glaser Test of Critical Thinking, Cognitive controls, such as Cognitive Complexity/Simplicity, Field Independence/ Dependence, and Necessary Arithmetic Operations. Effects on knowledge structures will be established by pre- and post-test comparisons of semantic nets of subjects, generated by Learning Tool. will also be assessed. Cognitive structures of each participant will be assessed using a cognitive mapping technique and backed up with word associations, the benchmark technique for assessing cognitive structure. The purpose of this measure is to assess the effects of the knowledge engineering process on knowledge structures.The first is a public domain shell developed by Tony Starfield at the University of Minnesota. It is simple to use and can be trained readily. More advanced development will depend upon a more sophisticated shell, probably VP Expert.

**Procedure**

The instruction and construction of rule bases will be accomplished on MS-DOS machines. Laboratories at the University of Colorado will be used for this purpose. Coors has agreed to participate by allowing their employees to construct knowledge bases.

Following pretesting, students and employees will be trained in the university or at their place of work in using simple, MS-DOS expert system shells. Some of these are public domain, while others are quite inexpensive. Students will be required to develop content-oriented rule bases while employees will be requested to simulate the operations or decision making in their organization in the knowledge bases. Each of the knowledge bases will be validated, using subjects from the target audience.

After producing one to three knowledge bases, learners and employees will be posttested with the above instruments. Evaluations of the systems in the company using the instruments or techniques identified in the first part of the study.

**Potential for Broad-based Technology Transfer**

Expert systems represent a useful cognitive tool and systems analysis tool, a computer-based tool that engages and supports generalizable cognitive processing (Kommers, Jonassen & Mayes, in press). As a generalizable tool, expert system construction can be used as an instructional activity in virtually every content domain and in most every operation in any business. Although corporations do not focus on intellectual self-aggrandizement, the effects of an enlightened work force cannot be underestimated.

The benefits of knowledge engineering extend beyond the development of generalizable learning skills. Building expert systems can also function as a systems analysis tool.for evaluating operations. This project proposes to identify and evaluate those effects.

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# DESIGN, DEVELOPMENT AND TESTING OF A CONTEXTUALIZED COMPUTER ENVIRONMENT FOR SPANISH LANGUAGE ACQUISITION

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**Abstract**
Issues related to the design, development, and testing of a contextualized computer environment for Spanish language acquisition are discussed in relation to the role of computer in school settings and the need to embody cognitive learning theories in computer-based instructional systems.

Context is an important component of any learning activity. Research has shown that initial pattern recognition (see Anderson, 1985), subsequent retrieval from long-term memory (Tulving & Thompson, 1973), and comprehension (Carpenter & Daneman, 1981) are affected by context, and that problem solving is also dependent on the context of the situation (Maier & Janzen, 1968). These findings have added to the growing speculation that the context of learning and problem solving situations influences thought processes, and that instruction that is situated in meaningful settings is more effective (Brown, Collins, & Duguid, 1989; Greeno, 1989).

In the field of foreign language instruction, a related shift in theoretical orientation has recently taken place. Rather than memorizing dialogues and practicing pattern drills, foreign language educators now believe that successful acquisition of a second language results from experiences which support natural language learning strategies such as language play (Peck, 1980), semantic processing (Hatch, 1978), and delayed oral practice (Postovsky, 1977). Research suggests that such strategies are best implemented in learning environments that are rich in context (Wong-Fillmore, 1989).

Parallel to the development of new curricular and instructional approaches in foreign language education, computer technology has sufficiently advanced to a point where the design of effective contextualized computer environments (CCE) is possible. These environments utilize pictures, drawings, sound and text to illustrate key ideas, events, or stories which engage learners in listening for information and demonstrating understanding. In the following pages, we present the results of extensive design, development and testing activities related to a CCE for Spanish language acquisition with the hope that others interested in designing computer learning environments will benefit from our descriptions.

**Design Assumptions and Features**
The basic assumption made in the design of our CCE is that communicative competence in a second language is not learned, but acquired. While controversial, this distinction as proposed by Krashen (1982), is based on the notion that acquisition of language abilities involves subconscious processes associated with the language "mental organ" (Chomsky, 1965). Learning a second language, on the other hand, requires conscious processes related to rule learning and correction of language performance errors (Krashen, 1985). The processes of acquisition depend on "comprehensible input" as an essential environmental ingredient (Krashen, 1982). Messages containing language forms just beyond the student's present level of competence, when presented in a familiar context, provide sufficient amounts of comprehensible input to foster language acquisition. Such conditions are difficult to provide in a traditional classroom since, in most cases, the teacher is the only speaker of the target language. In such instances, researchers have recommended that a "language-rich environment" be provided in order to allow children to interact in a variety of contexts and functions (Wong-Fillmore, 1989).

A CCE may serve as a viable alternative to provide a language-rich environment for elementary school settings. Essential factors for second language acquisition, including one's knowledge of the linguistic code, knowledge of the world, and knowledge of discourse structure (Omaggio, 1986), can be easily activated by one resource (the computer). Contextualized exercises (Omaggio, 1986), which "anchor" instruction in meaningful situations (Bransford, Sherwood, & Hasselbring, in press) encourage students to attain goals by dealing with problems that require recognition of features in given problem situations. Natural learning strategies such as language play, use of formulaic expressions, and considerable amounts of listening to messages in the target language should be provided in a CCE in order to enhance the acquisition process. The problem we encountered during the design process, however, is that many of the procedures and techniques prescribed by traditional instructional design models are not applicable to the design of a CCE. This problem is mentioned here only in passing, since it is beyond the scope of this paper to address the deficiencies in current design models (See Nelson & Orey, 1991).

With "Salamanca", the CCE described below, we have attempted to incorporate several of the design features just mentioned. Our main goal is to provide an electronic setting for receiving comprehensible input in spoken and written forms through a simulated visit to the Spanish city Salamanca. During the visits, the user meets two Spanish children, and engages in a variety of activities that require listening to recordings of spoken Spanish, reading captions or instructions in the language, and responding or selecting within simulated precommunicative practice activities. In addition several instructional activities are implemented in the CCE, including cloze activities (sentence completion), precommunicative practice (authentic information about the culture derived from written and spoken communication), and contextualized practice (listening and demonstrating understanding).

The CCE opens with a "tour" of the city, which includes numerous opportunities for obtaining cultural information by clicking on objects within the city (buildings, bridges, a coat of arms, etc.). As the user continues on the tour, Paloma, the protagonist in the electronic environment is introduced, and presents a series of descriptions, in Spanish, that provide general information regarding the operation and content of the different areas of the software (See Figure 1). Paloma also introduces the user to several settings in Salamanca, including avenida Alemania, Anaya Palace, and Plaza Mayor. The plaza provides the setting for two activities, accompanying Paloma on a shopping errand, and ordering a snack at an outdoor cafe. In both activities, the students hear authentic dialogues designed to provide both comprehensible input and a series of formulaic expressions needed for communication in certain settings. The user also learns how to call Paloma on the phone and visits the schools, where a dictionary, maps, a grammar book and several instructional lessons can be accessed.

During the tour the user is also introduced to Manolo, Paloma's cousin, and is invited to his house. If the student chooses to visit Manolo, a sequence unfolds where the correct address must be found in a address book and the correct doorbell must be rung. Unfortunately, the user learns from Manolo's mother that he is at the park. If the user chooses to go there, the games "Hide and Seek" and "I spy" can be played (See Figure 2). Similar activities are provided if the user visits Paloma's apartment, where "Veo veo" (a guessing game) can be played, songs can be heard on the phonograph, or the learner can read Spanish comics.

After completing the initial "tour", the user is free to explore any component of the software. Both Paloma's and Manolo's apartments can be visited, or the user can call them on the phone (See Figure 3). A dictionary of Spanish words and a "repeat" feature for some of the recorded dialogue is available at any time. The user also has the opportunity to visit the school, where several authentic activities are provided, including a recorded and illustrated "lesson" describing wine making, a language arts lesson featuring sentence completion and letter writing tasks, and a "cultural safari" where users can respond to various situations requiring cultural knowledge (See Figure 4).

The design assumptions made and the subsequent solutions implemented reflect the current theoretical orientation of foreign language education and cognitive learning theories. The emphasis on exploration, the high degree of context, and the authentic dialogues and communicative practice all contribute to a learning environment that differs significantly from the traditional classroom. It remains to be seen whether these differences contribute positively to learning a foreign language. The requirements of the CCE design had an impact not only on the instructional design process described above, but also required different approaches to development and evaluation than are normally prescribed by instructional design models. Some of these variations are described in more detail in the following pages.


Figure 1. Paloma greets new visitors to Salamanco

**The Development Process**

Salamanca was developed by a three-person team over the course of three months using Hypercard on a Macintosh SE computer. The team was led by the designer who was a Spanish teacher, and who also produced line drawings used as graphics in the software. The second team member was a programmer who constructed the stacks and wrote the code necessary for the various components of the software. The third team member assisted with the programming, and was responsible for recording and installing the sound resources into the stacks.

A rapid-prototyping approach (Tripp & Bichelmeyer, 1990) was utilized throughout the project. A storyboard prepared by the designer guided the development process. Initial stacks were developed quickly as shells, and then modified when graphics and sounds were completed. Several development tools, including a scanner for creating graphic images, sound digitizing equipment and software (Farallon Computing, 1989), and a resource utility (Maller, 1988) helped to speed the development process. Original graphics created by the designer were scanned and imported into the stacks, and in some cases, enhanced with commercial "clip art" images. The software was also instrumented with data collection scripts so that individual users could be tracked. This data, including the sequence of cards visited and the amount of time spent on each card, was stored in a disk file after each session.

The recording of sounds for the stacks was completed in just a few hours, but several more hours were needed to edit the sounds (removing unwanted silence and smoothing distortion) and compact the sound files. In fact, the extensive size of sound resources (even when recorded at a "compressed" sampling rate of 4K) caused the greatest problems during development. The initial design specifications called for four stacks (the Tour, Paloma's house, Manolo's house, and the school), but ultimately the program had to be split into ten stacks that totaled 4539K of disk storage space because we wanted no individual stack to be larger than 800K. Nearly 3000K of this total was taken up by sound resources.

**Results of Testing**

The CCE was pilot tested with thirteen 5th and 6th grade students at a "magnet" school in a large midwestern city during the Fall of 1990. All students were familiar with computers, although not the Macintosh, because their regular classroom instruction incorporated some drill and practice software for grammar and vocabulary activities. Students worked in groups of three at the computers for 14 sessions over the course of two months. 5th graders spent 35 minutes working with the CCE at each session; 6th graders spent 45 minutes. The results reported below are part of a larger study which implemented a qualitative approach to data collection in order to ascertain the impact

Figure 2. Playing in the park with Manolo.

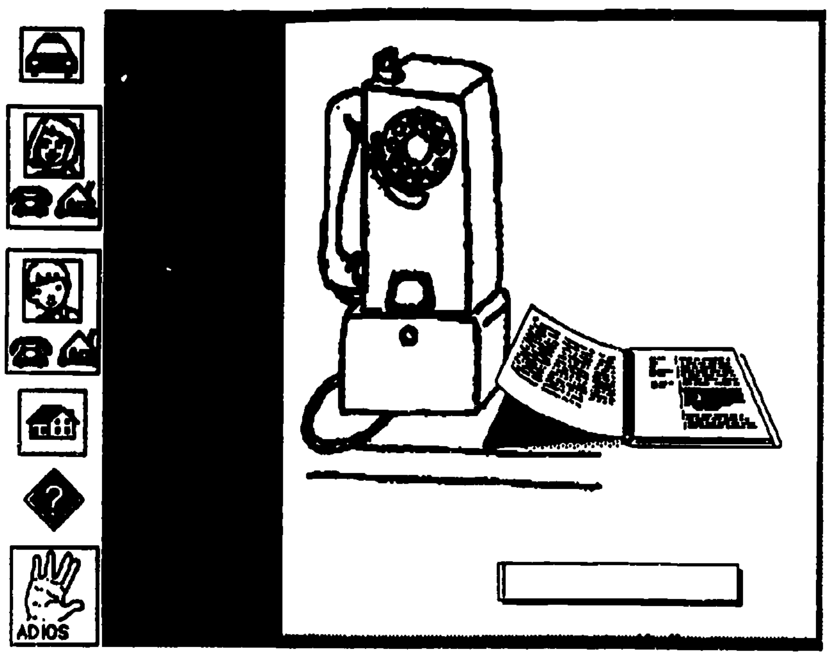


Figure 3. Phone Call to Paloma.

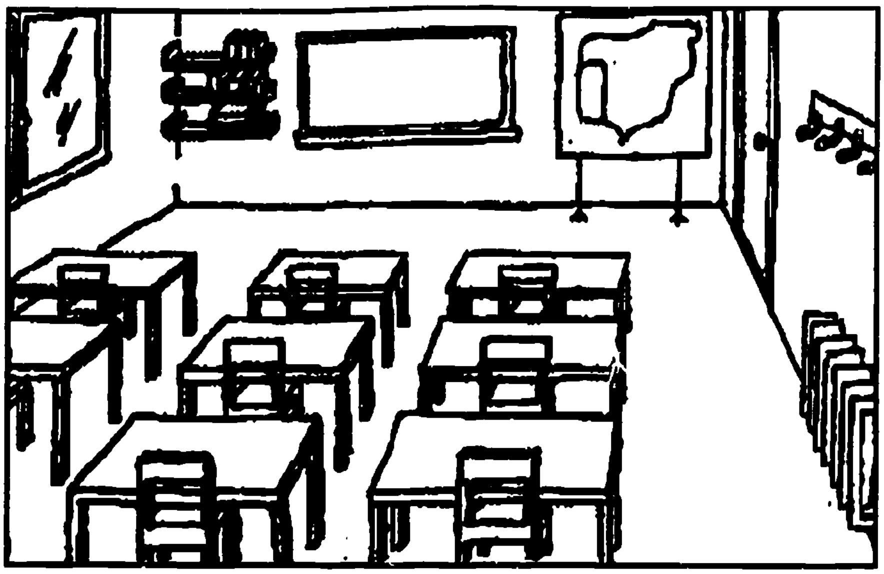

Figure 4. The schoolhouse.

of the CCE on the classroom setting. Ethnographic interviews, participant observation, oral proficiency interviews, writing samples, and data collected by the software during student interactions were used to describe details regarding student initiations and strategies in using the software.

Nature of interactions. In the computer sessions, several types of initiations made during peer interactions were observed classified and recorded. Table 1 provides a summary of the findings. The largest number of initiations (76%) were cooperative in nature. As the students became more familiar with the software and gained more experience working together in their groups, initiations seemed to include more cooperative overtures and greater direction in regard to the activity in which they were involved.

It was observed that computer-generated sequences involved several distinct interactions that occurred almost simultaneously. Instead of extended interactional sets, the computer-generated sequences often spawned multiple extended interactional sets. Responding successfully to the computer initiations required a cooperative effort. Even when the students established their roles within their groups and exerted a cooperative effort, multiple interactions continued. In addition, responding appropriately depended on the ability to make sense of the computer initiations.

A number of student explorations during the sessions with "Salamanca" revealed the nature of learner strategies used to regulate learning with the CCE. In the tour, the students were introduced to the notion of exploring the environment by clicking on objects. The first card in the stack exhorted the students to explore, and a few students found the hidden fields describing (in Spanish) the objects in the environment. Most students closed the fields without reading them; two students scanned the first field for familiar words before closing the field. Several student interactions were negotiations about what object should be clicked. All of the students seemed to be intrigued by the ability to initiate change among the objects on the screen. Sometimes these changes imitated communicative changes. For example, the icon labeled "Adios" was used by students to exit the program. Several students were observed saying "goodbye" when they clicked the icon.

Many other examples of playful interactions were noted. Students were intrigued by the visual effects used for card transitions, and the data files indicated that the students often moved quickly through certain card sequences in order to see the visual effects. In particular, one sequence was designed to be an animation that accompanied a song on cassette tape. Several students initiated this sequence without the tape; one student was observed completing the sequence while humming the song. During one observation the researcher watched a group of students click on the words in the dictionary several times in succession. They laughed and looked at one another before repeating the action again. They appeared to be creating an echo effect. On another occasion, the sixth grade group rang all of the doorbells at Manolo's apartment building. They rang some of the doorbells more than once. In general, the students were attracted by the computer's flash, but they also were drawn to substantive exchanges with the software. In exploring the CCE, the students sought to manipulate the environment to create communicative exchanges.

In exploring the target language messages in the environment, the students appeared to develop some resourcing strategies. Observations and data from the computer files noted many uses of the dictionary. They would often interrupt an activity in order to explore the dictionary before returning to the activity. In fact, the students' use of resourcing alerted the researchers to items that needed to be added to the dictionary. Other student explorations revealed the need for a "repeat dialogue" button on many cards. In the initial design, many of the recorded messages were played when the card was opened. Since many students were observed flipping between cards to repeat the messages, the "repeat dialogue" buttons were added.

Constructing lessons with "Salamanca". The nature of the lessons that were constructed by the students through their interactions with "Salamanca" were reflected by the information collected in the data files. Table 2 summarizes the recorded student-directed interactions with "Salamanca" that occurred during the sessions.

Several types of exploration were documented. For example, during one session the sixth grade students flipped through several pages of a story, pausing on cards where there were pictures. They also flipped forward and backward through the story sequence, never staying on any card more than two seconds. During another session, students spent over two minutes looking at a language arts writing assignment, but they did not write anything.

Subsequent opportunities to explore and direct their own interactions with the software revealed some patterns in student constructed lessons with "Salamanca" First, students continued to seek opportunities to listen to recorded Spanish. Although the students had written down the characters' phone numbers and addresses, they continued to try to follow the tour sequence by listening and accessing the information that they needed from the oral and written messages in the software. Some of the lessons constructed by the students seemed to be used to attain the student agenda of "thinking and remembering". For example, on several occasions the students selected to participate in the lesson on wild animals in Spain. In early interactions, they appeared to just be browsing, but during subsequent interactions, the students began to respond to the lesson activities. These interactions seemed to provide the students with opportunities to recognize and remember familiar vocabulary.

The students engaged in practice activities which differed from the formal practice required of them in the traditional classroom. According to the students interviewed, this practice entailed: "getting the general idea of what you need to do", "getting the clues for the entry words...to get in the passageways", "getting where you want and finding what you want to find", "answering in Spanish", and "grasping a little more Spanish because you're actually seeing it and seeing how it applies." The students practiced making sense of the simulated target culture environment by creating conditions for their learning.

The students also sought opportunities to respond in the target language. Students generally responded and initiated by using familiar set phrases. For example, the fourth card of the tour contains the picture of a girl and a recorded message says: "Hi friends. Welcome to Salamanca." A student was observed saying "Hi! How are you?" in response to this recorded message. In addition, the students' experiences with "Salamanca" seemed to broaden their concept of second language learning. The following excerpt sums up how listening to recorded Spanish took on new values:

Researcher: How would you describe the talking on "Salamanca"?

Christina: Because they have questions like...something like <what a pity> or something. They wouldn't say that on the "Spanish Bullfight" They would just command you to do what to do. Like type this answer, do this, do that. It's not like that with "Salamanca". "Salamanca" is...it's more just to get the general idea of what you need to do.

| TYPE | COUNT | EXAMPLE |
|---|---|---|
| **Cooperative** | | |
| Peer Assist | 10 | Ana looks down at the keyboard. Christina points to the return key. Ana nods her head up and down. "Favor...spell it like 'favor'. F-A-V-O-R." |
| Navigating | 4 | "Where do you want to go?" "What should we click on?" |
| Peer Evaluating | 12 | "You forgot 'favor'". "Yeah, 'marca' that means to call." |
| Request Info. from Peer | 5 | "What do we put?" "What's that?" |
| Directing | 17 | "Go to 'Cuenta', or whatever you call it." |
| Strategy | 10 | "Put a comma. You know, like when you write your last name first." |
| Request a turn | 3 | "Let me..." |
| Share | 3 | "Do you want to go first?" |
| **Competitive** | | |
| Compete | 3 | Oscar clicks on the window of a house instead of following the suggestions of his peers. |
| Usurp | 2 | Concha reaches across the keyboard while Jose is typing and hits the delete key several times. |
| Squatter's Rights | 1 | The first students to enter the laboratory scramble for the chairs around the computer. |
| Policing | 1 | "Do you want to control the mouse?" |
| Directing | 2 | "Go...Go forward." |
| Peer Evaluating | 4 | "Don't do that." |

Table 1. Number and types of initiations among peers while using "Salamanca".

| Session | Stacks Accessed | Total Cards | Average Secs. per Card | Type of Exploration |
|---|---|---|---|---|
| 1a | Tour<br>Paloma-House<br>Cuento<br>Manolo-House<br>Manolo-Phone<br>Paloma-Phone<br>Dictionary<br>Lessons | 183 | 11 | browsing (games, lessons)<br>flipping through (story)<br>input (pastry shop)<br>precommunicative practice (phone-house)<br>truncated interactions (game)<br>play (doorbells)<br>navigating (story) |
| 1b | Tour<br>Paloma-House<br>Dictionary<br>Manolo-House<br>Manolo-Phone<br>Paloma-Phone | 89 | 19 | resourcing (dictionary)<br>flipping through (comics)<br>precommunicative practice (phone-house) |
| 2a | Tour<br>Manolo-House<br>Paloma-House<br>Dictionary<br>Verbos<br>Manolo-Phone<br>Lessons | 106 | 18 | input (tour)<br>navigating (external)<br>resourcing (repeat dialogue)<br>browsing (lessons)<br>participating (lessons)<br>play (doorbells)<br>dueling (options) |
| 3a | Tour<br>Paloma-House<br>Dictionary<br>Lessons | 93 | 19 | researcher directed activity (song)<br>browsing |
| 3b | Manolo-House<br>Dictionary<br>Manolo-Phone<br>Verbos<br>Lessons<br>Safari | 188 | 11 | following other group's activity with researcher<br>flipping (story, comics)<br>context (story) |
| 4a | Paloma-Phone<br>Dictionary<br>Manolo-House<br>Manolo-Phone | 99 | 21 | input (pastry shop)<br>resourcing (dictionary)<br>context (comics)<br>precommunicative (house-phone)<br>flipping (comics) |
| 4b | Paloma-Phone<br>Tour<br>Dictionary<br>Manolo-House | 66 | 31 | navigating (external)<br>resourcing (dictionary)<br>input (pastry shop)<br>reading (comics) |

Table 2, continued

| | | | | |
|---|---|---|---|---|
| 5a | Manolo-House<br>Dictionary<br>Manolo-Phone | 105 | 15 | play (doorbells)<br>dueling (options)<br>flipping (comics) |
| 5b | Paloma-Phone<br>Manolo-House<br>Manolo-Phone<br>Verbos<br>Dictionary<br>Tour<br>Lessons | 146 | 12 | browsing (dictionary/lessons)<br>navigating (school)<br>flipping (verbs) |
| 6a | Cuento<br>Paloma-House<br>Dictionary<br>Tour | 148 | 13 | flipping (story)<br>resourcing (story) |
| 6b | Cuento<br>Paloma-House<br>Dictionary<br>Lessons<br>Verbos<br>Safari | 263 | 6 | flipping (story)<br>navigating (icons)<br>resourcing (story)<br>play/duel (school) |

Table 2. Student-directed explorations of "Salamanca".

**Conclusions**

In designing Salamanca, we attempted to address learning problems related to the classroom environment and the use of the target language in that environment. The activities implemented in the software were derived from communicative contexts and natural language learning strategies. During development and testing, we have sought insights regarding the potential use of a CCE as a resource for obtaining comprehensible input and for practicing learning strategies that may facilitate the development of language proficiency in the Spanish classroom settings of our schools. Preliminary results are encouraging and have identified several issues for further investigation.

Whether exploratory environments like "Salamanca" should be structured to provide exposure to concepts appropriate to the intellectual development of learners or whether they should present simulated environments where students can expand their grasp of the task of learning a second language merits further research. It appears, however, that contextualized computer environments have value for learners as resources for accessing target language meaning. In addition, "Salamanca" appeared to expand the learners' concept of learning Spanish. Finally, the students' interactions with "Salamanca" seemed to encourage participatory and cooperative learning behaviors.

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Table 1. Number and types of initiations among peers while using "Salamanca".

# THE COACHING NETWORK: A MODEL FOR CONDUCTING AND MANAGING LEARNING

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**ABSTRACT**
The Coaching Network is a mechanism for continually instructing and providing feedback to the learner during and after formal instruction. Six conditions necessary for the implementation of a Coaching Network are discussed. Use of the Coaching Network leads to improved performance, independent learning, improved skill/knowledge, and goal/objective setting.

**OBJECTIVES**
Two objectives have been developed to drive and evaluate this paper.
- the reader will be able to state the goal and definition of the Coaching Network and
- the reader will be able to describe the process, model, and results of the Coaching Network as it applies to industry and academic settings.

**INTRODUCTION**
An instructor's goal is to improve the performance of the students. That performance may be the ability to efficiently complete a task or the ability to seek out a solution to a problem. Unfortunately, instruction occurs with no guarantee that the students will actually use what was learned. Therefore, additional methods must be utilized to ensure continual learning transfer. The Coaching Network has been developed from the analysis of athletic coaching strategies, instructional strategies and management techniques and is utilized to provide continual instruction and feedback to the learner.

**DEFINITION OF COACHING**
We define coaching as an individual/small group process of interaction among coach and team members with the expected outcome of independent performance (Rudd & Smith, 1990). This does not mean that team members are expected just to work alone. Instead, the goal is for the team to be able to function individually and together in a self-directed manner, with or without explicit instruction from a supervisor (or coach). Looking at this idea in terms of a race, it is the team member who must accomplish the race goals, not the coach. But without the coach and other team members, the person running the race cannot achieve the goals. It is the same in any environment.

**THE COACHING NETWORK**
The Coaching Network involves seven steps; listed below:
1. Identify institutional philosophy,
2. Determine personal philosophy,
3. Create positive environment,
4. Develop team goals and objectives,
5. Develop personal goals and objectives related to team goals and objectives,
6. Orchestrate individual and small group assignments related to tasks of the group and
7. Evaluation of coaching process and progress toward all goals.

In identifying the **institutional philosophy**, the coach must determine the institutional goals and attitudes toward goal attainment and employees. The institutional attitudes will have a constraining effect on implementation options for coaching and team building. This means that the coach (manager) and team members must have a philosophy that is compatible with that of the company in order to be an effective team and to avoid unnecessary conflicts with management. Identification of the institutional philosophy is accomplished through a combination of talking with superiors and examining existing documents (such as annual reports, memos and other internal communications). Consistencies and inconsistencies are identified and compared with the coach's own philosophy.

The identification of **personal philosophy** and its "fit" with the institutional philosophy is critical for the success of the Coaching Network. If the personal philosophy is in conflict with the institutional philosophy, development of effective teams will be hampered at best. However, there is more to personal coaching philosophy than simply matching the institution. The coach must identify the personal coaching philosophy (management approach) that will be used to guide and motivate the team members.

Personal goals and how those goals relate to the members of the team and the institution must be identified. The relationship among the coach and team members must be determined (e.g. formal, informal). Linked to this relationship is the identification of the leadership style used by the

coach. In other words, the style of the environment (motivation, collaboration, individual and group focus on goals) is determined by the personal philosophy.

Creation and maintenance of a **positive environment** includes communication paths (both formal and informal), information availability, appropriate support (both individual and small group), availability of appropriate resources (for example, key people, hardware, software, course materials, library materials), and feedback mechanisms (including cheerleader and mentoring). In addition, positive attitudes and collaborative effort must be encouraged. As part of the environment, instruction must be provided. This instruction is both formal, a classroom, and informal, on the job training. Finally, care must be taken to build self-esteem on the part of each team member. This can be done through both formal and informal means. A positive environment does not mean a lack of discipline or consequences for inappropriate behaviors of team members. However, consequences are made clear prior to problems arising and are fairly and impartially administered.

## Coaching Chain

| | |
|---|---|
| **Coaching** | An individual/small group process of interaction among coach and team members with the expected outcome of independent performance. |
| Information | Knowledge and skill transger |
| **Support** | Positive indicidual/small group interaction |
| **Resources** | Locating and utilizing key players tools |

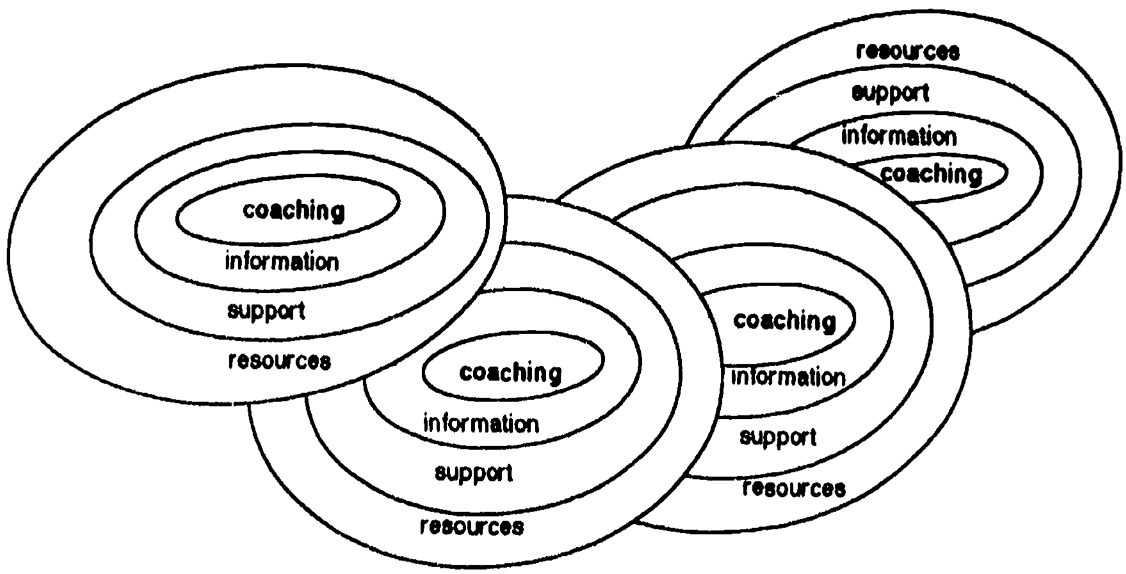


Figure 1 The Coaching Chain

In order to function, a team must have **team goals**. These goals may be defined by the administration (institution) or the coach, but they are most effective if the team members have a part in the decision. This leads to "buy-in" and motivation to attain the goals. The development of team goals can be accomplished by presenting the goals and expectations of the company to the team, inviting members to discuss the goals and identify their fit. Next, the team decides how to attain the goals. In this process, the team identifies the short and long term goals. Of greatest importance, however, is the team working together to identify the goals and reaching a consensus.

Once team goals are identified, **individual goals**/objectives supporting must be developed. This requires a one-on-one approach, with the coach working individually with each team member, setting goals that are achievable, challenging, and fit with the team goal. In this way, each member's relationship with every other member is defined, much like positions in basketball. Having defined roles, allows coordination of team efforts.

**Orchestration** of individual and small group assignments is a management problem. The coach must coordinate the assignments, whether they are classroom assignments or work tasks, so that they are focused on achieving the team (and in so doing, individual) goals. Communication about progress and problems is critical in this part of the model. Communication provides opportunities for cheerleading and group problem solving.

**Evaluation** of the coaching process and progress toward all goals/objectives is an on-going process. Results of the evaluation are used to modify team relationships, goals, tasks, and access to resources, support, and information to improve the success of the team. Success is measured in terms of:

- •attitudes
- •increased interaction among team members and other teams
- •progress toward goals/objectives and
- •attainment of goals/objectives.

The outcomes of the evaluation process include:

- •identification of individual needs,
- •identification of problems with the coaching process, and
- •identification of new goals.

**THE COACHING CHAIN**

The Coaching Chain model, Figure 1, represents the interaction of each team member with information, support, and resources needed to improve performance and or knowledge on the job. The support and resources needed include fellow team members; in effect each member becomes a peer coach. The coaching process also occurs from team member to subordinate and superordinate teams. As the process evolves, the additional links in the chain are formed. It is the chain and its growth that underlies the success or failure of a coaching model for management.

When this model is implemented in a setting, say a college course on computers in education, the instructor functions as the coach. During the first several class meetings, the ground rules for communication and the class goals are set. In individual meetings with the instructor, each class member identifies his/her fit with the team. This includes identifying both strengths and weaknesses each member brings to the class. The instructor then organizes the class into working groups whose focuses are on how each group will contribute to the class goals.

At this point, the instructor begins the process of instruction. That is, some direct "teacher-lead" instruction occurs. The purpose is to provide a minimum set of skills for each member such that the groups can begin to explore the information and skills needed to accomplish their tasks. As the exploration progresses, the instructor becomes a facilitator or guide, providing suggestions and directions as needed. On occasion, some additional direct instructions occurs to fill in some details or skills that have not yet been learned, but are needed to move forward toward the goals.

As the course continues, the individual class members begin to share individual expertise, contributing both to the accomplishment of the goals and to the general skill/knowledge level of all class members. By the end of the course, the goals are met and all of the students have increased their skills/knowledge. In effect, they have become their own instructors, with the course instructor acting as guide and mentor.

Several results are gained from implementing this process:

- •Improve skill/knowledge mastery,
- •Improve independent learning, goal setting, achievement, and performance,
- •Increased group cohesion leading to

improved performance, and
- Improved performance leads to increased production.

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Selected Formal Papers From the

# Special Interest Group for Health Education (HESIG)

# THE IMPACT OF COMPUTER BASED LEARNING ON EXAMINATION PERFORMANCE IN MEDICAL BIOCHEMISTRY

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**Abstract**
An optional student-controlled computer-based learning (CBL) environment (lecture, review, self-testing and clinical problem modules) covering over 50% of a Medical Biochemistry course was made available to first year students. Users experienced improved performance on multiple choice examination questions. The percentage improvement on questions for which CBL was used is predicted by the intensity of CBL use.

**Introduction**
In 1988 we posed the question, "What would happen if an entire medical school course were replaced by computer based learning?" Implicit in this question were several concerns that bear on basic science education in medical school, and on medical education in general. The question also made certain assumptions about the nature of the computer based learning that would replace the course.

The educational concerns included the following: Medical schools typically have overcrowded curricula which are heavily scheduled, and in which students are expected to master a very large and growing volume of facts in a short amount of time. (Chandrasekharan, 1988) Preclinical courses are often taught in a block that is separated from clinical considerations, both in time (being presented during the first year and a half to two years) and in content (being taught by Ph.D.s who sometimes give little attention to the clinical interests of their students). (Rothstein, 1987) The teaching and learning processes are often examination driven, with the immediate focus being course examinations, and the long term focus being the National Board of Medical Examiners Part I Examination. Courses are usually taught by the entire staff of the department, but sometimes with little integration among the faculty, except at the level of assigning specific topics to specific faculty members.

It seemed to us that the kind of CBL program needed to address these concerns would be a complete, student controlled learning environment. It would contain four major elements (Dennis, 1989): (1) The complete material content of the course in detail, including all graphs, tables, graphics (animated if appropriate) and behavioral objectives. (2) Review and drill materials. (3) Examination questions for self-evaluation. (4) Realistic applications of the basic information to clinical situations. The student would determine what activity he/she would engage in at any time, and the program would allow the student to move freely among types of learning within a topic as well as from topic to topic.

We embarked upon the construction of such a program for a Medical Biochemistry course, using HyperCard and the Macintosh computer (Dennis, 1990). The project, the Integrated Biochemistry Learning Series (IBLS), is now well over 50% complete (Table 1), and contains modules covering biochemistry topics occurring at all points in the course, from beginning to end. This is an interim report on the effects of this type of CBL on standard multiple choice examination performance.

**Methods**
The experimental population consisted of 243 medical and graduate students taking Medical Biochemistry at Hahnemann University in Fall of 1990.

Students were introduced during the course orientation to the availability of CBL, and they were told that IBLS could be used on the 12 Macintosh computers in the Microcomputer Learning Laboratory of the University Library during all regular library hours. Those with appropriate computer hardware were also offered, at no charge, a personal copy of IBLS. On the second day of the course the software was demonstrated during a regular class period, using a video projector in a lecture hall. The demonstration described the content and scope of the program, explained strategies for integrating its elements into a coherent study plan, and taught the specific techniques and conventions of the software, such as clicking

Table 1

Portions of the Integrated Biochemistry Learning Series
Complete at the Time of This Study

"X" denotes a module that was complete for the indicated topic.

| Topic | Lecture | Exam Questions | Tables | Clinical Problem |
|---|---|---|---|---|
| Amino Acids | X | X | X | |
| Bioenergetics | | X | X | |
| Carbohydrates | | X | X | |
| Enzymes | X | X | | |
| Hemoglobin and Gas Trans. | X | X | X | |
| Lipids | | X | X | |
| Macromolecules | X | X | | |
| Metabolic Interrelations | X | X | X | |
| Nutrition | X | X | | |
| Hormones from Amino Acids | X | X | | |
| pH and Buffers | X | X | | |
| Purines and Pyrimid | X | X | X | |

Note: The exam questions module is complete for all topics of Medical Biochemistry, including those not listed here, such as molecular biology.

on text in boldfaced type to reveal further details, *etc.* (Baggott, 1990)

Student attitudes toward CBL and student use of IBLS were assessed in two ways. First, survey questions were placed on the regular course examinations. Several "yes/no" questions about previous experience with computers and feelings about using

CBL were included, as well as, for each topic of Medical Biochemistry that had an associated CBL lecture module (CBL topic), an inquiry as to whether the students had learned the topic from lecture alone, some combination of lecture and CBL, or CBL only. Responses were assigned scores of 0, 1 and 2 respectively; the scores were used directly to identify type of use, and the sum of the scores over all CBL topics was taken as a measure of intensity of CBL use. Answers to the survey questions were recorded on the examination answer sheets. Answering was voluntary, and time for this was provided prior to the start of the examination. No more than five survey questions appeared on any examination. As a second source of use information, on the first day of the Spring semester of 1991, three weeks after the end of the Fall semester, students were asked to complete a 22-question CBL use survey. This survey asked, for each CBL topic, which module the student had used: lecture, review and drill, examination questions or the clinical problem. Possible answers were, "yes," "no," and "don't recall." The answer sheet depository was placed next door to the lecture hall, and $5 copy cards were offered to the first 50 students returning signed surveys.

Examination subscores for each student were determined for all CBL topics. Comparisons were made between performance on CBL topics where the CBL lecture module was used *vs.* where it was not, using the paired t-test and multiple regression/correlation. Analyses were carried out with Systat version 3.0.

**Results**
Student cooperation was nearly 100% while the course was in progress; nearly all students answered the optional survey questions on the examinations. The survey conducted after the course was over, however, netted only 93 responses. Further, these were returned in two waves. The first was immediately after the forms were distributed. In fact, some students completed the forms while standing in line to receive the photocopy card. The second wave arrived a day later, after it became known that seven cards were still available to be given out.

Data on computer ownership, prior computer experience and attitudes toward CBL were collected during a pretest given on the first day of the course (Table 2). A minority of students had access to a private computer, but most had

Table 2
Personal Factors Related to Use of Computer Based Learning

The following questions were asked of first year students at the start of the first semester Medical Biochemistry course. "Yes" and "No" were the possible answers.

| Question | Percent "Yes" |
|---|---|
| Do you have access to a computer (other than a public machine)? | 33 |
| Did you use computers as an undergraduate (for academic or recreational purposes)? | 79 |
| Have you taken any computer courses? | 50 |
| Have you ever used computer assisted instruction? | 44 |
| Do you currently feel favorably inclined toward using computer assisted instruction? | 80 |

used computers previously, and 80 percent were favorably inclined toward CBL. Regression analysis revealed that availability of a privately owned computer was a significant predictor of a favorable inclination toward CBL ($p = 0.008$). None of the other variables was independently a predictor of attitude toward CBL. At the time of the final examination the students were again asked whether they were favorably inclined toward CBL. 76 percent answered, "Yes," a change that was not significant in a paired t-test.

Data on CBL use collected during the course examinations showed in paired t-tests that there was no difference between examination performance on CBL subjects when the CBL was used *vs.* when it was not. Further, multivariate analysis with dummy variable coding to denote membership in the groups which learned from lecture only, from lecture plus computer or from computer only showed no effect of group membership. That is, in any given CBL subject, there were no differences in examination performance that could be attributed to different ways of learning.

This surprised us because pilot studies in previous years, when there had been far less CBL available, had suggested that there was an effect of group membership, and that use of CBL lecture modules improved examination performance. We had expected that with more CBL available, this effect would increase, and that statistical significance would be achieved. Failure to observe this outcome led to suspicion that students interpreted the phrase, "learned from some combination of lecture and CBL," differently this year as compared to previous years. In the past, CBL lecture modules were separate stand-alone programs, and it seemed natural to interpret the phrase, "learned from CBL," as referring to the lecture modules. This year, for the first time, all CBL was integrated into IBLS, and the distinction between primary learning from the lecture replacement *vs.* drill or self-testing may have become lost. We had known for some time (Dennis, 1988) that examination questions were the most popular CBL activity with our student population. We speculated that this year some students who claimed to have learned from both CBL and lecture had not used the CBL lecture modules at all, and had answered positively on the strength of having used only the examination questions. This was the reason for the post-course survey.

Comparison of the results of the two surveys provided evidence that the hypothesis of different interpretations of the same question by students in different years may have been correct. Some students who had previously claimed to have used CBL to learn a given topic indicated subsequently that they had not used the lecture module, but had used other modules of IBLS for that topic. In addition, some students who had previously stated that they had NOT used CBL claimed later to have done so. We accepted the former at face value, and the latter as representing additional CBL lecture module use subsequent to the earlier survey. Both groups were counted as nonusers of the lecture modules at the times of the examinations. These adjustments to group membership data failed to produce any significance in the paired t-tests or in the multivariate analyses.

Discussion of these findings with the manager of the Microcomputer Learning Laboratory yielded the following observation: He had the impression that there was a noticeable difference in the way students used the software this year in comparison with last year. Last year, he felt, they used lecture modules intensely and for prolonged periods, while this year use seemed more casual and more abbreviated. This observation, if substantiated quantitatively, could represent a difference between use of CBL when it is a novelty and routine use when a large fraction of a course is available on the computer. Clearly a way to distinguish between casual use and serious study was necessary.

The best reflection available in our data of serious study is the number of CBL topics for which a given student used the lecture module, modified appropriately for use of CBL instead of attending lecture whenever that occurred. This is given by the intensity variable defined in the methods section. Interpretation of intensity in this manner assumes that students who use CBL for many subjects do so because they feel it is effective for them, which in turn implies that they use it seriously. When this variable was used as a predictor of performance on CBL topics for which the lecture modules were used, it was positive and significant ($p = 0.012$). The predictive equation is

$$\%\ \text{correct} = 69.8 + 0.7\ \text{intensity}$$

This means that CBL does have a significant effect on exam performance, and that the effect is in evidence exactly to the extent that students take CBL seriously and use it conscientiously. In contrast, intensity was not a significant predictor of performance on topics for which no CBL was available ($p = 0.276$), nor on topics for which CBL was available but not used ($p = 0.702$). Lack of significance where none would be expected is consistent with the interpretation that intensity is not merely a reflection of overall academic diligence, but is specifically related to an effect of CBL use. Analogous results have recently been reported from a very different educational setting (Atkinson, 1991).

**Discussion**

The most reasonable interpretation of these results is that buried somewhere within the "intensity" variable is a factor or factors bearing a direct causal relationship to examination performance. It or they probably measure the amount of time and degree of seriousness with which the student used CBL, and therefore represent a true effect of CBL.

The effect is both statistically significant and practically significant. For each unit of intensity, performance on the CBL subjects increases by 0.7 percentage points. Over the nine CBL subjects currently available, this translates into a minimum of a ($0.7 \times 9 =$ ) 6 percent overall improvement attributable to use of CBL as an adjunct to the lecture. In practical terms, this would have meant a 6 percent upward shift in the grade distribution curve, resulting in 20 fewer course failures if CBL had been available for all topics and everyone had used it.

That intensity has predictive value eliminates a novelty effect. It is the users who make a sustained effort that achieve the most. Individuals who are initially enthusiastic, but later use fewer lecture modules (and presumably use them less diligently) experience a smaller performance increment for the topics in which they used CBL.

Our results could in principle be accounted for by a practice effect. We believe this is not the explanation. The components of IBLS all use the same conventions and user interface, and experience shows that most students become comfortable with the mechanics of its use within 15 minutes. What varies from module to module is the subject matter.

For the most part the lecturer in the course also wrote the corresponding CBL lecture modules and the examination questions, raising the possibility that the examination questions could have been biased in favor of the CBL users. The lectures and the CBL were designed to be identical in content, visuals, *etc.* Examination questions were based on written behavioral objectives, which were the same for both presentations. Further, the positive effect of CBL use suggests that potential subconscious cues such as gesture, intonation or repetition by the lecturer were not significant.

We speculate that the improved performance experienced by intense users is not merely an effect of spending more total time on the material. Students' days are heavily scheduled, and they do not have discretionary time. If they put more time into CBL it would have to be at the expense of some other academic pursuit. Given the tendency of medical students to be strategic learners (Newble, 1986), we doubt that this occurs. This interpretation is consistent with the belief that the way in which our CBL presents information, with advance organizers, animation, self-pacing, *etc.*, improves learning.

Failure of multivariate analysis with dummy variable coding to yield the anticipated result is probably because under the conditions prevailing this year, when a relatively large amount of CBL was available, the mere fact of use bore no implication regarding seriousness of use. Further, this year very few students elected to use CBL instead of attending lectures, although the majority made some use of the lecture module for every CBL topic. All of this may in turn be related to computer availability. Students may have found it impossible to use CBL to an optimum extent with a student/computer ratio of 20. Indeed, during the first month of the semester IBLS accounted for 70% of Macintosh use in the Microcomputer Learning Laboratory, and it was very difficult to find an available Macintosh during hours when the first year students were out of the classroom or laboratory.

In principle a randomized study might be carried out in which students would be required to learn the subject in prescribed ways and be required to keep detailed logs of learning activities. Such an approach, however, is antithetical to our principles of student-controlled learning. Also, it would be unenforceable upon students spending large sums of money to prepare themselves for a life's work.

It would probably be an error, however, to make improved performance attributable to CBL into a Holy Grail. As long as CBL and the lecture are demonstrably equally effective, as Haglor and Knowlton (Haglor, 1988) have argued they should be if the content and organization of the two media are identical, CBL still has advantages. It is always available; it is infinitely patient; it will do what the user wants when the user wants to do it. Further, it can achieve the ideal presentation of information, with sophisticated graphics and animations that are difficult to bring to the classroom, it never feels out of sorts (although computers do become infected with viruses), and it can be linked to related information in any way the program author wishes, thus integrating information across disciplines as well as within a given discipline.

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# A COMPUTER MANAGEMENT SYSTEM FOR PATIENT SIMULATIONS

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**ABSTRACT**
We are teaching clinical problem-solving skills, including diagnosis and management, to dental students using a series of interactive videodisc patient simulations. We call this series Oral Disease Simulations for Diagnosis and Management (ODSDM). (Finkelstein, et al., 1988) ODSDM presents an oral pathology diagnostic schema and thirty patient simulations. ODSDM is a prototype for a comprehensive dental simulation project. This paper describes a computer management system which assigns students patient simulations, tracks their progress, and generates reports.

Our computer management system was designed in response to the following needs. First, the sequence that students perform simulations is critical. Each student should be presented with the individualized sequence of simulations they require to master clinical decision-making skills. Second, maintaining records of completed simulations and student performance on each simulation is a time-consuming task for faculty. Third, the simulations and the simulation models require ongoing evaluation to ensure high quality instruction.

The objective of the management system is to ensure that each student masters diagnosis. Mastery must be obtained at a specified level before advancing to the next level. The management system does this by individualizing the sequence of the simulations to adapt to the needs of each student. Students who learn diagnosis quickly need to complete fewer simulations than those students who learn diagnosis less quickly.

The management system generates 200 demographic, progress, and system reports.

## INTERACTIVE VIDEODISC PATIENT SIMULATIONS

Dental students graduate with a solid knowledge of the basic sciences and the technical skills required to successfully treat patients. However, time and access to patients may limit clinical experiences in applying knowledge to the problems they may encounter in a normal practice. Students may also lack experience in developing a systematic approach to gathering information and solving diagnostic and management problems.

Patient simulations have been used successfully in teaching problem solving in medicine. In the absence of a sufficient quantity and variety of patients, simulations have enabled medical students to practice diagnosis and management, with no risk to the patient, and at a reasonable cost. (McGuirre, 1976; Templeton, 1985; Raj, et al., 1982; Abdulla, et al., 1983; Blancher, 1985) At the University of Iowa we have developed a patient simulation project titled Oral Disease Simulations for Diagnosis and Management (ODSDM). (Finkelstein, 1988) The ODSDM package consists of a series of interactive videodisc patient simulations that expose the student to case studies representing a variety of oral diseases.

ODSDM has been designed to meet the following requirements. First, students must take an active role in gathering and applying information to the formation of a clinical diagnosis and appropriate treatment recommendations. Second, students must be encouraged to develop problem-solving skills and to apply them to a broad and increasingly complex range of clinical problems. Third, these criteria must be met at a reasonable cost.

ODSDM uses a laser-reflective videodisc controlled by microcomputer (Figure 1). The student views two television screens and communicates via a microcomputer. One screen displays videodisc images while the other displays computer text. The system allows the student to gather visual and textual information on the patient's disease, offer a differential diagnosis, and propose treatment. The system also provides feedback to the student about the problem-solving process.

The videodisc presents high-resolution visuals of the clinical, radiographic, and histologic features of a patient's disease. The videodisc images can be randomly accessed almost instantaneously, and are durable and easily maintained.

Figure 1. An ODSDM Work Station

**PROBLEMS WITH SIMULATIONS**

The patient simulations solved an important instructional problem, but created three new problems. First, the sequence in which students complete simulations is critical. Each student needs to be presented with an individualized sequence of simulations that will ensure his or her mastery of clinical decision-making skills. The random assignment of patient simulations does not guarantee this mastery. Second, recording completed simulations and student performance on each simulation is time-consuming for faculty. Third, to maintain a high standard of quality, it is necessary to continually evaluate and revise simulations. Once the patient simulations were integrated into the curriculum, it became clear that the record keeping, evaluation, and revision processes needed to be streamlined.

**MANAGEMENT SYSTEM**

Our solution to the problems of student mastery, record keeping, evaluation, and revision consists of a management system and database operating on a local area network. The management system sequences the patient simulations for each student. The database holds demographic and performance information on each student.

The management system organized the patient simulations into a series of patient simulation models. Each simulation model differs in content, difficulty, and instructional techniques. Models of differing complexity appropriate to differing levels of student expertise and experience are defined by an instructor using a word processor.

A compa[illegible] of the sophomore and junior ODSDM models illustrates the variations in level of difficulty. Sophomore students are required to diagnose a patient's disease, but are not asked to recommend treatment. If the student's diagnostic decision is incorrect, the message "Reevaluate your decision" appears immediately, and the incorrect decision becomes unavailable. The junior model requires students to diagnose and propose treatment for a patient's disease. The "reevaluate" message is turned off. The student is informed of all correct decisions later in the Critique.

The primary goal of the management system is to ensure that each student master diagnosis. To accomplish this goal, the management system is told which students are assigned to each model. During a student session, the management system presents a patient simulation. If the student successfully completes a simulation, one of the model's requirements is "checked off" and another simulation is presented. When the student has "checked off" all of the model's requirements, he or she has met the requirements for mastery. When the students "fail" two patient simulations, they are remediated with an easier simulation, or an equivalent simulation with instructional prompts. Once the student successfully completes the remediation work, he or she is again presented with simulations that will fulfill the model's mastery requirements. This "check-off" and remediation process permits the system to adapt to the needs of the individual student. Those students who learn diagnosis quickly need to complete fewer simulations than those who learn less quickly.

**SEQUENCE OF SIMULATIONS**
The management system also individualizes the sequence of the simulations. The author of a simulation model specifies whether the patient simulations are presented randomly or in a specific sequence. We have specified our sophomore model to present simulations in a specific sequence because novices learn more efficiently with a structured approach. We have specified our junior model to present simulations randomly to challenge the developing problem-solving skills of the more mature student.

**RECORD-KEEPING**
The database associated with the management system stores demographic and performance information on each student and uses this information to generate reports about individual students, or groups of students. The reports allow us to track student progress. Those students requiring remediation can be identified for individualized attention.

**EVALUATION**
At the end of each simulation, students may comment on the simulation's strengths and weaknesses. At regular intervals, students complete forms evaluating a patient simulation. These comments and evaluations are stored in the management system and may be printed on request. These evaluation reports act as a quality control mechanism for the patient simulations and the simulation models. The student reports and the evaluation reports may be used to generate research data.

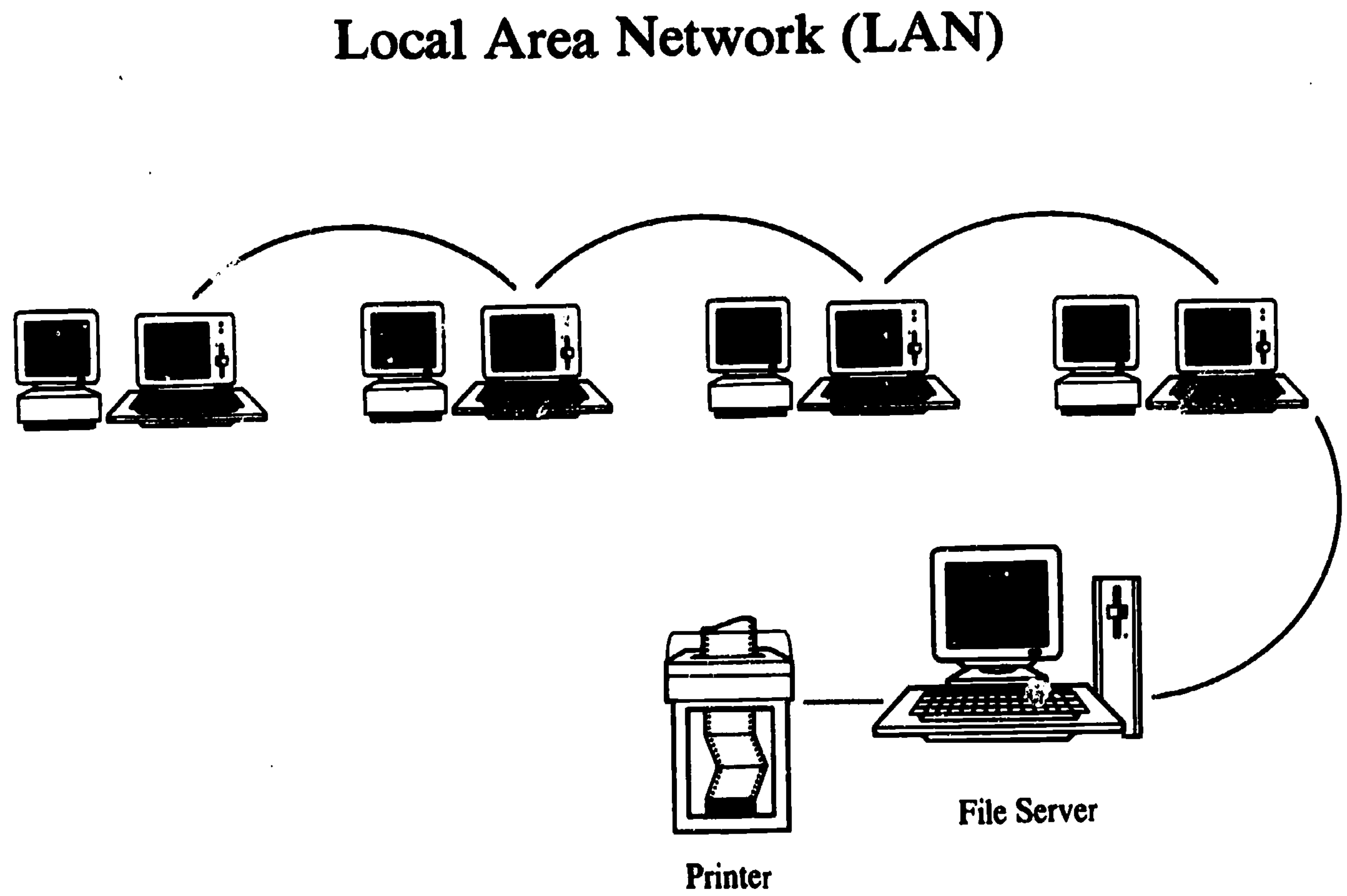


Figure 2. A Local Area Network (LAN) Containing Four ODSDM Work Stations.

**HARDWARE**

A local area network (LAN) allows a group of computers to send messages to one another and use the same programs. The LAN links the student work stations to a central microcomputer called a file server (Figure 2). The file server contains all the software for the patient simulations, the management system, and the database with its associated information. The LAN also enables the work stations to share a single printer. The LAN we use is Ethernet, made by 3 COM Corporation. Ethernet has a single coaxial cable linking the file server, work stations, and printer.

The computers linked by a LAN must be similar for the system to operate efficiently. We use an IBM PS/2 Model 70 for the file server, and IBM PS/2 Model 30's, each with a Pioneer LD-V6000 videodisc player, for the student work stations.

**SOFTWARE**

Our system utilizes multiple software packages. The user does not see or handle the software when performing simulations.

The most basic software is DOS, which is used to add or delete models and patient simulations, and to edit patient simulations. A word processor is used to author and modify the simulation models and their associated patient simulations.

The LAN runs on a software package called Novell. Novell controls access to ODSDM and the videodisc. Students have limited access rights. They cannot modify simulations, or demographic and performance information. Novell also controls sharing the simulation models and patient simulation files, and coordinates printing.

The management system uses a database called Paradox. Paradox allows us to store and manage student demographic and performance information, and all simulation comments and evaluations. It also is used to generate reports.

The patient simulations use three software components: the simulation driver program, three baseline files, and individual patient files. The driver program presents information from the baseline and patient files, permits movement within the program, scores the student's work, and controls the sequence of computer and videodisc material. The baseline files contain the information that is common to all patients, while each patient file contains the information specific to the individual patient.

The management system software coordinates a student's movement between DOS, Novell, Paradox, and the simulations. It also assigns patient simulations to students based on the simulation model requirements and individual student progress.

**MAINTENANCE OF THE MANAGEMENT SYSTEM**

Maintenance of the management system requires a significant amount of effort and skill. Someone familiar with the system hardware and software must be available as a trouble-shooter when problems arise. Our experience has revealed that clear, detailed software documentation is a necessity. As a result, we are presently writing the management system documentation. On-going tasks include entering student demographic information; performing back-ups of patient simulations, simulation models and stored data; and generating reports. The management system permits clerks to perform these tasks rather than faculty.

**COST OF THE MANAGEMENT SYSTEM**

The cost of the management system includes designing, programming, and pilot-testing the software. The total cost of development was \$58,700. This includes programming: \$28,000; faculty and instructional designer time: \$22,700; hardware: \$5600; software: \$1400; and documentation: \$800. The cost effectiveness of the management system derives from the reduction in faculty time required for record-keeping and simulation evaluation, as mentioned above.

**FUTURE DEVELOPMENTS**

An extensive summative evaluation of the ODSDM project is planned for the coming school year. The management system will be evaluated as part of that project.

The management system has been integrated into the oral pathology curriculum, and will eventually be a part of a broader dental simulation project called Dental Diagnosis and Treatment (DDx&Tx), which will encompass clinical decision making skills for diagnosis and treatment planning in all the dental specialties.

We have also developed *Dental Diagnosis and Treatment: A Videodisc Atlas*. This videodisc contains approximately 25,000 slides from ten dental and oral health care disciplines, a radiograph and histology imagebase, and motion and audio information representing patients' diseases. We are indexing audio and visual information into a database. Plans are underway to produce a second edition of the videodisc. We are also developing a videodisc testing project and a presentation program for lectures and individualized instruction.

**ACKNOWLEDGEMENTS**

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# DEVELOPMENT OF COMPUTER EDUCATION IN HEALTH SCIENCE (NURSING); SOME AUSTRALIAN EXPERIENCES

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**ABSTRACT:**
University-based nursing education is new in Australia in New South Wales, diplomas in nursing started in 1985 and universities are now offering Bachelor degrees. Computing has not been significant in these rapidly developed curricula. This paper looks at important issues in introducing computers in nursing education, because the nursing profession in Australia is challenged by changes in information technology.

**INTRODUCTION:**
Information Technology is reshaping our society day to day in all aspects of our lives. It has become an integral part of patient care in all clinical settings. As a result of the emergence of new technology the Australian Nursing Curricula will require restructuring so that our nurses can meet future technological challenges. We should put greater emphasis on nursing applications of computing in the curricula.

The need to introduce computing into nursing curricula has been discussed by several authors (Robinson, 1982, Happ, 1983, Hasset, 1984, Chang, 1984, Andresli and Musser 1985, Walker, 1986, Soya and Lentz, 1987, Staggers, 1988, Delaney, 1989, Summers etal, 1990 and Dover and Boblin, 1991).

The nursing profession was revolutionised by Florence Nightingale, who was also a pioneer in the introduction of scientific methods in nursing. "Nursing's evolution as a science can be traced back to the days of Nightingale" (Malinski, 1986, p.35).

The idea of introducing computing as a compulsory subject has generated considerable interest and concern among some Australian Nursing educators and students (Karmakar 1991).

Grobe (1984) also expressed some concern for the future.

"Our graduates cannot be thrown into the technological maze without under-standing the nature of Computer Systems as powerful technological tools, an experience base that includes competency in these tools, and a clear recognition of the ethical, professional and legal implications that accompany computer system adoption and use" (p.97).

Computing in Nursing, does it make a difference? My answer to this critical question is yes. Change occurs even in the most conservative societies. Health care is no exception to this. Information technology has become an integral part of patient care in all modern health care settings. We are now a part of a high technology society based on information exchange.

**LANDMARK EVENTS OF COMPUTERS INTO NURSING**
Computerised nursing education is very popular in the US, but this is not so in Australia. Several landmark events have occurred over the past 17 years. All have promoted computer awareness among nurses (Table 1).

**NURSING COURSES AT AUSTRALIAN UNIVERSITIES**
The transfer of undergraduate nursing education from hospital to tertiary institutions in Australia is relatively new.

On November 7, 1983 the then New South Wales Minister for Health, Mr Laurie Brereton, announced the transfer of basic nurse education from hospitals to Colleges of Advanced Education from January 1, 1985. As Mr Brereton stated, "I believe this change to be the greatest advance in nurse education in the history of nursing in this country". In the following year it was announced that such a transfer would be complete throughout Australia by 1993.

NSW is pioneering an University based nursing education in Australia. In all other states, the responsibility for basic nursing education from hospital to course is not yet complete. In NSW colleges of Advanced Education no longer exist. All Australian tertiary institutions will soon either be an independent University or a part of an established University.

Table 1. Landmark Events of Computer in Nursing

| Year | Title | Place |
|---|---|---|
| 1973 | Invitational conference on management information systems for public and community health agencies | Fairfax, VA |
| 1974-75 | Five workshops on management information systems for public and community health agencies | All over USA |
| 1976 | State of the Art conference in management for public and community health nursing agencies | Washington, DC |
| 1977 | Research conference on nursing information systems | Chicago |
| 1979 | Trimis conference on computers in nursing: A user's perspective | Washington, DC |
| 1980 | Early workshop on computer usage in health care: A national survey | Akron, OH |
| 1981 | First National conference on computer technology and nursing | Bethesda, MD |
| 1981 | Fifth Annual symposium on computer applications in medical care (SCAMC-5) | Washington, DC |
| 1982 | Study group on nursing information systems | Cleveland, OH |
| 1982 | International meeting: Working conference on the impact of computers on nursing | London and Harrogate, Yorkshire, ENGLAND |
| 1982 | Second National conference on computer technology and nursing | Bethesda, MD |
| 1982 | Sixth Annual symposium on computer applications in medical care (SCAMC-6) | Washington, DC |
| 1982 | First newsletter - Computers in Nursing | Austin, TX |
| 1983 | Medinfo-83: Fourth World Congress on medical informatics | Amsterdam |
| 1983 | Third National Conference on computer technology and nursing | Bethesda, MD |
| 1983 | Second annual joint congress | San Francisco |

| | | |
|---|---|---|
| | and conference | & Baltimore |
| 1983 | Newsletter - Computer in Nursing | Philadelphia |
| 1984 | Fourth Annual conference on computer technology and nursing | Bethesda, MD |
| 1984 | Eighth annual symposium on computer applications in medical care (SCAMC-8) | Washington, DC |
| 1984 | Third joint National Congress and conference | San Francisco & Washington, DC |
| 1984 | First Journal - Computers in Nursing | Philadelphia |
| 1984 | Council on computer application in nursing (CCAN) | Kansas City, MD |
| 1984 | National forum on computers in health care and nursing | New York |
| 1985 | The International symposium on nursing use of computers and information science, "building bridges to the future". | Calgary, Canada |
| 1985 | The first annual nursing interactive video conference | Sacramento, California |
| 1985 | On-Line - Off-Line: computer use in nursing | Atlanta, Georgia |
| 1986 | The 5th World Congress on medical informatics (Mediinfo 86) | Washington, DC |
| 1986 | The Fifth National conference on computer technology and nursing | Bethesda, MD |
| 1987 | The 1st World symposium on computers in care of the mother, foetus and newborn | Vienna, Austria |
| 1987 | Computer applications in medicine and health care (AAMSI Congress 1987) | San Francisco, California |
| 1987 | The Nursing Informatics Symposium | Columbus, Ohio |
| 1988 | Nurses and computers, an international symposium on nursing, computer use and information science | Trinity College, Dublin |

| | | |
|---|---|---|
| 1988 | The Fourth annual computers in nursing symposium: applications in practice and management | University of Massachusetts Medical Centre |
| 1989 | Medical informatics and education: an international symposium | British Columbia, Canada |
| 1989 | The Thirteenth Annual Symposium on computer applications in medical care | Washington, DC |
| 1990 | The Fourteenth Annual Symposium on computer applications in medical care | Washington, DC |
| [illegible]1 | Computers and nursing practice, 6th Annual seminar focusing on mainframe and micro computer applications (May 23 & 24) | NYV Medical Centre, USA |
| 1991 | The Fourth International conference on nursing use of computer and information science (April 14-17) | Melbourne, Australia |

Table 2

SUMMARY OF AMALGAMATIONS OF TERTIARY INSTITUTIONS IN NSW AND ACT 1990/91

| | |
|---|---|
| Australian Catholic University (NSW & ACT Campuses) | Incorporating: Catholic College of Education, Sydney Signadou College |
| Australian National University | Will incorporate Canberra Institute of the Arts in 1992 |
| Charles Sturt University | Incorporating: Mitchell College of Advanced Education (CAE) |
| Riverina-Murray Institute of Higher Education (IHE) | |
| Macquarie University Institute of Early Childhood Studies | Incorporating: Sydney CAE - |
| University of Canberra | Formerly Canberra CAE |
| University of Newcastle | Incorporating: Hunter IHE NSW State Conservatorium of Music, Newcastle |
| University of New South Wales | Incorporating: College of Fine Arts, (formerly City Art Institute). Sydney CAE - St George Institute of Education |
| University of New England | Incorporating: Armidale CAE, Northern Rivers CAE, Orange Agricultural College |
| University of Sydney | Incorporating: Cumberland College of Health Sciences. NSW Institute of the Arts - Sydney College of the Arts. NSW State Conservatorium of Music, Sydney Sydney CAE - Institute of Nursing Studies. Sydney CAE - Sydney Institute of Education. Sydney College of the Arts. |
| University of Technology, Sydney | Incorporating: Kuring-gai CAE. Sydney CAE - Institute of Technical and Adult Teacher Education |
| University of Western Sydney | Incorporating: Hawkesbury Agricultural College. Macarthur IHE, Nepean CAE. |
| University of Wollongong | |

Table 3

SUMMARY OF NURSING COURSES (UNDERGRADUATE) AVAILABLE IN NSW/ACT UNIVERSITIES

| University | Offered by | Min. duration (years) | Pattern of attend. | Name of the course |
|---|---|---|---|---|
| Australian Catholic University | Division of Nurse Education | 3/6 | Full time(F)/ Part time(P) | Diploma of Health Science (Nursing) |
| Charles Sturt University | School of Nursing & Health Administ. Mitchell/ Riverina | 3 | F | Diploma of Health Science (Nursing) |
| University of Canberra | Department of Nursing School of Applied Science | 3/6 | F/P | Diploma of Applied Science (Nursing) |
| University of New England | School of Nursing Armidale | 3 | F | Diploma Health Science (Nursing) |
| | Northern Rivers | 3/6 | F/P | Dip.Health Science in Nursing |
| University of Newcastle | Faculty of Health | 3 | F | Diploma of Health Science (Nursing) |
| University of Sydney | Faculty of Nursing | 3/6 | F/P | Diploma of Health Science (Nursing) |
| | Cumberland College of Health Sciences | 3 | F | Diploma of Applied Science (Nursing) |

| | | | | |
|---|---|---|---|---|
| University of Technology Sydney | Faculty of Nursing | 3 | F | Diploma of Nursing |
| University of Western Sydney, | Hawkesbury Faculty of Nursing and Community Studies | 3 | F | Diploma of Health Science (Nursing) |
| | Macarthur, The School of Nursing and Health Studies | 3 | F | Diploma of Health Science (Nursing) |
| | Nepean, Faculty of Health Studies | 3/6 | F/P | Diploma of Health Science - Nursing |
| University of Wollongong | Faculty of Health and Behavioural Science | 3 | F | Diploma of Nursing |

Our discussion concentrates on Universities in NSW and Australian Capital Territory (ACT). The University of Sydney, founded in 1850, was the first university to be established in Australia. A number of tertiary institutions were amalgamated in 1989

(Table 2). There are about 27,000 academics employed by all tertiary institutions in Australia.

The Nursing diploma courses available at Universities are shown in Table 3 (course handbooks, 1991).

The Diploma Course comprises 3 years of full-time study or 6 years of part-time study. The subjects consist of physical and biological sciences and the basic principles and processes of nursing.

Theoretical studies are usually conducted at the University campuses whilst clinical experience, which accounts for approximately 50% of the course is provided in community health centres, Early Childhood Centres, Nursing Homes, Schools and Hospitals for the Developmentally Disabled, General Hospitals for children and adults and Psychiatric Hospitals.

At the completion of the three year diploma students and registered nurses from hospital based certificate level courses may wish to continue their study full-time or part-time to gain a Bachelor of Nursing degree, which is limited to a few universities. The duration of this course varies from 6 months to 2 years full-time or 12 months to 4 years part-time.

There are a little over three thousand students enrolled in Diploma Courses at NSW and ACT Universities, but only about 150 students are enrolled in Bachelor Courses. The Bachelor of Nursing Courses are gaining popularity among students. This is encouraging other participating universities to offer bachelor degrees in nursing.

Successful completion of the Diploma enable the graduate to register with the relevant State Health Registration Board and practice in a variety of clinical areas, including general medical and surgical, psychiatric, developmentally disabled, paediatric, geriatric and community health.

**COMPUTERS IN NURSING CURRICULUM**

Computer technology is playing an insignificant role in nursing education in Australia. But some new universities have eagerly pursued the introduction of the computer technology in the curriculum. The University of Western Sydney, Hawkesbury is a pioneer in introducing Computing as compulsory subject. This is not the same in other more conservative and traditional universities. In fact, the author could not locate another university in Australia where computing is taught as a compulsory subject.

The author is involved in teaching computing to Nursing students. The aim, objectives and course contents are as stated below.

UNIVERSITY OF WESTERN SYDNEY, HAWKESBURY

FACULTY OF BUSINESS AND LAND ECONOMY

**NUR 433 - COMPUTER APPLICATIONS IN NURSING**

COURSE OUTLINE - AUTUMN SEMESTER 1991

LECTURER: **Dr Nitya KARMAKAR**

AIM:

To develop nurses with knowledge, skills, understanding and applications of computer technology.

OBJECTIVES:

Upon completing this component the student will be able to:

- understand the basic attributes of the three most commonly used application software packages;
- describe the advantages of word processing over typing, spreadsheets over ledger sheets and electronic databases over filing systems;
- define integrated software and describe the advantages of integrated packages over single task packages;
- explain what to look out for when purchasing packaged software;
- develop confidence in their ability to successfully interact with micro-computers and use them in a variety of situations;
- provide opportunities to see computer technology as an important tool in the solution of problems in nursing;
- demonstrate the practical skills in the use of the three popular applications software packages.

TOPICS:

A. Fundamentals of Computing

- The Evolution of Computing
- Hardware
- Input and Output
- Software
- Operating systems
- Software development
- Social Issues and Technological Trends
- Computer Applications in Nursing

B. Application Packages

- Word processing
- Spreadsheet
- Database

DURATION:
**2 hours per week for 14 weeks (one semester).**

Most of the students are very positive about studying computing.

RECOMMENDATIONS:
The introduction of computing into nursing is essential in relation to all of the following areas:

- Nursing practice
- Nursing standards
- Nurse supply
- Nursing services
- Nursing education
- Nursing research

"The Nursing Curriculum needs to be reviewed very urgently to prepare our nursing students for the 21st century" (Karmakar, 1991). The critical question is: 'Has computing, as it has advanced during the last decade, influenced and brought about changes in nursing in Australia?' The answer is no. Computing has a very insignificant role at present in the nursing profession and education in Australia.

There is some change in the curriculum at the more progressive Universities, but the pace of change at other Universities is frustratingly slow.

A strong and diverse nursing education and service will be based on the following developments:

- Designing a suitable computing curriculum for all nursing students at Australian Universities.

- Development of the curriculum being based on interviews with Australian nurse educators, questioning of graduate nurse students and review of Australian health needs, nursing education and practice, nursing administration and research.

- Search for successful models to follow especially reviewing the development of University nursing education in the US and European countries.

- Available funds for in-service training for all nurse educators who have not had any training in computing.

- Development of specific training curricula for all practising nurses to become computer literate.

We can learn what not to do from the United States and to some extent from Britain.

CONCLUSION:

The transfer of nursing training from the hospital system into Universities in Australia has warranted the need to develop curricula with the introduction of computer into nurses' learning and practice environments to prepare them for careers in our increasingly computerised health care settings. Most of the existing courses have strong emphasis on physical, social and biological sciences. Recently Australian Nursing students have complained about the structure of their curricula being too academic (Throp, 1990). The nursing curricula should reflect the combination of the best of traditional values in teaching with the latest innovations in thought and technology.

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Dr Nitya L Karmakar is a Lecturer of Computing/Applied Mathematics at University of Western Sydney, Hawkesbury, New South Wales, Australia. He graduated from Calcutta University, India with honours in physics. At University of North Bengal, India, he obtained an M.Sc and a Ph.D both in physics and also a degree in Law (L.L.B.). He obtained his Diploma in Education from the University of Technology, Sydney.

Dr Karmakar has worked as post-doctoral research fellow during 1978-1981 at University of Kiel, Germany, Deutsches Electronen Synchroton, DESY, University of Hamburg, Germany, European Council for Nuclear Research (CERN), Geneva, Switzerland Argonne National Laboratory, Illinois, U.S.A. and the International Centre for Theoretical Physics, International Union of Atomic Energy, Trieste, Italy. He is the author of a number of referenced journal papers and has presented papers to international conferences. He is presently researching in several areas of Computer applications.

Selected Formal Papers From the

# Special Interest Group for Home Economics (HOMEC)

# CAD INSTRUCTION IN INTERIOR DESIGN PROGRAMS

*Stephanie Clemons, M.S., Colorado State University*
*Joan McLain-Kark, Ph.D., Virginia Polytechnic Institute*

**Abstract**
In May 1990, the Interior Design Educator Council (IDEC) membership was surveyed to determine the portion of interior design programs that have incorporated CAD into their curricula and other pertinent information. The responses indicate that of the IDEC interior design programs nationwide, an impressive 89 percent have incorporated CAD instruction.

**Introduction**
Although the national design organization memberships of practicing interior designers have been surveyed to assess their attitudes toward CAD training for interior design students and to assess their usage of CAD, little data has been compiled to determine the extent to which CAD instruction is being offered nationally through interior design programs. Institutions across the nation that teach interior design are adding CAD classes to their curricula with the assumption that the courses will enhance graduates' marketability.

As the implementation of CAD as a design tool continues, many new issues and challenges are becoming evident for the interior design education field. Some of the questions this research and the following discussion begin to explore are: When should CAD instruction be offered? How does the timing of CAD instruction relate to the sophomore review board? How does an instructor remain current on the software he/she is teaching?

**Purpose of Study**
In May, 1990, the Interior Designers' Educators Council (IDEC) membership was surveyed to determine the proportion of interior design programs that have incorporated CAD and to obtain other pertinent information concerning CAD instruction. By studying both practicing interior designers' attitudes and usage of CAD as well as educators' implementation of the design tool, one can obtain a clearer understanding of the stage in the adoption process CAD is currently at in industry and education. One can also estimate the level of CAD education design students are receiving and if the CAD needs of the design industry are being met or surpassed by interior design graduates.

**Background**
A 1985 study of practicing interior designers' attitudes, American Society of Interior Designers (ASID) membership, revealed that only seven percent of the responding designers used CAD (McLain-Kark & Tang, 1986). In 1987 a random sample of the ASID membership revealed that 60 percent of the responding designers believed that CAD was needed as a tool in the design field. Eighty-five percent agreed that design students should be trained on CAD during their college or design school education (Clemons & McCullough, 1989). A 1989 poll of the Southwest Region membership of IDEC found that, of the respondents, 72 percent of the interior design programs require at least one CAD course (Gartska, 1990). Clearly, usage of CAD as a design tool is growing rapidly.

**Methodology**
A survey of the IDEC membership was conducted in May, 1990 in order to investigate how many interior design programs require students to have some CAD instruction before graduation. Surveys were sent to 216 U.S. design institutions listed in the IDEC Membership Directory 1898-1990. The surveys were addressed to the department heads of each interior design program. Usable responses were received from 153 (71%) of the schools.

The one page survey requested information about the respondents' positions, and whether their programs offered CAD instruction. For those offering CAD, additional information requested included who taught the course(s), when it was offered (level of student), proximity of the facilities and the amount of time spent giving CAD instruction. Responses were coded for computerized statistical analysis. Frequency distributions and descriptive statistics were derived using a statistical computer program.

Seventy-one percent of the surveys returned were completed by the department head or program coordinator at that school. The remainder were filled out by instructors who taught CAD courses (7%), another interior design faculty member (14%), or by others (8%).

**Results**

Of the IDEC interior design programs nationwide, an impressive 89 percent (136 schools) have incorporated CAD instruction. (See Figure 1). Of those offering CAD, 63 percent indicated CAD instruction was offered as part of a required course. (See Figure 2). A few, four percent, voluntarily responded they offer both required and optional CAD courses. As this option was not available on the survey, the actual percentage for schools offering both required, as well as optional course, may be higher.

Eighty-two interior design programs (over 60 percent) had an interior design faculty member teaching CAD. (See Figure 3). About 12 percent of the CAD instruction was taught by architects and, interestingly, 11 percent by industrial science instructors. Responses in an 'other' category included engineering (3%) and technology education (2%), while apparel design, agricultural science and architectural drafting each had one percent of the programs' instruction.

CAD instruction begins at varying levels in the surveyed programs. (See Figure 4). Only 10 percent of the programs begin CAD instruction during the freshmen year. It is more common at the sophomore and junior levels. CAD instruction begins at the sophomore year in 37 percent (50 schools) of the programs, with almost an equal percentage, 36 percent (49 schools), beginning their instruction during the junior level. Only 16 percent of the programs begin teaching CAD during the senior year. Several respondents explained that CAD was introduced, in their programs, in small segments during the freshmen year and then included in various studio projects throughout the courses offered before graduation.

Time spent giving CAD instruction also varied. (See Figure 5). Fifty-one percent or 110 programs offered a one semester CAD course. Twenty-two percent of the programs required more than a semester or quarter, while 16 percent of the programs spent a quarter teaching CAD to their interior design students.

CAD courses were taught within 57 percent of the interior design facilities while 32 percent were taught in facilities across campus. (See Figure 6). Several respondents (7 percent) indicated that the facilities were across campus but that they were considered interior design facilities.

**Discussion**

CAD Issues for Design Education

**Sophomore Review Board**

Recently, it has been observed that certain interior design students who are not exceptional at producing ideas with traditional design tools (T-square, pencil, pen and markers), excel using a CAD system as a communication device. In the past their ability to express their ideas and design solutions may have been hampered by the tools available and their insecurity with the skills to use them.

Proper graphic presentation skills count a great deal in education, as in the design profession. Nationally, many interior design programs select a portion of top students to continue in their upper division program. Usually, a "sophomore review board" evaluates students' abilities by reviewing compiled portfolios and taking grades into consideration. Often, the portfolio is comprised of projects displaying the student's design and drawing skills using "traditional tools" since CAD instruction is typically introduced during the junior/senior levels. The student is expected to demonstrate abilities to communicate design ideas using traditional tools. If the Board decides a student lacks these skills, he or she are is not allowed to continue in the program, and subsequently, in the design field (Whiteside-Dickson & Rothgeb, 1989). If we assume that some students' abilities to express design solutions have been hampered by the available tools, interior design programs may need to rethink their decision criteria, portfolio content, and/or placement of CAD instruction.

Individual student attitudes and personality traits, may also be part of the reason the computer is easier and, therefore, more desirable to use than the typical design tools. With the increased use of CAD, we may discover that students who were not "artsy" enough to competently communicate their ideas using typical design tools, excel with computer graphics. Their ideas and designs, goals to be designers, and needs can be expressed through, what is still labelled a non-traditional medium. Individuals with personality traits more compatible with computer usage may surprise us with the quality designs they produce. One might say that a communication gap has been breached. An entire new breed of designers may be on the horizon.

## CAD Instruction in ID Programs

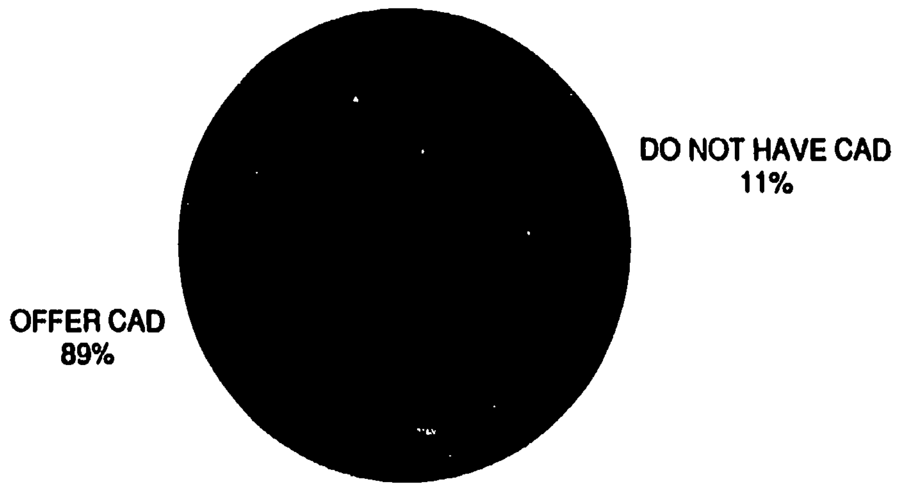


Figure 1

## Required/Optional Courses

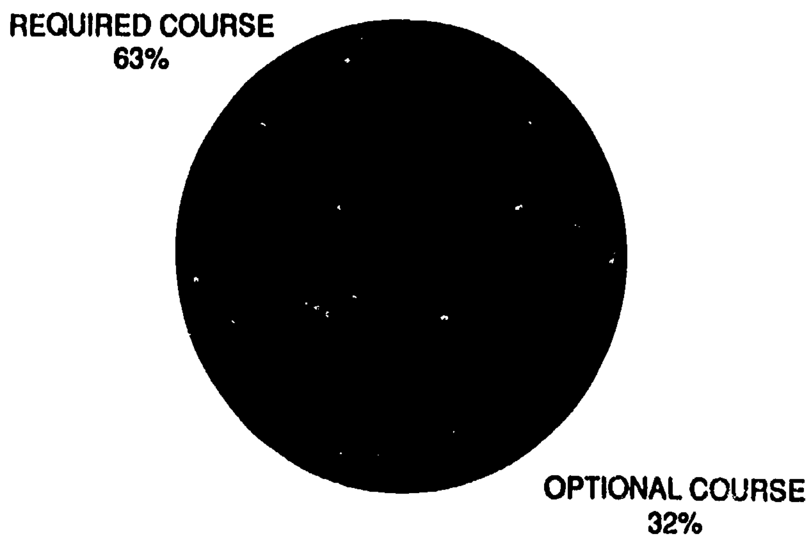


Figure 2

## Instructors of CAD

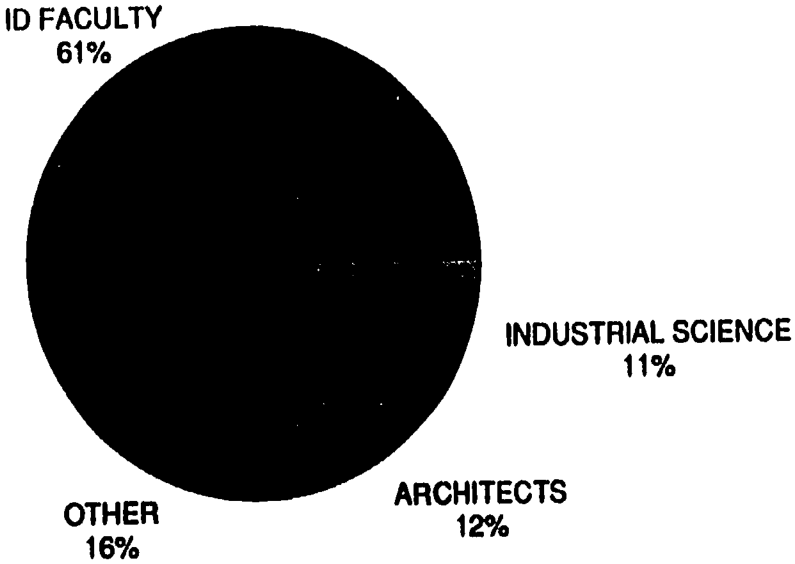


Figure 3

## Level CAD Instruction Given

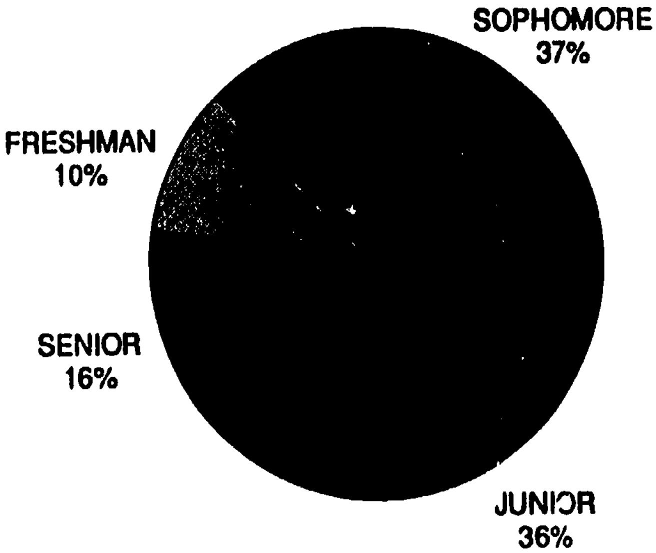


Figure 4

# Time Spent on CAD Instruction

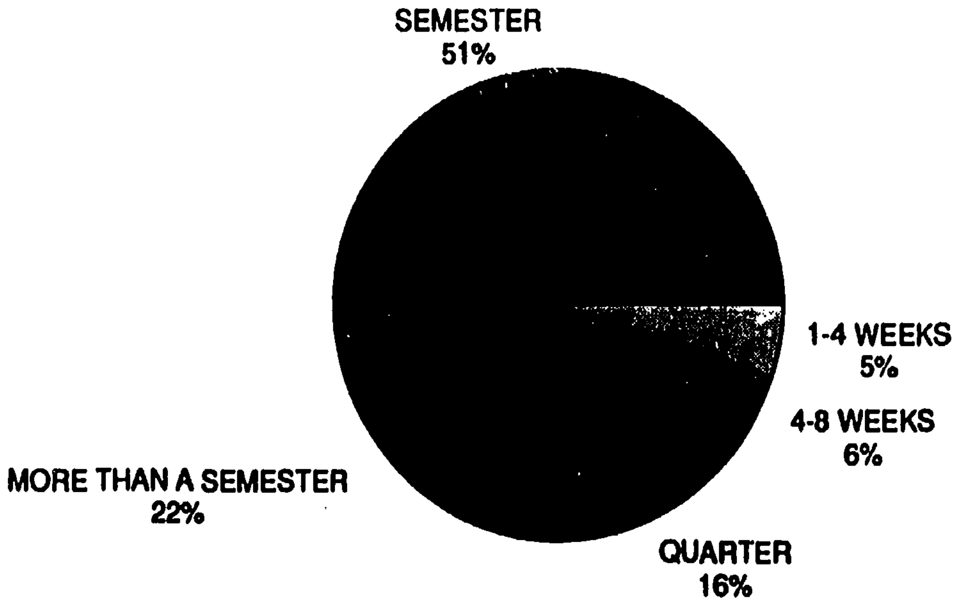


Figure 5

# Location of CAD Course

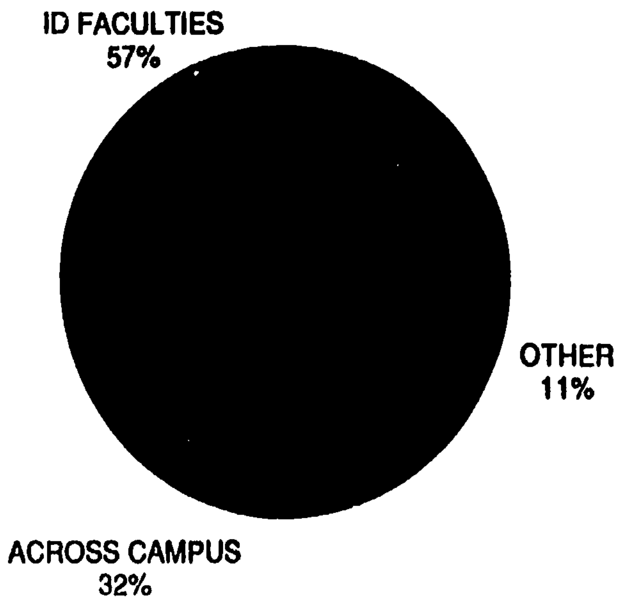


Figure 6

**Continuing Education for Design Educators**

Continued education of faculty is another issue to be addressed with the implementation of CAD instruction. New releases of software packages appear on the market annually, if not more frequently. Thus, incentives such as release time or funds for continuing education may need to be given by the administration so that CAD is implemented in other courses and programs. A successful example of this is Purdue University's Interior Design Program (Inman, 1990).

The department head allowed each semester, two faculty members release time to develop a two-week module of CAD for implementation into an existing course. CAD instruction was successfully implemented from the freshmen to senior levels in studio and lecture classes.

A college, university or area "user group" might be one solution for keeping abreast of new software releases. Continuing education courses at nearby community colleges during the summer may benefit both faculty and community college personnel. Annual conferences and workshops, such as ADCIS's, are other avenues for remaining current on software/hardware revisions, assignments, and new teaching techniques.

**Summary**

This study investigated the prevalence of interior design programs nationwide that offered CAD instruction to their students. It is apparent that the adoption process of CAD as a design tool, despite its controversial disadvantages, is escalating in design education in an attempt to meet or surpass needs of the field.

CAD has become an important part of interior design curriculum as indicated by the high level of interest in the study expressed by the number of surveys returned (71 percent) and the percentage of schools incorporating CAD (89 percent). The majority of instruction is being offered by interior design faculty for a semester during the sophomore or junior level. This indicates that interior design educators have shown leadership developing a crucial component of their curriculum.

With the use of CAD in interior design education, many issues are developing which need our attention. We may discover that design students who were not competent to communicate their ideas using typical design tools, excel with computer graphics. The make-up of the design community may change as those typically unskilled with traditional tools grasp the intricacies of computer graphics and enter the design profession.

Technology, when used appropriately, can improve teacher efficiency, creativity, productivity, and professionalism. Emphasis must be placed on the ongoing education of faculty to fully take advantage of the tools currently available and being planned for the future. (Charp, 1989). The interior design field is counting on the graduates produced from these programs to act as catalysts in the implementation or continuation of CAD usage within their firms.

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# INTEGRATING COMPUTER AIDED DESIGN AND DRAFTING (CADD) INTO INTERIOR, APPAREL AND DISPLAY DESIGN COURSES

*Diane M.Davis, Valparaiso University*

**ABSTRACT**
CADD applications in interior design, fashion design and visual merchandising are a growing reality. Students entering these professions therefore must be CADD literate. To help students meet this challenge, the author has chosen an approach of integrating computer experiences into existing coursework with the objective of using the computer as a design tool rather than as a specific computer system to be mastered.

**INTRODUCTION**
CADD applications in interior design, fashion design and visual merchandising are a growing reality. Consequently, educators are faced with multiple demands. One, they must learn to use the computer and its myriad of software applications; two, they must help students develop necessary computer skills to prepare for the job market; and three, they can offer retraining for professionals who were not exposed to CADD in their formal educational training.

Faced with these challenges, it seemed inappropriate to train students or myself on only one specific hardware and software system since the application needs vary between and within each discipline. Also, time does not stand still for the computer industry and the one thing we can be sure of is short-term obsolescence for whatever systems we learn and teach.

I therefore made the decision that I wanted my students to learn *how to learn* to use computers so that they would have the confidence to learn whatever system the work world presented. To meet these objectives, CADD projects were integrated into a major portion of their design courses. In all cases, one of the main objectives of each project was to approach the computer as a design tool. Therefore, project concepts were determined first and the commands necessary to execute the projects were identified second. This approach ensured that the emphasis was on using the computer as a tool in the design process rather than learning specific hardware and software first and applying that knowledge later. The majority of projects were completed within 20 instructional hours. A moderate amount of additional hours out of class were necessary in most instances.

A variety of computer software and hardware was used for the projects, and these decisions were usually determined by availability. Most of the projects, however, could be done on several different hardware-software combinations. Projects relying on drafting features were done on either Macintosh with MicroStation by Intergraph or on a PC with AutoCad. Projects relying on graphics features were done on Macintosh with either FreeHand by Aldus or Illustrator by Adobe.

**INTERIOR DESIGN**

**Background**
The use of CADD in architectural design has long been documented in trade and academic journals. Now its application in the interior design profession is also being documented. Loebelson (1988) reported the percentage of top interior design firms using CADD continued to increase dramatically from 49% in 1986, to 58% in 1987, and 69% in 1988. In 1989 the trend continued upward to 92% for the the top 100 firms. (Lobelson, 1989)

Educators are looking to the profession to help develop necessary programs for training students. In a study to assess the need for CADD training in interior design programs, Clemons and McCullough (1989) reported that 90% of a random sample of members of the American Society of Interior Designers felt that interior design students upon graduation should have CADD skills as well as manual drafting skills.

**CADD Projects for Interior Design**

**Design Fundamentals Project Based on the Concept of Line**
***Objectives.***
Interior designers must deal wit line in a variety of ways such as contours of building details and furniture details, and as a design

element on fabrics, carpeting, wall coverings. Therefore, the objectives of this project were to help students observe lines in the world around them, to recognize the visual rhythm lines can create, explore the physical characteristics of line, to create visual rhythm with line, and to experience CAD as a tool in creating linear designs.

***Description.***
In this project, students were asked to create a minimum of 4 linear designs using the computer. The arrangement of the linear elements within the designs was to reflect a specific type of visual rhythm. This rhythm could be achieved by line placement, line repetition and/or variation in line shape, thickness, lightness, or darkness. Sources of inspiration for the designs were to come from either a linear translation students had made from a photograph or from a line drawing of a campus building. One of the designs was to be refined and matted for a formal presentation.

***Solutions.***
...re 1 is an example of student work.( Figure ...ine Project Solution by Amy Rohlk, ...raiso University.)

***Summary.***
This project allowed students to become familiar with the hardware and software while exploring multiple design solutions involving line. When a similar project which used paper and pencil techniques was used, students were more hesitant to explore multiple options than they were with the computer. Also, the design solutions created on the computer were more refined than those created with paper and pencil techniques.

**Floorplan-to-Isometric Projection Project.**
***Objectives.***
It is often difficult for students to see the relationship between a 2-dimension plan and the 3-dimensional reality of the completed space. Isometric and perspective projections are commonly used methods of 3-dimensional visualization, but they are usually hand-drawn, time intensive and difficult for students to learn. It was not intended that this project replace learning hand-drawn perspectives. Instead, the objective of the project was to help students:

- explore the use of 3-dimensional projections on a small aspect of a larger project while in the process of developing the 2-dimensional plan view and the elevations;
- utilize the computer's ease of generating multiple elevation and perspective views; stimulate interest in the power of the computer; and
- motivate students to want to do more with the computer.

***Description.***
In this project students were asked to select a small segment of a larger floor plan which contained furniture, fixtures, cabinetry or office systems. In AutoCAD, the 3-dimensional elements of height and elevation for perspective projection and elevation views were entered when the plan view was created. The final perspectives were plotted and rendered off of the computer in multiple media depending upon student preference. In MicroStation they entered elements in both plan and elevated views while watching the results of what was happening in the isometric view since all views could be open at the same time. Final elevations were plotted and rendered in color off of the computer.

***Summary.***
In the AutoCad project, most students felt that the project not only helped them to learn to use AutoCad, but also to help them visualize the workstation in multiple views. (Davis, 1991) Anonymous student feedback in the MicroStation project indicated that students felt that:
- plan, elevations and isometrics were easier and quicker on the computer;
- the experience gave them a better idea of how the space might look; and
- problems in the plan of the space were more obvious in the isometric projection and since it was on the computer, it was easier to go back and modify the plan.

**Surface Design Motifs for Interior Furnishings and Clothing.**
***Objectives.***
Interior and apparel designers are often asked to create custom designs for a variety of surface materials. The objectives of this project were for students to study historic and contemporary design motifs, to create new motifs representative of their own place in time, to apply design motifs to specific surfaces, and to experience the power the computer has to manipulate and modify, color, texture, scale.

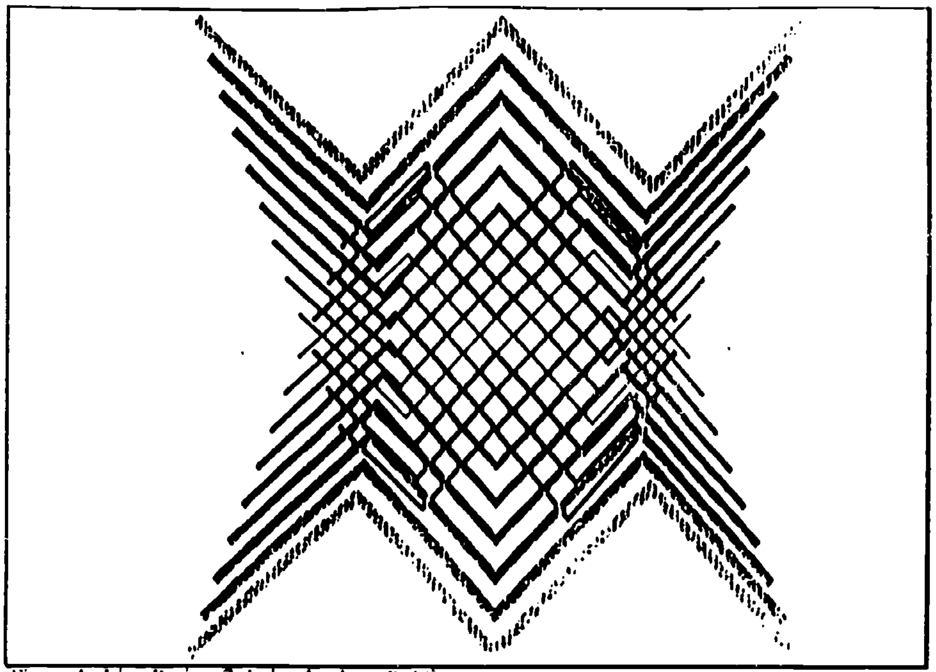

Figure 1. Line Project Solution by Amy Rohlk

***Description.***

Students were asked to research historic and contemporary design motifs found in architecture, clothing, furniture and interior finishes (wall paper, carpet, tile). These motifs, along with a personal motif designed by each student, were then sketched on or scanned into the computer. Next, a variety of grids were developed to which the motifs were added. This resulted in an exploration and manipulation of each motif through repetition, placement, and variations in scale, value and color. After exploratory manipulations, 3 design motifs were chosen for refinement and formal presentation, and one of the three was applied to a surface, e.g. garment, carpet, tile, wall paper, or furniture upholstery. All images were created on the computer. Color was added to Laser printed copies for formal presentations.

***Solutions.***

Figures 2and 3 are examples of solutions to this project. ( Figure 2. Surface Design Project by Lynn Barkan, Valparaiso University and Figure 3. Surface Design Project Application by Beverly Parks, Valparaiso University)

***Summary.***

Anonymous student feedback revealed that students felt that this project helped them to learn:

- more about historic design motifs;
- how to use a grid to create a repeated motif design;
- how to use MicroStation; and
- how a motif was transformed when repeated and applied to the surface of an object.

**APPAREL DESIGN**

**Background**

The apparel design and manufacturing field is also experiencing computerization growth. According to Van De Bogart (1989) the U.S. apparel industry has faced severe job losses over the last 10 years because of stiff competition from countries who can produce more goods for less through automated equipment. This industry, which is second in size only to the oil industry, is moving toward computerization. According to the American Association of Apparel Manufacturers, in a period of five years the industry has gone from less than 5 percent computerization to the point where at least one quarter of the estimated 40,000 plus fashion designers working in the United States use computers. While this growth is strong, it still places the U.S. behind Europe and Japan (Van De Bogart, 1990).

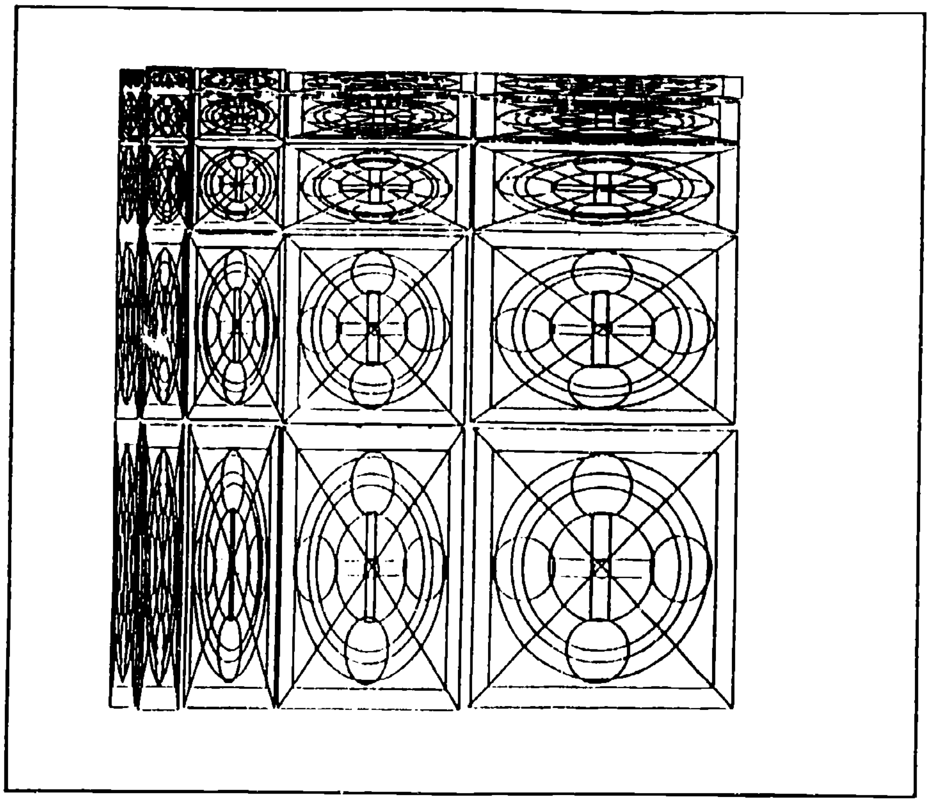

Figure 2. Surface Design Project by Lynn Barkan, Valparaiso University

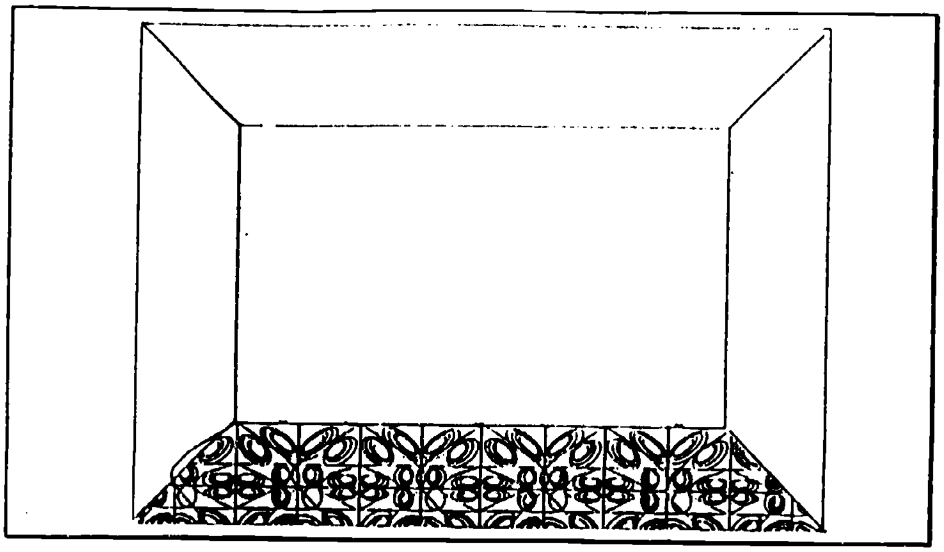

Figure 3. Surface Design Project Application by Beverly Parks, Valparaiso University

With respect to computer education for current design students, Van De Bogart (1989) reports that Van Fossen, President of Computer Design Inc. "...feels that seasoned designers will probably not change over to computerized designing of clothes, but that new designers who have grown up with computers will." (p. 30) Gwendolyn J. Sheldon of California State University, Chico feels that the age of new computer-literate designers is upon us and predicted that by 1993, "...designers entering the apparel industry would have to understand the capabilities of, and have hands-on experience with, computerized design, illustration, pattern making, grading, costing, and color matching equipment." (Van De Bogart, 1990, p. 10).

## CADD Projects for Apparel Design

### 3-D Constructions with 2-D Surface Design.

***Objectives.***

The project objectives were to have students become aware of the importance of the interrelationship between the 2- and 3-dimensional aspects of clothing design; to understand the relationship between surface design and the 3-dimensional object; and the explore how the computer can be used to generate patterns for 3-dimensional constructions.

***Description.***

In the following projects students were asked to design a 2-dimensional flat-pattern for a simple, 3-dimensional, geometric shape(square or rectangular box). They were then to create a 2-dimensional design which would work well on the surface of the box. This 3-dimensional box with the patterned surface was then to be constructed out of paper from the plot of the 2-dimensional, flat pattern.

***Solutions.*** Solutions included the creation of a variety of boxes with colored surface designs on all sides. Since the computer generated 2-D patterns were to be cut, scored, and folded into the 3-D form, patterns were plotted on Bristol board with colored pens. One student evolved a more complicated rectangular box design using AutoCAD. The box pattern was then scanned into the Macintosh and graphics for the box surfaces were designed using FreeHand. An AutoCAD box pattern was plotted on bristol board for stability and on the LaserWriter for the surface graphics. The two images were then bonded together with adhesive before the final cutting, scoring and folding process.

***Expansion of this project concept.***

One student expanded the above project by creating a series of three dimensional shapes using AutoCAD, plotting these shapes on colored Canson drawing paper, and creating a 3-dimensional, low relief composition by scoring and folding the shapes. She then took the concept a step further by drawing and plotting simple garments using AutoCAD. These garments and actual fabric samples were then scanned into Aldus FreeHand on the Macintosh using AppleSCAN. The scanned fabric images as well as computer based patterns were then placed on the garment designs. The designs were printed on colored papers, cut out, scored, folded for a 3-dimensional relief effect and mounted on a presentation board.

***Summary.***

These projects not only helped students bridge the gap between 2- and 3-dimensional design, but they also provided them the opportunity to use hardware and software which would best fulfill their project solution needs.

### Apparel Design Using a Historic Electronic Library of Garment Segments.

***Objectives.***

The objectives of this project were to have students integrate information they learn in the history of clothing into the design of contemporary clothing; to learn how to create a line of garments; and to explore the use of CAD as a design tool in the process of designing garments. (In the case of one of the students, the main objective was to design period costumes for the play *Hay Fever* rather than a line of garments.)

***Description.***

In this project students were asked to design a line of garments for today, based on garment designs from the past. They were to explore the use of CAD as a design tool in the process of designing this line, and compare it to traditional paper and pencil techniques. To achieve this, an electronic library of garment segments was created based on styles representative of five, 10-year periods from 1900-1950.(Figure 4 shows a scaled down version of the library.) Line drawings of segments were scanned in so that bodices were aligned to but not attached to skirts, sleeves, and collars. This allowed for ease in mixing. Students were then able to evolve either period costumes using just one time period, or new designs mixing components from any of the 5 periods. For example, they could use a skirt from the 1900's, a bodice from the 1920's and sleeves from the 1920's. They could also modify any of the segments should they wish to do so. For instance a collar could be reshaped into a bodice, or a ankle length shirt could be shorted into a mini length or vice versa.

Data was collected to compare the use of the computer as a design tool with the traditional paper and pencil tools. The class assignment required students to design a line of six garment using the historic garment library as a reference source. Three garments were to be designed using standard paper and pencil techniques and three using CAD. The library was available in hard copy format for the paper and pencil designs, and in electronic format for the computer designed garments. Final rendering of garments was done in each student's own rendering style off of the computer. Students were also required to complete flats and color story boards for the project. Davis (1990) describes the research objectives and results of the study.

***Time.***
Each treatment was two instructional weeks in duration (12 instructional hours). The amount of out-of-class work varied greatly and was greater for the computer generated designs as most students were learning computer skills as well. A longer instructional time would have been preferable, but unfortunately the availability of the computer lab dictated the time frame.

***Expanded Use of the Garment Library.*** The garment library has also been used in connection with an interior design competition project where students were to design a resort hotel. One of the aspects of the project involved designing uniforms for hotel employees. The libraries became a invaluable resource, especially since interior design students had not had experience in apparel design.

***Solutions.***
Even though all students were using the same garment library, their design solutions were quite individualized and varied. The library provided an immediate resource of styles, it allowed for easy and expansive modification, and it allowed for a wide range of design solutions. The project proved to be a good way of integrating CAD into an apparel design course with students of varying computer experience. The hard copy library also appeared to increase the number of design alternatives and variations students considered before developing a garment designs with paper and pencil techniques. Figure 4 shows a portion of the library and Figure 5 shows an example of hotel uniforms designed using the library. (Figure 4. Historic Garment Library Segment created by Diane Davis and Figure 5. Application of the Historic Garment Library for Uniforms for a Resort Hotel by Gail Kanning, Valparaiso University.)

***Summary.***
The implications for using an historic garment library for the design of new and period garments, especially in an electronic format, is very exciting. The project nicely integrates the use of computers into an existing course and provides students from diverse backgrounds with a guided opportunity to integrate historical information into the design process.

## VISUAL MERCHANDISING AND DISPLAY DESIGN

**Background**
Visual merchandising has been slower to integrate the use of CADD in merchandise presentation and display even though CADD is widely used in store design by interior/architectural firms designing for the retail market. It's use as an "in house" tool for merchandise presentation and display design has lagged behind because of the lack of CADD trained personnel in these areas (Davis 1985). This, of course, is not true for other computer applications in the retail business.

Several educators are beginning to include computer designed displays, merchandising plans, and fixture planograms as part of their visual merchandising curriculum (Dilbeck, 1990; Mehlhoff, 1990; Miller, 1990).

### CADD Projects for Visual Merchandising and Display Design

**Balance Through Size Variation and Placement Project.**
***Objectives.***
Visually strong merchandise presentation relies on the basic elements and principles used by all facets of design. Balance is one of the principles very critical to display design. The objectives of this project were to help students understand the principles of symmetrical and asymmetrical balance, to understand positive and negative space, to learn to use the computer as a design tool, and to see how efficiently the computer can replicate and move shapes. This project has also been used with interior design students.

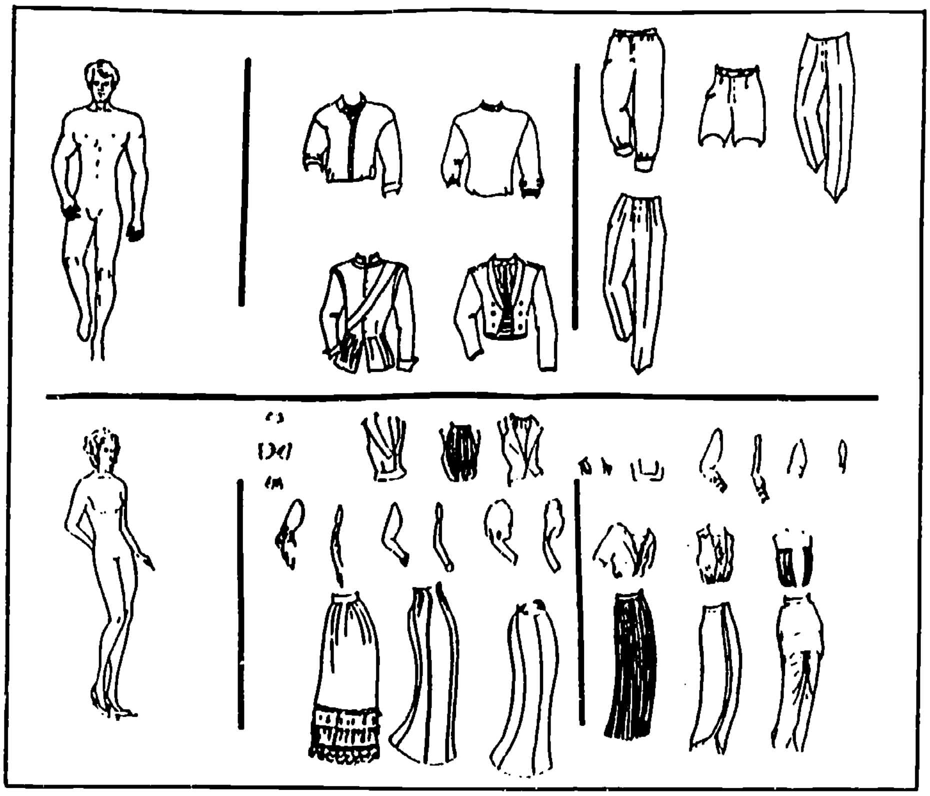

Figure 4. Historic Garment Library Segment Created by Diane Davis, Valparaiso University

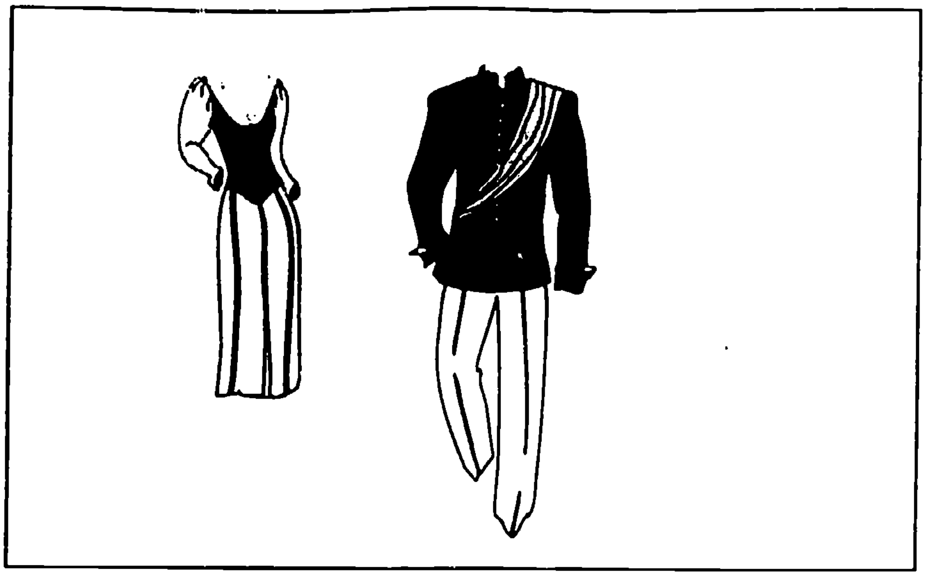

Figure 5. Application of the Historic Garment Library for Uniforms for a Resort Hotel by Gail Kanning, Valparaiso University

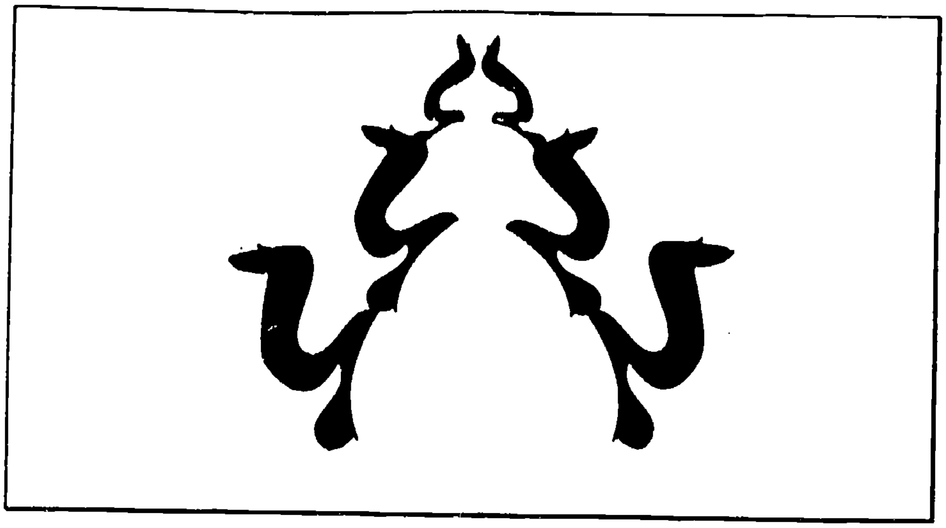

Figure 6. Symmetrical Balance Project by Stephanie Moehring, Purdue University

*Description.*
In this projects, students were asked to design two compositions, one symmetrical and one asymmetrical. In the symmetrical design, one shape was to be created and repeated or copied five times for a total of six shapes. The shapes were scaled in size so that two were large, two medium and two small. These shapes were then arranged symmetrically within a 6"x 6"" square. For the asymmetrical design, one shape was created and scaled five times creating a range in size from large to small. These five shapes were then arranged asymmetrically within a 4"x 6"" rectangle.

*Solutions.*
Figure 6 shows and example of a symmetrical balance solution for this project. (Figure 6. Symmetrical Balance Project by Stephanie Moehring, Purdue University.) The project proved to be a good introduction to the computer. It allowed for exploration in the development of the design shape and in the placement of the shapes before a student selected a solution. The ease and accuracy of scaling and duplicating the shape resulted in visually stronger and better crafted compositions than when the project was used with a cut paper technique.

**Display Design and Signage Development Projects.**

*Description.*
In a visual merchandising class, students designed, constructed and installed displays for local merchants. As part of these display they were asked to present their design ideas to the instructor and the retailer before constructing the displays. Their display designs were therefore represented in a plan and an elevated view. These views along with display signage were executed on the computer.

*Objectives.*
The objectives of this project were to guide students in graphically working out their display designs; to familiarize them with the concepts of floor plans and elevations; to help them develop visual presentation skills; and to give them some experience using the computer as a design tool.

*Summary.*
Students did learn the concepts of plan and elevation views, and they chose to use the computer for creating signs rather than the Kroy sign making equipment because of its flexibility and font options..

**SUMMARY**
These projects have been effective in integrating CADD into a variety of design courses. This integrative approach appears to aid in the assimilation and retention of computer learning in that computer commands are focused on specific, meaningful tasks. These commands are presented and practiced within the design process rather than being presented as separate commands and functions with little time for manipulative practice. The testing of this hypothesis is an area where future research could be conducted. Project revisions and additions can be anticipated as students gain more CADD experience. As students of the future begin their college years with greater computer literacy, projects and applications will become more expansive and CADD will truly be a common design tool.

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# ELUCIDATING TIME MANAGEMENT ACCOUNTABILITY THROUGH SPREADSHEET ANALYSES

*Thomas L. Houser, The University of Tennessee,*

**Abstract**
In service professions such as architecture, engineering and interior design, fees are determined on an hourly or project basis. Either base challenges the professional's time management accountability. Firms maintain detailed records to vouch for efficiency and effectiveness and to predict requisite staff commitments for future projects. Accountability is critical to the individual and the firm's success.

The challenge for the educator lies in cultivating the student's sensitivity to time management principles. To address this challenge, computer-based spreadsheet exercises have been developed to record and analyze time usage. These timesheet projects have been used in microcomputer applications and business procedures classes. Students delineate coursework and employment activities for a minimum of three months, entering this information into spreadsheets beginning midway through the study. They then extract and make analyses of pertinent data. Students also prepare tables and graphs by using the application's chart commands or by running macros developed for the project. Representative analyses include comparisons of time spent on academic and non-academic endeavors, distribution of efforts among tasks associated with specific courses; patterns of effective time management displayed throughout each week and over the term; and percentages of effort relegated to individual commitments.

Through course evaluations, students have indicated these exercises to be beneficial. Findings reflect enhanced sensitivities to accountability and improved effectiveness in time management.

**Background**
Effective time management is important for everyone. . . . To manage time successfully, you must firmly believe that every demand on your time is a request to give up the most valuable thing you possess (American Institute of Architects [AIA], 1988, p. 22).

Although professionals in all fields appreciate the significance of effective time management, they often find it challenging to practice the principles behind it. The proliferation of articles on the topic highlights this point. Just one reference database, limited to business and management journals, indexes 494 articles on this topic over the past five years, nearly two per week (ABI/INFORM(R) Ondisc, 1991).

The first step toward understanding time management is knowing how one actually spends time. Architects, engineers and interior designers maintain timesheets to account for their time usage and to track progress on projects. Although used primarily for billing purposes, data collected from timesheets can be used to analyze time management effectiveness.

From a business perspective, timesheets are very important for several reasons. Managers use these records to monitor the performance of individual staff members and of their departments. They employ project data as historic gauges while preparing contract proposals, first using it to anticipate potential staff commitments, and then, to determine fees. Once a contract is secured, managers again refer to past records to make project assignments and to prepare project flow charts. Occasionally, they reference timesheet notes when justifying invoices or while defending the firm's actions. For these reasons, the designer's diligence in recording time directly affects the firm's profits and losses. Misleading data lead to unrealistic fee proposals and to unachievable performance expectations, two unrelenting origins of financial fiascoes.

A common marketing attitude places additional pressure on the professional's time management skills. In their discussion of ways to garner increased profits, Getz & Stasiowski (1984) suggest that the manager compress the project's schedule and have the staff work overtime to complete it. This creates more "profitable projects by reducing excess perfection, . . . [possibly] without incurring

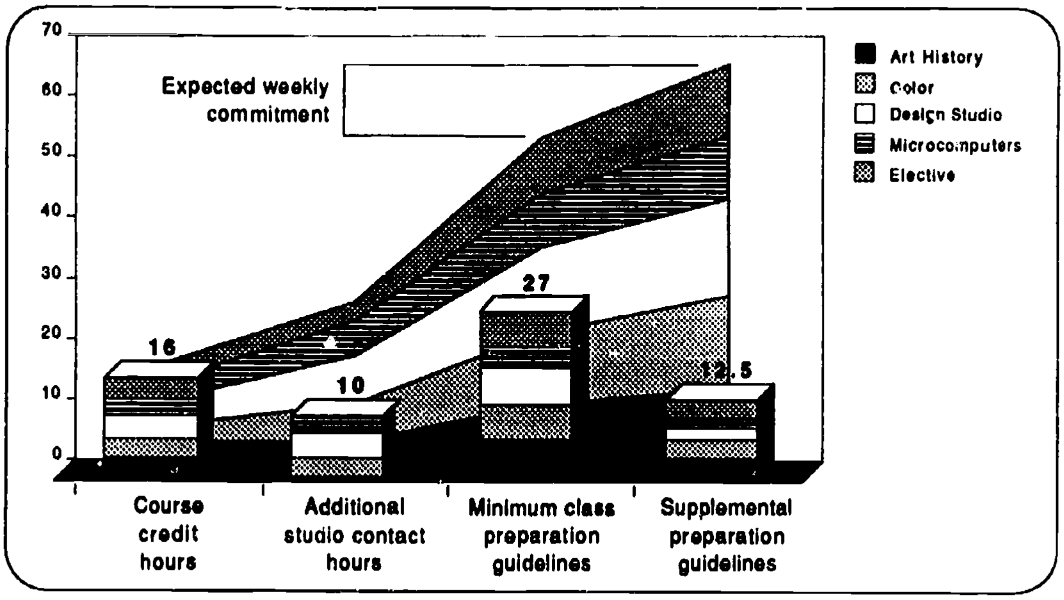


Figure 1 Weekly time allocation expectations related to one semester's curriculum. (The stacked bar charts represent components of course efforts. The area chart reflects the impact each component has on the weelly commitments.)

additional salary or overhead costs (p. 51). "Reducing excess perfection" challenges designers' professional standards, and working overtime, often without compensation, adds stress to their professional and personal lives. Proficient time management, even in this type setting, presents the designer with the opportunity to create higher quality projects in less time. In this sense, designers are accountable to themselves to develop efficient time usage patterns.

The expanded use of microcomputers provides another rationale for this project. Crosley notes, "the thinker [is becoming] the doer," and professionals now perform many of the tasks that secretaries finished in the past (1989, p. 109). Significantly, a recent AIA report reveals that financial management software, used in part for time record management, is the third most popular type of computer applications program used in architectural firms -- preceded by word processing and specification-writing software, and followed by computer-aided design programs (Witte, 1990, p. 113). Some applications recommended for smaller firms, e.g. Timeslips III, track the duration of activities as they are being performed. The programs then use this data to generate invoices (Tully, 1990). The designer is the catalyst for the entire time record keeping process. As a credential, computer literacy is more important than ever.

Students experience significant demands on their time management abilities, too. They must balance curricular, extracurricular, social, and, often, employment activities. The magnitude of this challenge can be illuminated through an examination of course requirements and professorial expectations. During one semester at the University of Tennessee, interior design students take 16 hours of coursework, spend 26 hours a week in class, and are expected to commit 27 to 39.5 hours on outside preparation (see Figure 1). For 16 hours of credit, students, ideally, consume from 53 to 65.5 hours of their time each week (Houser, 1991).

The student's perception of self-initiated time management is a critical factor in controlling anxiety. After a recent study of correlations between academic performance and stress, Dipboye and Phillips (1990) reported that "students who perceived [effective self-]control of their time reported significantly greater evaluations of their performance, greater work and life satisfaction. . . and fewer job induced and somatic tensions" (p. 760).

Timesheet Project. A computer-based spreadsheet project can address all these challenges. Students in microcomputer applications and business practices courses use the timesheet exercises described here. Procedures are modified to reflect course objectives. In microcomputer classes more emphasis is placed on the spreadsheet; in business practices more is placed on time management.

The objectives behind this timesheet project are (a) to develop procedures for analyzing time usage, (b) to cultivate the student's sensitivity to time management accountability, (c) to foster computer literacy, and (d) to create an extensive database upon which to conduct related research.

Students delineate coursework, employment and miscellaneous activities for three months. They begin maintaining timesheets during the second week of the semester, after comprehensive time management discussions during the first. Midway through the project students begin entering information into computer spreadsheets. With this data as tangible evidence, they analyze their time usage from multiple quantitative perspectives. They also examine their records in light of intangible time management concepts, e.g., intent vs. reality, planning vs. reacting, and organizing vs. drifting. The last two weeks of the semester are not recorded to allow the students to complete their projects.

The validity of self-reported data is critical. Student integrity is nurtured through an atmosphere of trust among the students and the instructor. They are reminded regularly that the underlying objective of the project is for them to understand how they use their time. This cannot be accomplished without accurate records. At no time should students feel threatened by conclusions drawn from their data; nor should they feel elation from receiving external praise. Both threats and kudos can encourage the submission of dishonest information. Therefore, students are neither rewarded, nor punished for spreadsheet findings.

Project grades are based on students' record keeping abilities: not on how they spend time, but on how effectively they record and analyze it. As the study proceeds they are encouraged to discover and address emerging time usage patterns, but their project grades are not contingent upon demonstrating improved time management skills. Accountability is the issue here.

Although timesheets are collected weekly, they are checked during other class periods and during chance encounters outside class. Frequent examination engenders accuracy by ensuring records are current and by reducing post facto guesswork by procrastinators (see AIA, Ch. 1.11, p. 18).

Since they know their projects are part of a larger study, students are assured of anonymity in ensuing research procedures and reports. This non-disclosure policy helps counter vested interests that may encourage the reporting of specious information.

**Project Methodology**

Students maintain time records in manners similar to those employed by professionals (see, for example, Getz, 1984, p. 128). The students:

*identify projects by name and number;
*indicate generic tasks and activities;
*make germane observations on specific activities; and
*tally the duration of each project effort.

Further, they log activities based on specific ground rules adapted from accepted professional procedures (see Figure 2).

**Using Timesheet Formats.** Students use two timesheet formats: hourly and weekly (see Figure 3). The first tracks activities throughout each day and the second summarizes them by the week. Students submit both timesheets for review and comments, before entering data into the computer.

A chronological timesheet is an efficient instrument for daily record keeping. Because of the erratic nature of students' schedules, each form is subdivided into 15 minute segments around the clock. The student makes a new entry each time a task is begun and then notes its duration. After the day's activities are complete, the student indicates subtotals for each project:task combination.

Students use the second timesheet format to summarize all activities for the week. Each row of the timesheet represents daily subtotals for one type of task on a specific project. Students transfer the information entered onto this form into the computer spreadsheet's database, after it has been edited for inconsistencies with their daily timesheets.

**Entering the Spreadsheet Database.** At this point each student starts entering records into a preestablished database, the part of a spreadsheet that contains the data to be analyzed later. The database for this project includes the 12 fields discussed below.

1. Maintaining time records requires self-discipline. Keep your timesheets with you as you go through your day. If you make an entry each time your activities change, your records will be accurate. It is difficult to be precise if you wait until the end of the day to make entries.
2. Record time in 15 minute intervals. This will require some judicious decision-making, as few activities start and stop on the quarter hour. In general, round an extra five minutes down, and ten up. To keep from under- or over-crediting routine activities, reverse this process periodically. The approach you take is assumed to be relatively consistent throughout the study.
3. Use decimals to record partial hours: record *15*, *30* and *45* minutes as *.25*, *.50*, and *.75*, respectively.
4. Do not record time spent in transit between home and the university or your place of employment.
5. Once the first activity occurs at the university, record time spent traveling to the next with the latter. For example, record the 10 minutes it takes to cross campus to a 50 minute lecture with that class' time: log one hour for the course. This is consistent with the professional practice of charging travel time to a specific design project.
6. Only record SOCIAL time between 8:00 a.m. and 5:00 p.m., Monday through Friday, excluding time for meals and personal errands. You will note the effects interruptions have on the productive parts of your day. Professionals account for every minute during the work day. Assignments not completed by "quitting time" must be finished on overtime.
7. ILLNESS, EMERGENCY and HOLIDAY are special project categories. Entries for these can occur only on a weekday between 8:00 a.m. and 5:00 p.m. and must equal eight hours or fewer. When productive entries occur on the same day, record the difference between the productive activities and eight hours. For example, if you work on a paper from 7:30 to 9:45 p.m. on Tuesday during spring break, make a 2-1/4 hour entry for the class and record a 5-3/4 one under HOLIDAY. If coursework or employment activities last longer than eight hours, no entries are made under these three categories.
8. HOLIDAY entries preempt ILLNESS, EMERGENCY and SOCIAL ones.
9. If you have a job in which you are allowed to study while "on the clock" subtract productive coursework efforts from your EMPLOYMENT entries. This is comparable to the professional practice of charging indirect time to a specific project.

Figure 2 Ground rules established for students to record information.

Week: Weeks are numbered to simplify extracting information from databases. Classroom experience has shown that students find it difficult to extract information based on dates.

Project identification. This coding system provides thebase for organizing data. Course designations consist of three letters and three numbers. (Note the use of three letters is critical: It prevents the software from confusing Project IDs with cell references.) One word identifiers are used for EMPLOYMENT, ILLNESS, EMERGENCY and SOCIAL activities. Subnumbers divide a project identification into components. For example in a third-year studio class, IDE340.00 encompasses general activities, IDE340.01 represents the first project, and IDE340.02 the second. Likewise, EMPLOY.01 may refer to a work-study assignment and EMPLOY.02 to a part-time job at a local design firm. Consistent use of identifiers is critical, as Project IDs are a primary criteria for organizing and extracting spreadsheet information.

Project/class: This text field identifies the project or the subproject. Entries may be as broad as the course name, for example, Art History; or as specific as a project name, such as Giotto paper. This information serves as a check for the accuracy of the entire project record.

Task: The task coding system identifies generic project activities. This provides a means for comparisons of similar activities among courses or projects. The validity of subsequent database analyses is contingent upon the consistent use of task designations by all students.

M, TU, W, TH, F, SA, and SU: Each database record contains the time spent throughout the week on a particular project:task combination. Subtotals for each day are indicated in the appropriate fields. Students are cautioned to leave cells blank if no activity occurs on a particular day. (A zero in a cell distorts certain spreadsheet functions, like Counting or Averaging field entries.)

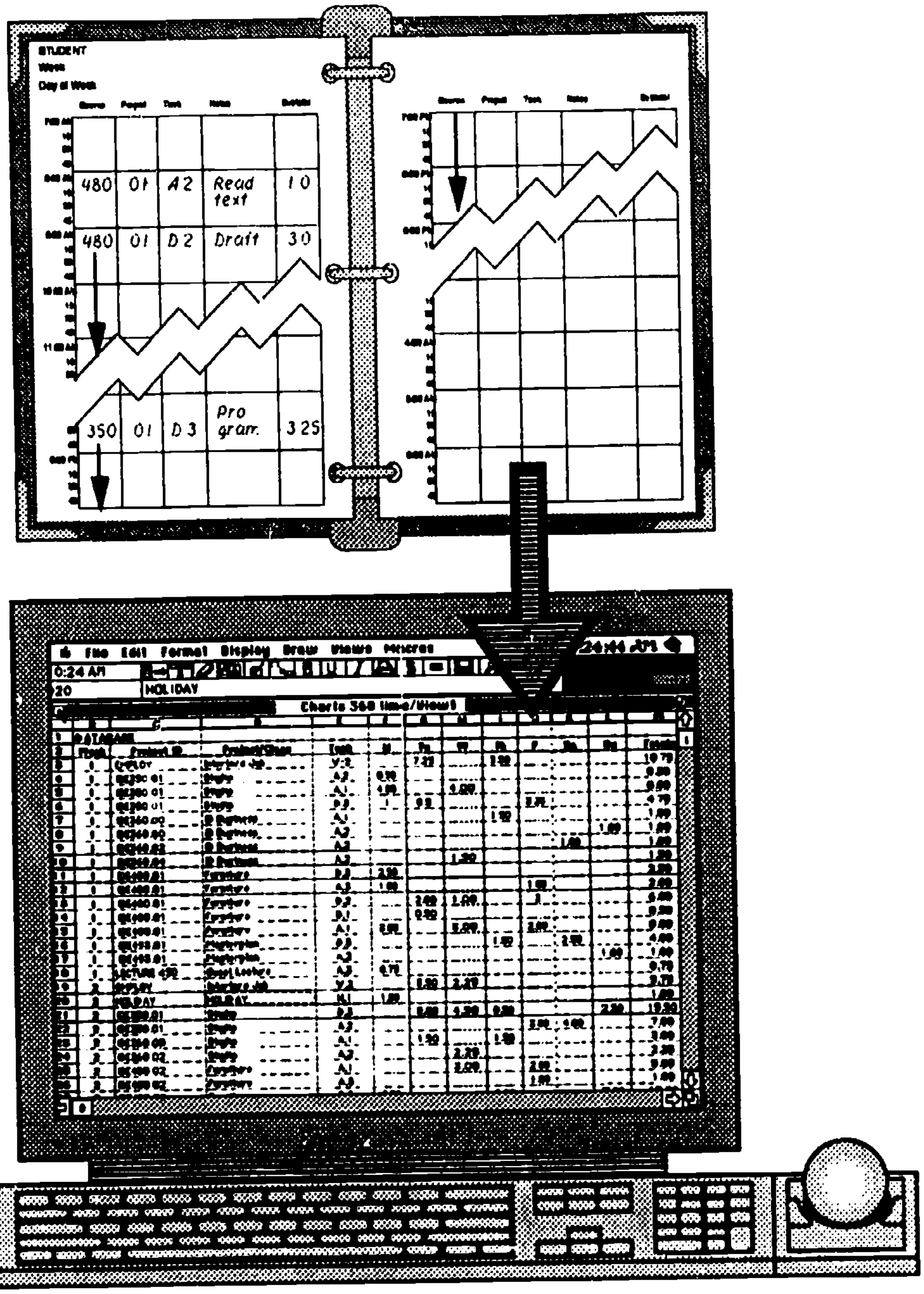


Figure 3 Timesheet formats. (Students maintain daily timesheet information in a 5"x9" binder, and they enter weekly data into the computer spreadsheet.)

| DIRECT TIME | | | INDIRECT TIME |
|---|---|---|---|
| DESIGN TASKS | ACADEMIC TASKS | EMPLOYMENT | GENERAL TASKS |
| D.1 Freehand work | A.1 In class (lecture) | W.1 On-campus | G.1 General |
| D.2 Drafting | A.2 Studying new material | W.2 Off campus | I.1 Illness |
| D.3 Programming | A.3 Reviewing material | | E.1 Emergency |
| | | | S.1 Social |

Figure 4 Primary task designations used in this study.

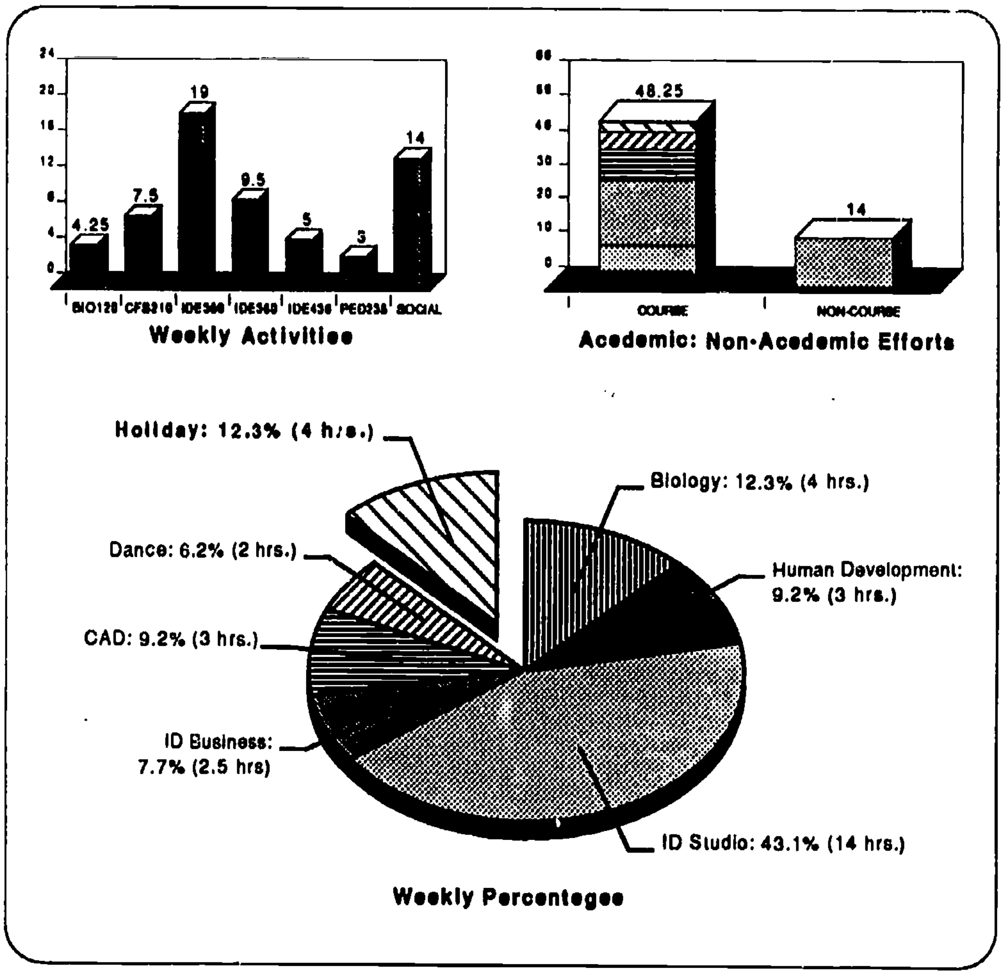


Figure 5 Representative time usage charts based on weekly extracts. (The bar charts depict one student's activities during the fourth week of the project; and the pie chart shows activities during the second week.)

Totals: Because of the presence of preset formulas, the weekly subtotal for each project:task combination appears here automatically. In addition to these fields, the spreadsheet contains a Remarks column next to the database. Students may use this area to explain project activities. Although few students enter comments into this field, most do make observations in the corresponding column on their hand-written timesheets. These notes do not affect computer analyses.

Use of the Task field on this project merits special consideration. In the design professions this information may be subdivided into entries for the project's design phase, e.g. schematics or design development, and for the specific activities, like drafting or space planning. The complexity level employed in coding activities varies significantly among firms. One representative sample identifies 33 design phase and task combinations and eight indirect expense categories (Getz, 1984, p. 129).

Few undergraduate students completely understand the nuances inherent in such a system. After experimenting with the number and type of task designations, 12 have been adopted for the more recent studies: three each for design studios and academic courses; two for employment; and four for personal matters (see Figure 4). Experience has shown this level of detail approximates the understanding of task categories held by most second and third-year students. Greater delineation baffles the younger students, and less nets insufficient data to study work patterns. Although students may add to this list with prior approval, few second, but most third-year students exercise this option.

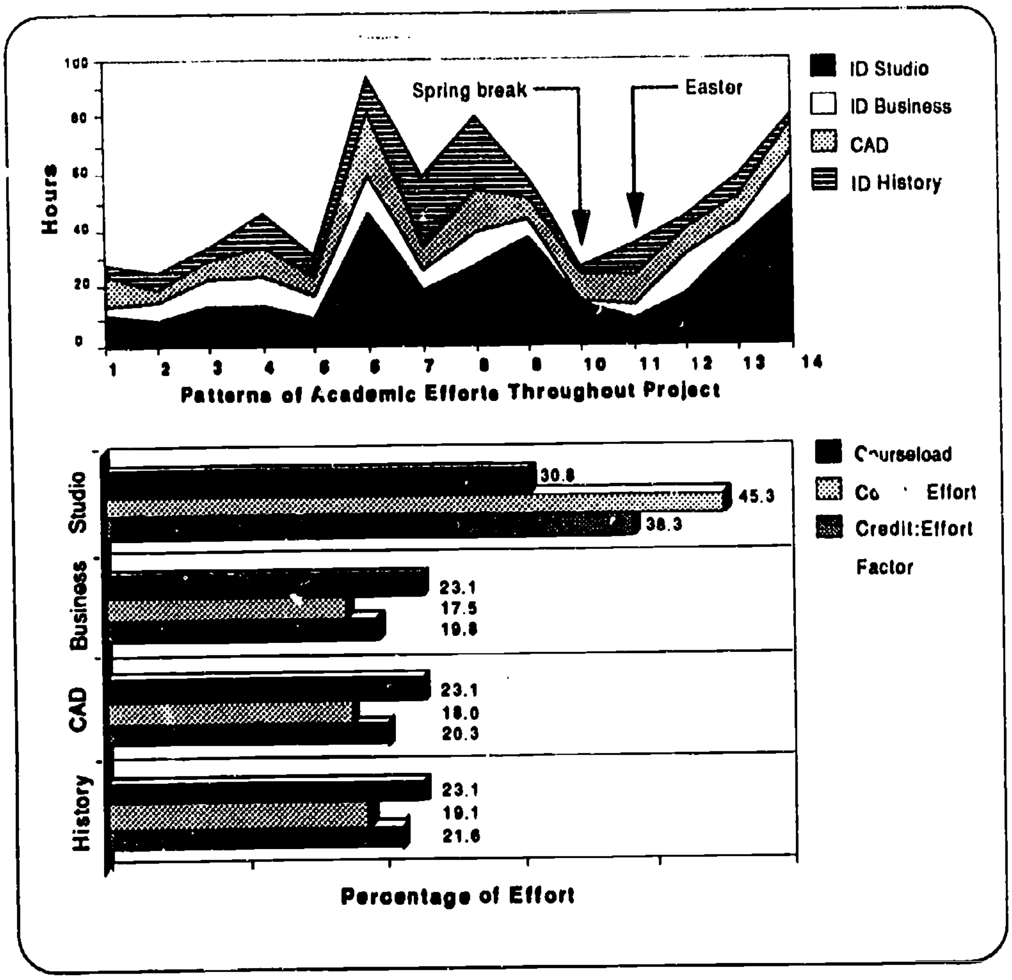


Figure 6 Representative semester-wide time usage charts. (The area chart reveals dramatic, time commitment fluctuations for one course; and the bar chart reflects disproportionate relationships between course credits and the student's efforts. These observations must be qualified. One cannot look just at numbers and conclude the student is spending too much time on one course; or, conversely, conclude that the course demands too much from the student.)

**The Macintosh Environment**

- desktop hierarchy
- opening documents
- menus
- windows
- scrolling procedures
- using the Clipboard
- saving documents

**Spreadsheet Terms and Concepts**

- cells
- columns and fields
- rows and records
- named ranges
- database
- criteria
- criteria ranges
- extract
- output ranges
- text and numbers
- formulas

**FullImpact Procedures**

- selecting cells
- entering data
- adding formulas
- entering cell references
- editing cell contents
- inserting rows
- sorting databases
- using icon bars
- running macros
- creating views
- charting data
- editing charts

Figure 7 Basic software terminology and procedures students need to understand to complete timesheet projects.

By modifying the task coding system, students, educators, or professionals in other disciplines can use this timesheet project effectively. The degree of detail recorded must match both the level of planning the individual is able to achieve and the hierarchy of information that the manager or researcher can extract (see AIA, Ch. 1.11, p. 18).

Extracting Data and Making Reports. Learning how to record time is important, but the significance of this project is analyzing how students use their time. Here is where the power of a computer spreadsheet shines. Here, too, is the point at which one can turn the routine task of keeping timesheets into an illuminating catalyst for self-initiated professional development. Visually oriented design students find the charts prepared in this part of the project to be both appealing and helpful. Almost without exception, skeptical individuals see the value of this projects as soon as the first graph appears on the screen.

Students extract data by weeks, days, project identifications, tasks, durations of time spent, and combinations of these criteria. They then prepare graphs to analyze data and to report their findings. Both weekly and semester-wide efforts are examined (see representative charts in Figures 5 and 6).
Weekly analyses include computing project subtotals; comparing time spent on academic and non-academic endeavors; evaluating percentages of effort among courses; and comparing task efforts associated with specific courses. These weekly analyses provide snapshots of students' efforts. They see the distribution of their efforts among courses, the depth to which they are applying themselves, and the balance they are striking among academic and non-academic activities. They can then use these analyses as a base to address deficiencies in their time management practices.

Semester-wide analyses produce more meaningful information than weekly ones. Most are similar to their briefer counterparts; however, temporary time warps -- caused by factors like tests, due dates, football games and illnesses -- are averaged into the bigger picture. Students gain a truer perspective of their efforts, as these analyses portray trends, as well as data.

Several semester-wide studies deserve additional attention. The first tracks the student's weekly academic efforts throughout the semester. Data linkages connect weekly extracts to a secondary database. Because of these linkages, the software automatically updates the database each time the student adds a weekly extract to the project. An existing area chart, linked to this secondary database, graphically depicts shifting emphases among courses. When reviewing their charts, students can evaluate how working ahead on particular projects could have affected the intensity of their out-of-class commitments throughout the term.

Another significant semester-long analysis examines the percentages of the student's academic commitments among courses. Data linkages to weekly extracts, modified by spreadsheet formulas, create another secondary database. This consists of three fields: The first indicates the percentage of the student's courseload each course represents; the second reflects the percentage of the student's total academic effort each course received; and the third factors the commitment percentage against the course credit percentage. The information is placed automatically into a horizontal bar chart for comparisons. Like the weekly analysis described above, this chart is updated each time the student adds a weekly extract. When reviewing this information, students see how their time allocation decisions impact all of their courses. They can then determine if their priorities are well-placed.

**Computer Techniques.** Students prepare their projects on Apple Macintosh SEs and later models, using Ashton Tate's FullImpact 1.0 and 2.0 spreadsheet programs. Some students enhance their report graphics via Claris' MacDraw II. Note, however, the procedures discussed here can be adapted for different spreadsheet programs on Macintosh and other computer platforms.

In microcomputer courses, students go through FullImpact's computer-based tutorials, and they complete smaller spreadsheet projects before entering data on this one. In professional procedures courses, students learn a minimum of basic spreadsheet terms and operations before they input data from their timesheets (see Figure 7). This enables them to enter information and to see results without becoming overwhelmed by either the computer or the software.

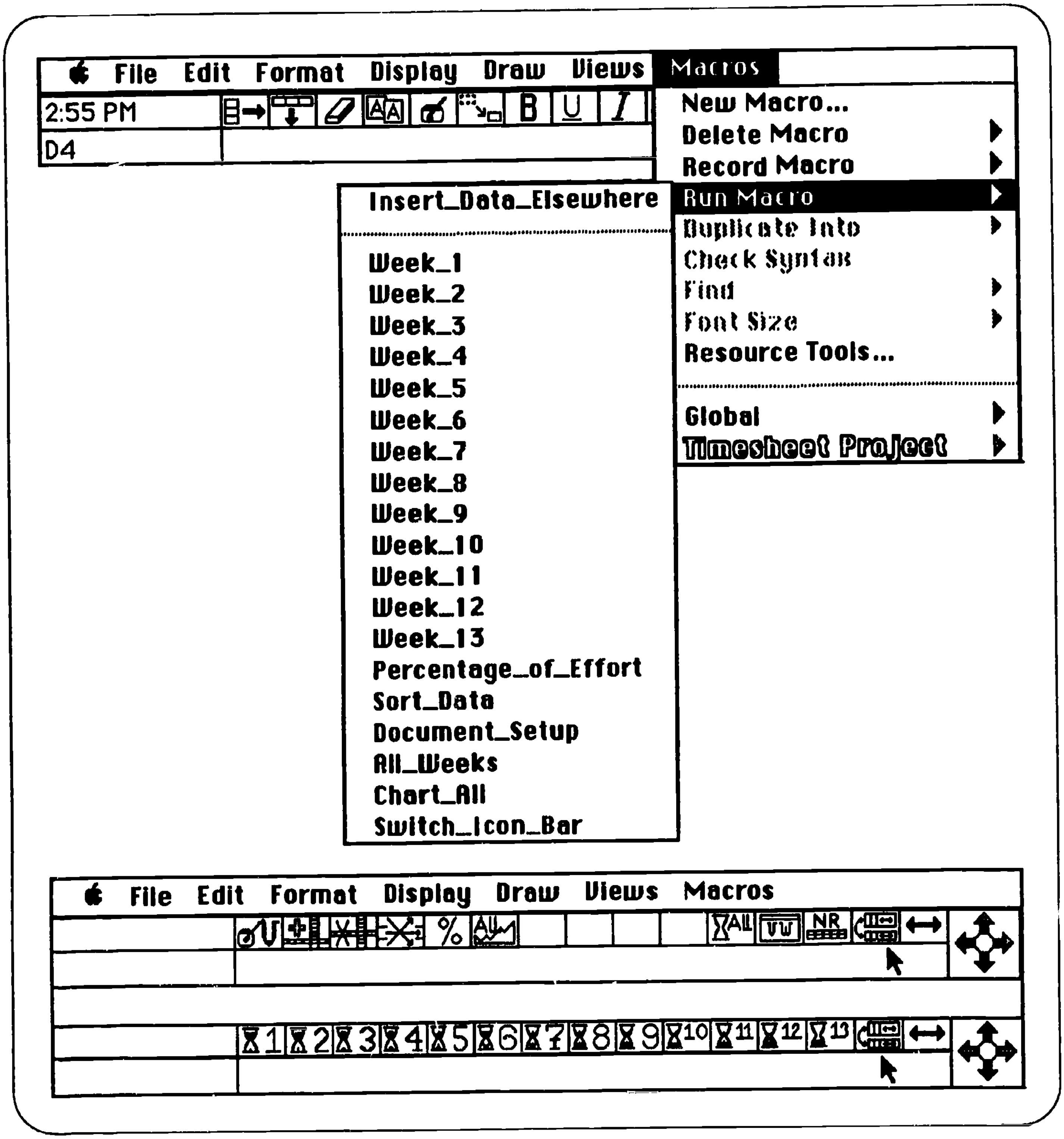


Figure 8 Macros and custom icon bars developed for timesheet project. (Students can switch among these two command bars and FullImpact's standard bars. All but four of these icons launch macros developed for this project. One of the two bars is dedicated to the project's 13 weekly macros.)

Just as students are accountable for how they spend time, so are instructors accountable for how they ask them to spend it. For this reason, students follow one of three sets of procedures for extracting and analyzing database information. Students use Exercise A in microcomputer applications courses. Those in business procedures use Exercises B and C. These two variations reduce the time it takes to complete the project, and thereby, help to meld course and project objectives. (For additional observations about these exercises, see Computer Techniques in the Findings section.)

Exercise A: Students input records into an existing document having a preestablished database range. From this point they prepare all criteria ranges, extracts, charts and reports. Exercise B: As in the first exercise, students input records into a document with an existing database range.

After their records have been reviewed and sorted, they transfer their databases into another document. (In some programs, they could simply switch to new worksheets at this point.) This second document is organized into weekly and semester-wide views. Each view contains all criteria ranges, references, and formulas needed to complete relevant analyses. Students extract information at designated output range locations. They then paste preformatted charts onto their extracts. After editing charts and making observations, the students are finished.

Exercise C: Students follow the procedures prescribed in Exercise B to establish their databases. They then run macros that automatically complete weekly and semester-wide time usage analyses. After editing the spreadsheets and making observations, the students are finished with the project.

**Project Macros.** Stated simply, a macro is a series of prerecorded commands, launched by a single click of the mouse. The nineteen macros I developed for this project are described below. All of these can be accessed through FullImpact's Macro menu, and most can be launched from one of the two custom icon bars, also developed for this project (see Figure 8).

Insert Data Elsewhere macro:
This global macro expedites the process of copying the values of cells containing cell references and/or formulas and entering them into another part of the spreadsheet. This macro performs FullImpact's two-part, Paste Special command. Because the use of the standard Paste command can make cell references and formulas meaningless, this macro replaces formulas with their values before entering data in the new location.

Week 1-13 macros: These local macros:
*extract information from the database according to multiple, prescribed criteria ranges;
*organize that data into tables and charts; and
*place appropriate data into a predetermined report format.

Percentage of Effort and Chart All macros:
These project macros extract data from the output ranges created by the weekly macros and prepares the semester-wide analyses described earlier in the discussion on student reports.
Sort Data macro: This local macro eliminates the data scrambling that occurs if students use the Sort command when their records contain references to cells in other rows. This macro:
*copies the selected data range;
*replaces formulas and cell references with their values;
*pastes the modified data on top of the original;
*sorts the records; and
*reinserts formulas in the line total field.

Document Setup macro:
This macro prepares a new document for this project by setting all page layout parameters, including identifying the course and student. The macro is used once on each project.

Switch Icon Bar macro:
Because FullImpact only allows one custom icon bar at a time, this macro toggles between the two developed for this project. Both custom bars contain an icon for this macro. Students can switch between the two with one click of the mouse, without remembering the steps for loading a new bar.

All Weeks macro:
The longest macro developed for this project merges databases from all timesheets and runs all other macros. I use this macro for grading and research purposes. Because students do not need this macro, it is not included in their documents' Macro menu or icon bars.

**Findings**

Accuracy of Self-Reported Data. Evidence of record keeping accuracy exists in the fact that students willingly reported lower levels of outside activities for my classes than I reasonably could expect, based on assignments and published expectations. Theoretically, had students felt vested interests in "looking good" to me, activities in my courses would have been exaggerated.

For several other courses, students consistently reported semester-wide efforts not much greater than the total class times. In fact, records for one course often showed that students spent less than 32 hours on it over a 13 week period: That class was in session 39 hours! ("My grades went up after I quit going to class," observed one student.)

Additional evidence of accuracy was garnered by:
- •comparing records among students enrolled in the same course sections;
- •verifying significant course assignments, deadlines and exam dates;
- •checking time usage patterns for corresponding increases and decreases among courses; and
- •checking class attendance records.

No significant evidence of implausible timesheet entries existed within the spreadsheets of 56 of the 63 students involved with these projects. Consequently, 89% of the records submitted can be data sources for future studies.

Hand-written Timesheet Formats.
During the first year of the study, students maintained all records on hand-written copies of the weekly form. Some expressed difficulty in tracking which row reflected particular combinations of projects and tasks. The use of daily timesheets alleviated this problem, although students had to transfer information to the weekly format before entering data into their spreadsheets. When this procedure was followed, more students expressed confidence in the accuracy of their databases.

From a spreadsheet perspective, the weekly format has distinct advantages over the daily one. First, it requires fewer entries per week; thus the student can input data more quickly and with fewer chances to make mistakes. Second, this format consumes less computer memory, as both the database and the subsequent extracts are shorter. Third, because many spreadsheet programs recalculate information and regenerate screens slowly, using this format is good time management in itself!

Additional Database Field.
A thirteenth database field, similar to the billing column on most design firms' timesheets, should be added. In professional practice, such a column indicates if a time entry is: (a) billed directly to the client; (b) recorded on the project, but not billed directly to the client; or (c) not billed to the client or charged to a project, but noted as a general activity associated with the operation of the firm (e.g. general meeting, space reorganization, illness, or holiday). These classifications commonly are referred to as billable, record, and non-billable, respectively. (Individual design firms may have additional guidelines for using these classifications.)

For student projects this additional field would be named charge classification, and would indicate if a time entry is: (a) billed to an employer; (b) recorded for the course for attending class or going on a field trip; (c) credited to the course for working outside of class; or (d) not charged, reported or billed to a course or employer, but noted as a general student activity (e.g. sorority or fraternity meeting, emergency, illness, or holiday). To acclimate students to professional jargon, these classifications could be referred to as billable, record, credit, and non-billable, respectively.

Adding this field would provide several significant benefits. It would:
- •simplify some extractions and macros.
- •resolve the issue of how to identify the use of time spent in studio classes (Is it lecture time, or is it project time? In theory it is one or the other: In reality it can fluctuate between the two, depending on the instructor, the students, and the project.).
- •emphasize the amounts of time, or lack thereof, students spend on coursework outside of class.

Computer Techniques.
Students gain valuable spreadsheet experiences by completing Exercise A; however, the project consumes an inordinate amount of total course time for both the students and the instructor.

Although students complete their projects in much less time by following the procedures set in Exercise B, they gain less spreadsheet experience. This approach is more appropriate for business courses than for computer courses, unless students develop additional criteria, extracts, and charts. Moreover, these procedures produce very large spreadsheet documents, in the range of 400,000 - 500,000 bytes each.

By using the macros in Exercise C, students complete their projects in less time, with less effort, and with fewer errors, than by following the either of the preceding methods. Like Exercise B, this approach is more appropriate for non-computer courses. However, the resulting documents are smaller and contain fewer errors. This is also the most efficient of the three exercises for research purposes.

Student Errors.
Working with students on a preestablished spreadsheet is somewhat like playing Russian Roulette on the computer: It's difficult to know what they're going to throw out next!

Experience has shown their more common data entry errors include:

*using inconsistent text entries (project name, spelling, abbreviations, extra spaces)
*omitting information repeated in consecutive records;
*misadding daily subtotals for specific project:task combinations;
*using incorrect decimals, e.g. 45 minutes entered as .45, instead of as .75; and
*entering project identification numbers like cell references, e.g. ID360 instead of IDE360.

Likewise, their more common command errors include:

*copying and pasting cell references or formulas instead of values;
*pasting data into cells that already contain data;
*sorting records containing references to cells in other rows;
*adding or deleting rows or columns that affect data in other parts of the spreadsheet; and
*not re-extracting data after they have made changes to their databases.

As is the case with most computer novices, their most common procedural errors are:

*not saving their documents frequently; and
*not making backup copies.

Fortunately, the majority of these errors can be corrected through editing. Others can be avoided by following common tips on spreadsheet organization, e.g. working diagonally on the spreadsheet when establishing smaller databases and extracts. The most fatal error occurs if students use the Sort command inappropriately. Unfortunately, detecting this error is difficult; and it is impossible to correct once another operation is performed. Using the project's Sort Data macro averts this disaster. In worst case scenarios students have to revert to their most recently saved versions.

Student Feedback. Although some students complain about keeping timesheets for an entire semester, most realize they will follow similar procedures throughout their careers. Very few students make negative comments about the project on anonymous course evaluations; even then, students most often follow complaints with positive statements on the value of the project.

The following comments are relatively typical. One student wrote,"I find myself getting mad at myself if I lose half an hour because I'm disorganized." One married student told a graduate assistant, "I've gotten to a point where I feel guilty if I waste time. I feel like I'm getting more done at home and school." Several weeks after the end of one project, a fairly well-organized student said, "I really enjoyed seeing where my time was going. I didn't like what I saw at first, but I was glad to know." Perhaps the most unnerving comment came from a student who wrote, "I wish all our instructors could see our charts, maybe they would plan their courses better, so that [course]work was spread more evenly across the semester. If [he or she] were better organized, I could be, too."

**Future Research**
Having developed this computer-based instrument, I can now begin analyzing data from the students' databases to determine if there are correlations among factors like patterns of time usage, efforts dedicated to specific tasks, course grades, grade point averages, and characteristics of various student population groups. The impact time management instruction has had on participating students can be examined by comparing academic records of participants to non-participants. Finally, significant area of study exists in the comparison of the students' self-reported patterns of time usage and the expectations of their instructors.

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Selected Formal Papers From the

# Special Interest Group for HyperMedia Education (HYPERSIG)

# MEDICAL HYPERTEXT BASED UPON COGNITIVE FLEXIBILITY THEORY

*David H. Jonassen, University of Colorado at Denver*

**Advanced Knowledge Acquisition**
In order to solve complex, domain- or context-dependent problems, learners must acquire advanced knowledge, which occurs after the introduction of knowledge and prior to the development of expertise (Spiro et al, 1988). Since introductory learning stresses simple reproduction of rigid examples based upon limited cases, learners often fail to achieve advanced knowledge. Without being able to reason with or apply the information that they acquire, learners will not be able to transfer the knowledge to novel situations. Since nearly every case in medicine is unique, transfer skills are essential. Learners need instructional conditions that stress multiple interconnectedness and different perspectives on the same cases. Learners need flexible representations of domain knowledge. Hence, we recommend cognitive flexibility theory.

## Solution: Cognitive Flexibility Theory and Hypertext

**Cognitive Flexibility Theory**
Cognitive flexibility theory is a conceptual model for instruction that is based upon cognitive learning theory. Its intention is to facilitate the advanced acquisition of knowledge to serve as the basis for expertise in complex and ill-structured knowledge domains. The primary tenets of cognitive flexibility theory (Spiro et al 1988) include:

**Avoids oversimplifying instruction.**
Ill-structured knowledge is particularly prevalent in biomedical education. Because of the interdependent nature of physiological sub-systems, environmental constraints, and their medical problems, biomedical eduction should stress conceptual interrelatedness and combinations. Instruction should reflect the complexity that faces practitioners, rather than treating medical problems as simple, linear decision making.

**Provides multiple representations of content.**
Among the weakest assumptions of most learning theories is that there is a best way to conceive knowledge, that is, there is a single schema or concept that best describes any object or event. This assumption relies on an objective reality as the one true representation. This objectivistic assumption is gradually being replaced in learning psychology with a more constructivistic assumption that claims that we each individually construct meaning ( in the form of schemata) for objects or events based upon our experiences that we relate to them (Jonassen, in press). In order to comprehend the complexity of the world, we must perceive and reconcile its different interpretations. Transfer of acquired knowledge to novel situations, which is essential in problem solving, requires multiple mental representations that are best achieved through the instructional use of multiple analogies (Gick & Holyoak, 1983). "It is only through the use of multiple schemata, concepts, and thematic perspectives that the multi-faceted nature of the content area can be represented and appreciated" (Jacobson, 1990, p. 21).

**Emphasizes case-based instruction.**
Rather than basing instruction on a single example or case, it is important that a variety of cases be used to illustrate the content domain. The more variegated these cases are, the broader the conceptual basis that they are likely to support. The ill-structuredness of any knowledge domain is best illustrated by multiple perspectives or themes that are inherent in many cases. The extensive use of multiple cases also supports a variety of clinical contexts for the acquisition of biomedical knowledge.

**Context dependent knowledge.**
The importance of a clinical context for the acquisition of biomedical knowledge cannot be overemphasized. The basic sciences approach to instruction decontextualizes knowledge. Information is presented and knowledge acquisition evaluated either in a contextual vacuum or in a situation that is dissimilar to its ultimate use. At some future date, medical students are required to retrieve that information and try to relate it to its new context. However, their schema may likely be too constrained to support that type of reasoning. Biomedical knowledge is best acquired in relevant situations that are likely to be encountered by the student as a practitioner (Brown, Collins & Duguid, 1989).

**Knowledge construction; not transmission.**
Rather than transmitting objective knowledge, learners must become responsible for constructing meaningful knowledge representations in order to adapt and use it in novel situations. The basic sciences approach to instruction stresses recognition and recall of specific information, which makes it less useful. In order for knowledge to become transferable to different problems, it must be constructed using parts from different cases and contexts.

**Supports complexity.**
It is important that medical practitioners acquire non-compartmentalized knowledge that are not based upon rigid, external knowledge structures. Rather than mapping knowledge onto the learner, the learner must map different contexts onto his/her own knowledge as it is being acquired in order to support the transferability of that knowledge. This is best supported, according to cognitive flexibility theory, by the use of multiple representations and different thematic perspectives on different cases. In order to construct useful knowledge structures, learners need to compare and contrast the similarities and differences between cases.

**Effectiveness of Cognitive Flexibility Theory**
Although flexibility theory is new, it has been subjected to empirical verification. Flexibility theory has been operationalized in terms of case-based instruction that requires learners to examine information from a variety of perspectives (ie. criss-crossing the landscape). Research on flexibility theory has hypothesized that control group learners studying traditional, single-perspective materials would concentrate more on detail and memorization, and that learners studying flexibility theory materials would be able to transfer learning better. Spiro et al (1987) found that indeed control group learners outperformed the experimental group on reproductive memory tests, but the flexibility theory learners exceeded controls on six different measures of transfer. Hartman and Spiro (1989) proposed a new form of text based upon post-structuralist thought and flexibility theory which included multiple perspectives, flexible representations, and assessment of transfer. They found no differences in reproductive memory, but significant differences in transfer and knowledge application favored the flexibility group. Finally, Jacobson (1990) compared a computer-based drill treatment with a criss-crossing treatment which provided multiple representations of knowledge, linked abstract ideas to case examples, and stressed the interrelationships between surface and structural knowledge components. The drill group recalled more facts than the criss-crossing group, but the latter attained higher scores on all knowledge transfer tasks. The research has provided consistent empirical support for the theoretical predictions of cognitive flexibility theory. Flexibility materials engage learners in more meaningful, transfer-oriented, advanced knowledge acquisition. What then is the best medium for presenting information organized by cognitive flexibility theory?

**Cognitive Flexibility and Hypertext**
Perhaps the ideal medium for conveying cognitive flexibility theory is hypertext (Spiro & Jehng, 1990). Hypertext is non-linear or dynamic text. Although its antecedents date to 1945, the term *hypertext* was coined by Theodor Nelson (1974, 1978, 1981) to describe non-sequential writing. In traditional text, the readers/learners are expected to follow the author's style and organization of text, which reflects the author's knowledge structure. Hypertext, on the other hand, allows the user immediate access to any piece of text or information in the knowledge base. In hypertext, readers are not constrained by the subject matter structure or by the author's organization of the text. Since an individual's knowledge structure is unique, the ways that individuals prefer to access, interact with, and interrelate information is also distinct. So, access to and organization of information should be under the control of the learner. In hypertext, users may explore information and even alter it in ways that make the information more comprehensible.

Hypertexts possess some or all of these characteristics (Jonassen, 1989):

- Nodes or fragments of information
- Associative links between the nodes
- Network of ideas formed by the link structure
- Organizational structure that describes the network
- Ability to represent explicitly the structure of information in the structure of the hypertext
- Dynamic control of information by the user
- High level of interactivity with the user
- Database-like structure for storing information
- Multi-media information environment (hypermedia)
- Multi-user access to the information.

## Implementation: Transfusion Medicine Hypertext

### Content

Transfusion medicine includes those disciplines in medicine which are involved with the collection, processing, and storing of cellular and acellular components of blood, the administration of blood components and products, and the survival and function of the elements in transfusions. The field is very broad and entails a number of basic sciences, including biochemistry, immunology, physiology, and clinical areas, such as hematology, surgery, internal medicine, and pediatrics.

### Learning Context

This Cognitive Flexibility Hypertext on Transfusion Medicine is being developed as part of a Transfusion Medicine Grant from the National Institutes of Health. In the past, eduction of medical students, residents, and practicing physicians in the area of blood banking and hematherapy has been incomplete and plagued with misinformation and opinion. As transfusion medicine has grown more complex, the need for additional training has become obvious. The purpose of the grant is to identify and implement a transfusion medicine curriculum which draws on multidisciplinary contributions, some of which is to be delivered via computer-based learning. Through the educational activities of this project, outstanding students and clinicians will hopefully be drawn to this area. Ultimately, the project hopes to enhance the quality of medical care received by patients in the region.

### Knowledge Domain

An analysis of the relevant outcomes of instruction for third year medical students and residents related to transfusion medicine determined that the primary goal of transfusion medicine for physicians is risk assessment. This knowledge base comprises the declarative knowledge base of transfusion medicine, that is, the information relative to risk events in transfusion medicine that physicians need to acquire. The database describes the different aspects of each event, such as the pathophysiology, symptoms, screening tests, treatments for reactions, and so on. That is, causes of these events may produce a variety of possible symptoms or require a variety of optional medical interventions. These are clear indicators that the transfusion medicine knowledge base is ill-structured. Because of its ambiguity, no single case could represent all of the possible transfusion effects. That is, there is no prototypic case in transfusion medicine because the causes and effects are interactive and depend upon whose perspective the case is being viewed from, the condition or physiology of the patient, the purpose for the transfusion, and so on. Rather than merely requiring medical students to memorize the information in the knowledge base (already better organized and more relevant than much instruction), flexibility theory suggests that the information should be accessed from the context of various cases, because what was important in one case may be irrelevant in another.

### Transfusion Hypertext

The hypertext knowledge base that supports the outcomes described above is being constructed in *Plus* to run on the Macintosh family of computers possessing two or more megabytes of RAM or under Windows 3.0 on 286 or 386 IBM machines with 2 or more megabytes of RAM. The software consists of five stacks of related cards, including: the knowledge base (known in the program as the textbook); a glossary of all terms that may be unfamiliar to the third year medical students for the whom the program is intended; required actions that the student may take including ordering screening tests, treating the patient, or getting more information; a set of six primary, in-depth cases; and a set of 24 related cases.

The program is oriented by the primary cases. That is, students access the program and are offered help in using the program. If the student is familiar with the operation of the program, then s/he is led to one of seven primary cases (see Figure 1 for case solution options). Access to any information is through these well defined cases, that is, case-dependent. The student must determine the information needed to take an action prior to taking that action. S/he has the option of accessing information from a transfusion medicine textbook (a very common source of information in case resolution), asking questions of important operatives in the case such as the attending physician, resident, patient, phlebotomist or blood bank director, ordering tests or comparing the current case to similar cases. The student may also criss-cross this case-based landscape by comparing the current one to similar cases. These 20 cases are less detailed than the primary cases. They have one or more more fields with common attributes. The more matching fields, the more similar are the cases. Each of these information sources provides a separate point of view that perceives the case in a different way. The greater the level of similarity, the more useful the case should be to the medical student in helping him or her to take an appropriate action. These are the multiple perspectives that are normally available to a resident in solving a case. When the student takes an action, s/he is presented with feedback about the advisability of each action taken.

**Flexibility Theory Applied to Transfusion Medicine**

The tenets of flexibility theory described earlier are used to evaluate the transfusion medicine hypertext described above.

**Avoids oversimplifying instruction.**

Since the transfusion medicine knowledge base is ill-structured, like so much of medicine, no single event or case is prototypic. With nearly thirty different possible events and a large number of possible symptoms and pathophysiological responses to each event, the number of interactions is very large. The options available to the doctor, both in terms of information gathering and treatments further complicates the picture. This natural complexity needs to be conveyed by the instruction in order to avoid the reductive belief that transfusion medicine is a simple knowledge domain.

**Provides multiple representations of content.**

The information available to the medical student is varied. S/he may seek multiple perspectives from the patient, resident, attending physician, phlebotomist, or even the blood bank director. S/he may consult similar cases that exhibit similar symptoms, events, or tendencies or a textbook which represents yet another perspective. S/he may take some action, such as ordering tests, prescribing treatment etc. The information is represented in this hypertext on at least three different dimensions representing a large combination of representations.

**Emphasizes case-based instruction.**

Rather than basing instruction on a single example or case, it is important that a variety of cases be used to illustrate the content domain. The cases in this transfusion medicine hypertext are very irregular, with different perspectives or factors assuming a more important role. There are six primary cases. More could be used, but curricular time constraints are imposed on the use of this material. E these few primary cases involve the student with multiple symptoms and problems. Students will be able to compare these cases with 24 other similar but somewhat different cases. The knowledge, perspectives, and information are all case-driven, so that any information is provided by the hypertext only in the context of a case.

**Context dependent knowledge.**

The importance of a clinical context for the acquisition of biomedical knowledge cannot be overstated. Biomedical knowledge is best acquired in relevant situations that are likely to be encountered by the student as a practitioner (Brown, Collins & Duguid, 1989). The cases provided in the transfusion medicine hypertext are based upon real experiences. The contexts are made more realistic by the availability of realistic advice from different people and realistic information from authoritative sources.

**Knowledge construction; not transmission.**

Learners must construct meaningful knowledge representations in order to adapt and use the information in novel situations. The transfusion medicine hypertext requires that users access and then associate information in relevant, practical situations. In attempting to solve cases, learners build complex schemata that consists of procedural (how to) knowledge rather than an amalgamation of unrelated facts. Procedural knowledge is more readily transferable.

**Supports complexity.**

It is important that medical practitioners acquire non-compartmentalized knowledge based upon rigid, external knowledge structures. Users of the transfusion medicine hypertext are required to build their own knowledge structures in order to solve cases. The goal of the instruction, as represented in the evaluation techniques, is identical to the instructional strategy -- solving relevant cases. In order to construct useful knowledge structures, learners need to compare and contrast the similarities and differences between cases. This is supported by the multiple perspectives on each case and the related cases for comparison and contrast.

**Conclusion**

Physicians in training need to learn to diagnose illnesses and prescribe treatments. This involves clinically oriented problem solving. Rather than solving problems during instruction, medical students memorize information which is often poorly organized and is generally devoid of contextual relevance.

This information is often not applied until a point much later in their training. The information that they are acquiring is full of complexity, irregularity, and inconsistency.

This paper has presented a solution to many of these problems, cognitive flexibility theory, a solution that may have implications as a model for medical education. Cognitive flexibility theory is able to represent the complexity of medical problems while permitting the learner to investigate the multiple perspectives represented in the knowledge domain in a problem solving context.

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# A NEW COMPUTER-BASED LEARNING EVNIRONMENT: THE HYPERMEDIA-ASSISTED KNOWLEDGE CONSTRUCTION SYSTEM

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**Abstract**

We are at transition point in history; between what has been traditionally known as the industrial age and what will probably become known as the age of technology. Some components our of society have successfully begun the transition between the two. One need only look at the integration of technology into the business arena and the design sciences. Spreadsheets and CAD systems have fundamentally changed the way these disciplines operate. The educational system has been notoriously slow in adapting to the needs of the technological world. Instructional systems of the future will be more adaptive largely because they will become more integrated, both in terms of the technology and user involvement. HAKCS, our vision of what CAI should be, is a prototypical learning environment under development at the University of Houston-Clear Lake which will, upon completion, elicit and store the mental models (semantic networks) of experts of various domains, permit other users to browse the components and organization of these mental models, and finally, actively engage the user in the construction of the mental model on screen and in their mind. HAKCS is said to be a hypermedia-assisted system, versus a traditional hypermedia system, since the primary goal of the system, knowledge construction, requires hypermedia features only indirectly. We see this system as the primitive but necessary first step toward a new generation of learning environments.

**Introduction**

Hypermedia systems (non-linear, associative multimedia) have received considerable attention as next generation learning and communication environments. Exponents have referred (metaphorically?) to such systems as the first "knowledge medium" (Stefik, 1986), "peripheral brains" (Carlson, 1990), a "psychological landscape" (Shirk, 1991), and "the next step in civilization" (Nelson, 1989). The comments do not, of course, refer to existing hypermedia systems, but rather to the more elaborate (and literarily safe) integrated systems of the future. This is as it should be, for there is currently little, if any, empirical support favoring hypermedia-based instructional or communication systems over traditional, linear systems or approaches (Jonassen, 1991; Locatis, Letourneau, & Banvard, 1989). An ode to Santayana would have us remember the familiar ring, and subsequent fate, of high-hype, low-empirical support technologies of days past–where is programmed instruction, anyway?

Much of the excitement surrounding hypermedia arises amidst talk of a new medium of communication. Hypermedia is often represented as the latest in an evolutionary progression of communication media whose phylogeny includes artifacts such as the spoken word, written word, still images, and full-motion images (Dede & Palumbo, 1991). With regard to education, however, we must be careful to evaluate hypermedia as a medium of education rather than a medium of communication–communication is, afterall, a necessary, but insufficient condition for learning. Gilbert (1982) wisely warns that overemphasis on delivery systems in training and education has underemphasized the development of pedagogy; i.e. new media have simply reinforced the transfer and translation of bad pedagogy to new technological platforms. The (hyper) medium may influence the message, but it is not, by itself, going to teach us the message.

DiSessa (1987) suggests that new insights into more effective pedagogy might come from developments in the cognitive sciences. As knowledge about knowledge increases, and as thinking becomes functionally reproducable on computer, opportunities for insights and research concerning the way we learn will be unprecedented. Technology-based instructional systems will presumably exploit this new information by actively incorporating, adapting, and perhaps even interfacing with user knowledge. It is possible that the now evident distinction between user and computer knowledge will in time blur–computers might become natural complements to our own cognitive shortcomings: short-term memory, recall inefficiencies, etc. The actualization of future knowledge-related systems will require further development of at least three basic areas research within the cognitive sciences: (1) knowledge acquisition, (2) knowledge construction, and (3) human-computer interaction (HCI).

Knowledge acquisition refers to the elicitation of the functional structures of memories in long-term memory. This process, traditionally conducted by knowledge engineers for expert system development, is complicated by the obvious fact that the structures are unobservable. The knowledge engineer attempts to circumvent this little inconvenience by employing a variety of techniques such as associative recall, knowledge mapping, story telling, etc., but these techniques have proven time consuming, costly, and in the end, not very effective. Knowledge construction refers to the notion that learning involves the active construction and continual refinement of mental models. Generally, mental models are internal models of reality comprised of something akin to semantic networks which, in turn, form structures which empower us to adapt to both novel and common situations (Minsky, 1986; Schank, 1990; Bartlett, 1932). Knowledge construction is receiving considerable empirical attention, albeit indirect, from a number of research domains in the cognitive sciences (mental models, memory, learning, etc.). Human-computer interaction, though probably not considered by many to fall within the cognitive sciences, will undoubtedly play a major role in the effective implementation of all technology-based systems. And, as the knowledge link between user and computer becomes more intimate, HCI will expand in scope to accommodate the blur (arguably, it has already done this) and likely join the plethora of disciplines composing cognitive science.

**The Hypermedia-Assisted Knowledge Construction System**

Semantic network theories (e.g. Collins & Quillian, 1972) suggest that the storage architecture of long-term memory is functionally equivalent to networks comprised of nodes (concepts) and pathways or links (directional, semantic associations between nodes). Hypermedia, based on a comparable node-link architecture, appears, at least superficially, to be an ideal medium for representing semantic network both functionally and visually. The trick is, of course, to achieve a relatively accurate transfer from long-term memory to the hyper network–then wonder what to do with it. We have wondered, and, with Jonassen, we believe the answer lies in the creation of a new kind of learning environment.

HAKCS is a prototypical learning environment under development at the University of Houston-Clear Lake which will, upon completion, elicit and store the mental models (semantic networks) of experts of various domains, permit other users to browse the components and organization of these mental models, and finally, actively engage the user in the construction of the mental model on screen and in their mind. HAKCS is said to be a hypermedia-assisted system, versus a traditional hypermedia system, since the primary goal of the system, knowledge construction, requires hypermedia features only indirectly. We see this system as the primitive but necessary first step toward a new generation of learning environments.

**Knowledge Acquisition**

The knowledge acquisition component of HAKCS employs a top-down process of node development and association designation. The process begins with the primary domain node (the deepest level of abstraction within that particular semantic network) and proceeds to lesser degrees of abstraction. HAKCS queries the expert with each node addition to find out its relationships with other nodes in the network. The query parameters are limited to eight possible semantic relationships structured in a X (is related to) Y format. The semantic relationships supported are : 1. analogy (is similar to), 2. equivalence (is equivalent to), 3. inclusion (is a part of), 4. definition (is defined as), 5. example (is an example of), 6. cause/effect (causes), 7. spatial relation (is spatially related to), and 8. temporal relation (is temporally related to). So, for example, if the system began with a primary domain node of quantum mechanics, HAKCS would ask for definitions, examples, analogies, and so on. until the expert was unable to provide further input. At this point, the system would begin the same process on the examples, analogies, etc., just entered. The process continues in this fashion until the network is completed, at which time the expert begins a process of iterative fine-tuning, adding nodes and/or relationships which were not recalled during the initial acquisition pass.

The process is not particularly different from techniques now used by knowledge engineers. The basic approach is as follows: When person A attempts to explain X to Person B, person A

(1) Analogy {is similar to}
- -functional
- -topographical
- -property
  - -abstract
  - -physical

(2) Inclusion {is a part of}
- -abstract
- -physical

(3) Definition {is defined as}

(4) Equivelence {is equivalent to}
- -functional
- -topographical (5 senses)
- -property
  - -abstract
  - -physical

(5) Example {is an example of}

(6) Temporal {is temporally related to}
- -prior
- -concurrent
- -post

(7) Spatial {is spatially related to}
- -above
- -below
- -beside
  - -right
  - -left
- -before
- -behind

(8) Cause/Effect {causes}

Figure 1 Semantic Relationships

might try to define X. If B still did not understand, A might provide an analogy. If B did not understand, A would continue to provide analogies, examples, spatial relationships, etc., until B can relate something to his or her mental model. Two interesting things are happening here: person A was recalling a number of memories by semantic type, person B was provided these memories in a semantic context. Person A provided B with a glimpse of his mental model, and person B has made a connection between one of A's memories of one of B's own, providing B with some understanding of X. This process of communicating knowledge happens all of the time–it is, in fact, the essence of traditional instruction. It should not be surprising, then, to find empirical evidence that students begin to assume the knowledge structures of their instructors (Shavelson, 1974).

Although the acquisition process is greatly simplified by allowing only eight semantic associations, the intrinsic complexity of knowledge continues to make even this a fairly laborious endeavor. HAKCS can simplify the process somewhat by inferring a substantial number of the relationships automatically, reducing the front-end investment of the expert. For example, if the expert enters the following:

Electron {is a part of} Atom
Proton {is a part of} Atom

HAKCS infers:

Electron {is similar to {by abstract property}} Proton

HAKCS would then create the appropriate analogical link. You may have noticed that the analogical inference was by abstract property. The eight types of semantic relationships are divisible into finer categories (see figure 1). The expert determines the grain of semantic detail necessary to convey what is in his or her semantic network. There will be occasions in which the expert will not feel comfortable operating within the confines of the semantic relationships provided, or perhaps wishes to qualify a node description, or whatever. HAKCS provides for these types of messages in what are called signposts. Signposts are simple textual and/or graphical additions which are connectable to nodes and links to make the user aware that the expert had something additional to share. As stated, this might be something as simple as a sketch or qualification of a selection, or something like a personal anecdote or joke relevant to a particular concept. The idea is to impose sufficiently narrow semantic parameters to facilitate the acquisition, browsing, and construction of the mental model, but also create within those parameters a process sufficiently exhaustive to capture the essence of knowledge.

Once the expert has completed the process of relating his or her mental model of a domain into the computer, system and instructional designers work to translate many of the nodes into multimedia displays using computer animation, laser disc video, CD-ROM, etc. Upon completion, nodes might be as primitive as textual descriptions, or as sophisticated as full-fledged multimedia productions. In general, nodes are presented as real-time as possible, but can be augmented with process highlighters or similar devices to focus user attention on the particular phenomenon relevant to that node.

The final step of the acquisition process is the recording of the expert's background, education, awards, current employment, and personal interests. This information is made available to users in the form of a small biography, along with a digitized image of the expert, by simply clicking on the expert's name which has, at that point, become a permanent member of the expert log.

**Knowledge Browsing**

The HAKCS browser is designed to allow the user easy and intuitive access to, and exploration of, the expert mental model. Utilizing a combined onion-landscape metaphor, nodes at a particular level of abstraction are located on the surface of a sphere. Depth of abstraction is visually represented by the circumscription of spheres within spheres. The deepest level of abstraction, the sphere at the center of the onion, is the primary domain node. Nodes on the outermost layers will consist mostly of experiences (i.e. multimedia representation of experiences) called "primitives."

Nodes are represented on an altered-perspective view of the landscape as three-dimensional cubes, the face of each displaying a picon corresponding to its contents. Semantic relationships shared by the nodes are represented as color-coded lines, a different color denoting different types of semantic relationships. Users browse this knowledgescape by pointing and clicking on one of the four directional arrows located in the center of the control panel (see figure 3). A window revealing the name of the node directly in front of the display is found just above the directional arrows. Unwanted complexity can be filtered by clicking on the appropriate buttons to the left of the control panel, or all relationships can be displayed at once. The buttons to the right of the control panel include a search feature which permits the user to quickly locate a specific node of interest, a help feature providing on-line help, and a button to return to the launch platform (see figure 2).

Circumscription of one sphere within another denotes an abstract, inclusive relationship (recursively inclusive) between nodes on each of the two spheres--the nodes on the inner sphere being more abstract. Connections between the two spheres are visually represented as cones, similar in appearance to Robertson, Mackinlay, and Stuart's (1991) tree cones, forming on the outer sphere and coning into a node on the inner sphere. The vertex of the cone, meeting at a node on the inner sphere (a composite node), expands upward so that the top of the cone encompasses all of the nodes and relationships of which the composite is comprised. For example, a composite node representing Doppler Effect might include nodes of passing trains and airplanes (laser disc video sequences), wavelength, frequency, etc. The visual representation of this relationship would have the vertex of the cone meeting the top of the node Doppler Effect, and expanding upward to encompass the nodes of passing trains and planes, wavelength, and so on (see figure 5).

The tree cones are visually self-evident if users are looking at composite nodes, but if users are on a level on top of the tree cone, they would see what is called a semantic fence. The semantic fence is a structure resembling a small wall encircling all of the nodes comprising the composite node below. Upon coming across a semantic fence, users could choose to explore the deeper level of abstraction by clicking the down vertical arrow beneath the navigational arrows, and return by clicking the up vertical arrow.

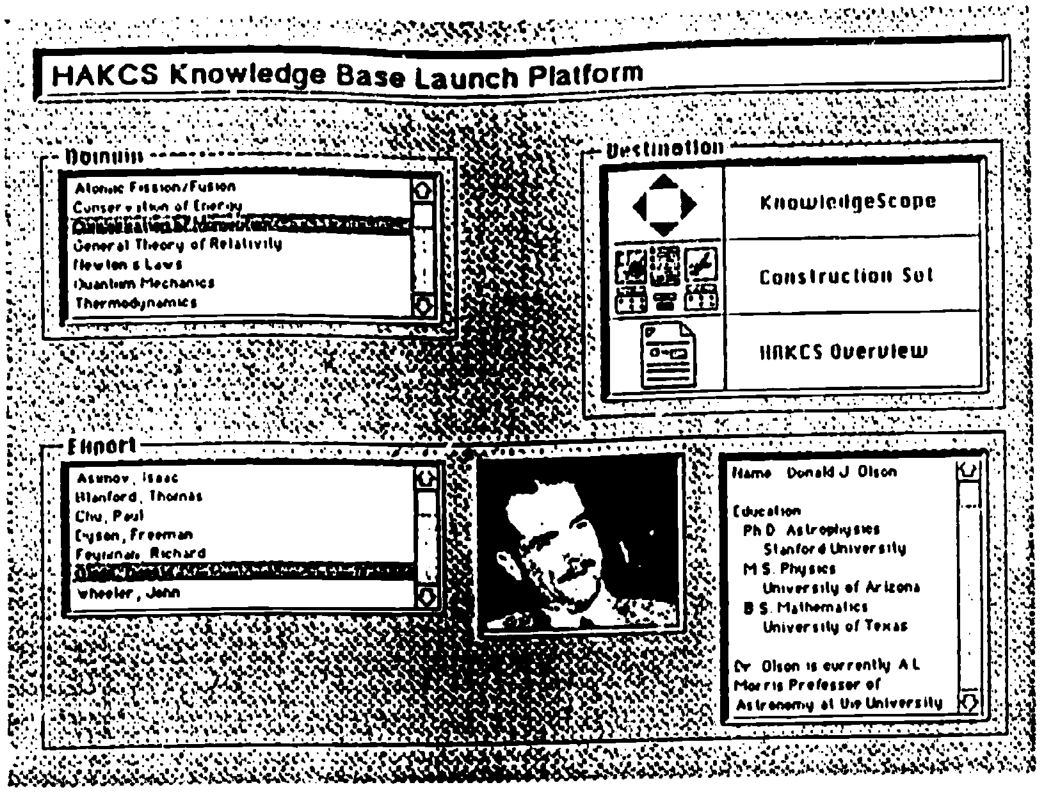


Figure 2 HAKCS Luanch Platform

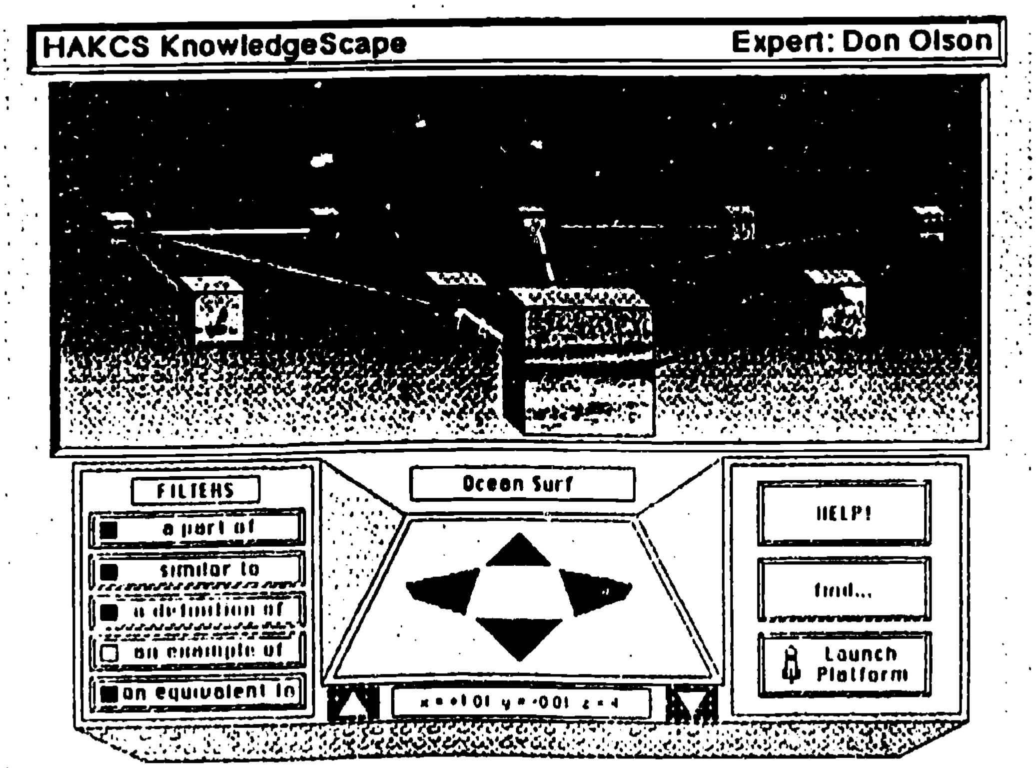


Figure 3 HAKCS Knowledge Scope

The design rationale behind the knowledgescape browser has been the creation of a functional, intuitive, and interesting visual representation of a mental model. Unlike many hypermedia systems, the browser is not expected to substantially contribute to the learning process, but rather to provide a greater organizational context in which to view and think about the content of the model. While we think browsers might be useful in the creation of meta-mental models (mental models of mental models), it is believed that the mental models constructed from hypermedia environments will focus primarily on the navigational and contiguous aspects of the display, versus comprehension of the directional semantics of which the knowledge is constituted. We posit that the development of mental models centers around the visible interactions between components of systems. Mental models give us the ability to understand the syntax of what we perceive, but introspection of that model provides the semantics. Introspection, it is held, requires thought, probably consciously thought. Hence, transfer of the expert mental model residing in HAKCS' memory will require more than browsing, it will require thought about the knowledge displayed. It will, in effect, require the metacognition of the semantic structures of the representation.

**Knowledge Construction**

Introspection here refers to the contemplation of existing mental models. Craik (1943) argued that mental models operated in a manner functionally equivalent (or approaching functional equivalence) to processes being paralleled. Objective system processes, however, are without semantics until observed (Young, 1988). Hence, semantics requires more than the modelling of objective system processes. It is suggested that the creation of mental models deals primarily with the syntax or mechanics of reality, while meaning arises from the introspective comparisons between parts of, and/or whole, mental models involving a different category of knowledge. This other category is best characterized as a priori associative knowledge,
whereas the former is characterizable as a priori modelling knowledge. A full theoretical account is beyond the scope of this paper (see Lidwell, & Palumbo, in press), but a taste was necessary to understand the rationale of the knowledge construction component.

The HAKCS knowledge construction set (see figure 4) has been designed to promote the metacognition of the semantic relationships on screen. Two nodes are displayed on screen as picons with a number of buttons between them. The nodes, as in the browser, reveal their content when double-clicked. The buttons each represent a different semantic relationship. Users view the nodes in their various multimedia representations and attempt to determine the semantic relationships that they share. The user considers the nodes and the possible relationships and then selects the relationship of choice by clicking on the appropriate button. If the selection is correct, i.e. corresponds to the expert's selection, the system provides positive feedback, updates reference maps, and presents the user with new nodes.

Reference maps are located below the the node picons and display all nodes which have previously been linked correctly. Users can refer and review previously linked nodes of one node and then compare those with the reference map of the other node. It will often be the case that nodes will appear in both maps under different semantic categories. It is hoped that these maps will facilitate inferencing and, consequently, improve selection performance. The extent to which the maps will prove useful, however, is questionable, and the maps are currently designed so that they can be revealed and concealed at the user's discretion.

If the user selects a relationship which does not correspond to the expert's, HAKCS informs the user that the selection was incorrect, and then proceeds to change only one of the nodes on screen. The logic, as discussed previously, is that in attempting to communicate a novel concept to another person, one provides analogies, examples, and so on, until an association is made between the memory expressed and some memory in the person's mental model. HAKCS, too, provides nodes which are semantically related until a connection is made. Once an association is successfully established, HAKCS continues providing the network node by node until the user reconstructs the expert's mental model. In reconstructing the model on screen, it is believed that similar semantic structures will be constructed in the mind of the user (Lidwell & Palumbo, in press).

The construction set currently supports two user modes: novice and expert. The novice mode provides neither all eight of the relationships, nor does it support the finer distinctions in each semantic category. The novice level is being designed primarily for use by children approximately twelve years of age and older. The expert mode is being designed technical training in industry and higher education. It supports all eight relationships and the finer distinction therein. In working with these semantic relationships explicitly, one might reasonably expect an improvement in users' ability to associate experiences in non-HAKCS environments. If this is correct, HAKCS might do more than construct knowledge, it might make the construction process, in general, more efficient.

**Conclusion**

Philosopher Arthur Schopenhauer advocated what he called the "natural method" of education. To Schopenhauer, depth of knowledge required depth of experience. The whole of the experience, its essence, is only attainable through natural experiences (first-hand exposure). Natural education, then, was defined as an education comprised entirely of natural experiences. The trend in education, even in Schopenhauer's time, was toward "artificial" experiences (second-hand experiences; e.g reading, listening about, etc.).

The idea of a wholly natural education is obviously impractical–or is it? Providing students with hands-on experience is the current fad in education. Children are conducting actual scientific investigations, creating computer programs in a variety of programming languages, and building robots using construction kits like Lego/Logo. These activities are genuine, fulfilling experiences which get at the heart of Schopenhauer's philosophy.

But what of those experiences that do not involve the physical construction or manipulation of something? What of experiences like seeing the grand canyon, hearing the fugues of Bach, or exploring the moons of Jupiter? How can such experiences be presented in an economically feasible and "natural" fashion? The answer, in a word, is hypermedia. Certainly Schopenhauer had no conception of the types of technologies that are or soon will be. Presently most experiences can be presented in near complete form through hypermedia technology. In the future, virtual realities will provide even more complete, and perhaps perfectly authentic experiences to the user.

**HAKCS** circumvents the impracticalities of Schopenhauer's natural method by bringing the experiences to the user. The experiences are presented free from the chaos and distractions of truly natural experiences and permit system developers to emphasize the relevant elements. In this sense, technology has done nature one better. Presentations can be augmented through the use of process highlighters, voice guidance, and computer-enhanced video to concentrate user attention on those elements relevant to the linking task.

Developments in technology and the cognitive sciences hold tremendous promise for training and education. Technology has proven a capable medium for transferring, processing, and recreating information. As our knowledge of the way we transfer, process, and recreate information increases, technology will effectively merge and become an interactive part of the process. HAKCS is seen as the first step in this direction.

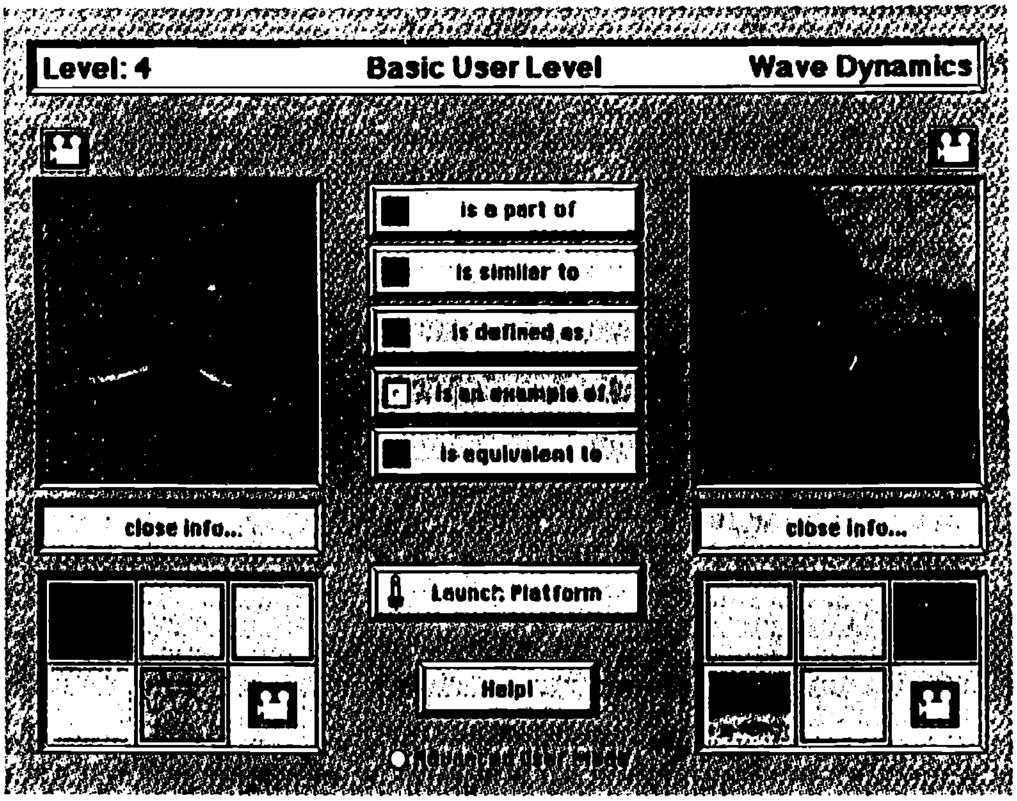


Figure 4 HAKCS Conclusion Set

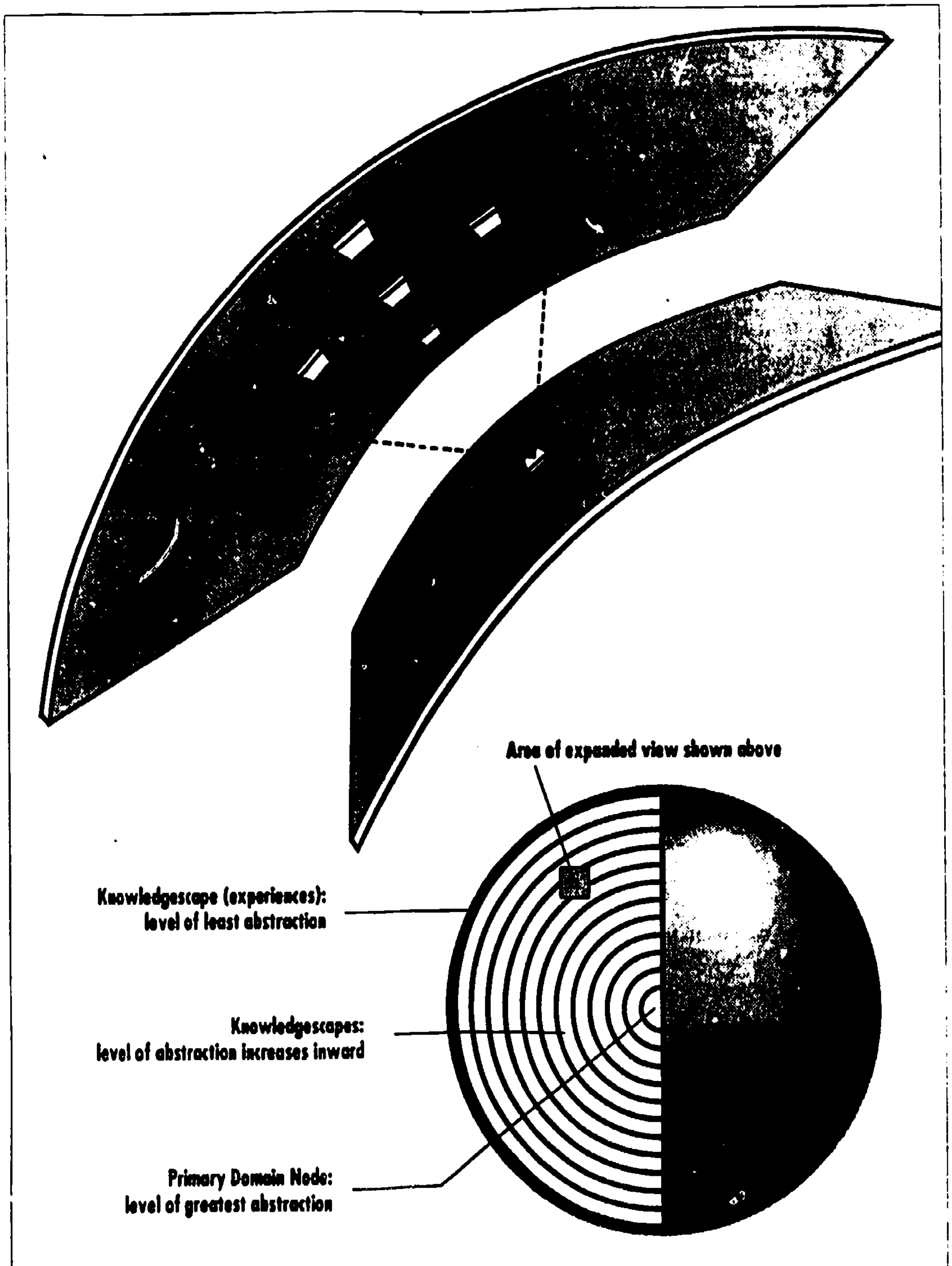

fig. 5 — Onion-landscape metaphor

Figure 5 Onion Landscape Metaphor

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# HYPERTEXT DELIVERY SYSTEMS

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**Abstract**
Hypertext and Hypermedia have captured our imagination with their capabilities to support instruction, learning, and collaborative research. For IBM users taking the first step often means selecting a hypertext system that will provide the links between text, graphics, audio, and video. In this paper, emphasis is on a comparison of two hypertext systems based on the object-oriented paradigm.

**Introduction**
Enthusiasm for hypertext projects is growing rapidly due to the appearance of personal computer authoring environments and the increased power of personal computers making them powerful enough to support hypertext. The fascination of being able to link documents and ideas, in a manner that heretofore could not be done, has reenergized researchers, teachers, and developers. Within their reach li possibilities for collaborative work with colleagues world-wide and the development of large multimedia databases. It is now possible to give students many diverse materials to explore that previously were not easily integrated into the traditional classroom, library, or museum setting (MacKnight, 1990).

The task ahead is not a simple one, however. Gathering the appropriate texts, translations, dictionaries, video images, drawings, maps, other relevant documents, and selecting the appropriate tools illustrate the enormity of the task. The size of the information to be represented, how it is to be represented (text or a combination of text and graphics), whether the plans call for multi-or single-user system, and the characteristics and computer capabilities of potential users all impact on the hypertext system selected (Nielsen, 1990). (See also Halasz, 1988; Verreck and Lkoundi, 1990; and Locatis, 1991.)

Knowing the limitations of the available hypermedia systems is essential in planning for the present and in being able to take advantage of emerging technologies in the future. The hypertext system chosen depends on what one is willing to sacrifice, since there is no universally best system (Nielsen, 1990).

In this paper we describe some advantages of the object-oriented paradigm as implemented in Guide and LinkWay --two hypertext systems that run on the IBM personal computer.

**Interface**
Guide and Linkway are interactive systems that give authors a new way to organize and present text, graphics, audio and video information. Both systems have graphic interfaces and several features in common:
- functionality used to create objects, links, and applications,
- editing objects and links,
- managing objects,
- configuring display features and attributes of the objects, and
- navigation between objects.

Features common to both systems that support the object oriented data model form the subject of our comparison.

**Description of Terms**
In Guide, a *document* is similar to LinkWay's FOLDERS in that both form the basis of an application. A *document* contains many *frames*, each of which can have several objects. Guide treats all elements--text, graphics, video and audio--that can be selected individually or as a group as an object. The system also provides objects--*reference*, *note*, *expansion*, and *command* buttons--that link source and target information objects. *Reference* buttons create links to either another part of the document or to another document. *Note* buttons display context sensitive text or graphics information; *command* buttons execute other programs, open and close documents, and control the serial port; and *expansion* buttons function as menu items leading to subtopics and function as text and graphic frames.

In a LinkWay application, FOLDERS contain several screens called PAGES. PAGES consist of different combinations of text, button, and graphic objects. Buttons perform such actions, such as creating links or text and graphic pop-up windows and executing external programs.

| Folder | Page | Object | Go to | Option |
|---|---|---|---|---|
| Open | Print | New | Base Page | DOS |
| New | New | Move | First Page | Directory |
| Access Level | Cut | Move + Size | Last Page | Set Mode |
| Quit | Paste | Edit | Next Page | Bg Color |
| Save | Delete | Cut | Previous Page | Fg Color |
| Exit Linkway | Line | Paste | Link | Status |
| | Box | Delete | Find | Menu Bar |
| | Bar | Tools | Findnext | Fonts |
| | Undraw | | Retrace | |

**Table 1**
Linkway Menu Bar and Pull-Down Menus

**Menus and Customization**
Because of the simplicity of its five item menu bar, the LinkWay menu system is very intuitive to use (see Table 1). The FOLDER, PAGE, and OBJECT menus provide file, page, and object creation and management functions. The GOTO menus provides navigation functions and the OPTION menu offers a way to change font types, set backgrounds and foregrounds, execute DOS commands, and the like.

Guide closely follows the MS-Windows menu structure and the Open Software Foundation Motif (OSF Motif) conventions for menu design (see Table 2). Due to the complexity of the functions provided and the requirements to follow the object selection and action paradigm, its menus are less intuitive for novices to use. Once users understand the new interaction paradigm, however, the interface becomes much easier to use. All menu items have keyboard accelerators (short cuts), which are attractive to experts. There are no such shortcuts in LinkWay.

The program window and document window display parameters are customizable in Guide--an important feature when an application uses multiple windows. In contrast, LinkWay's program window is fixed, filling the entire screen.

Linkway has options for setting the background and foreground colors of a document. FOLDERS have a *base page* where elements--text, graphics or link objects--common to all PAGES reside and appear as a background in a document. Implementing this feature in Guide is complex and requires considerable knowledge of Guide and concepts of object-oriented interaction. The user has to create a *document* with special attributes to implement this feature.

**Object Creation and Editing**
In Guide, any text or graphic object in a *document* can be selected and made into a button. Selecting the destination object and using the Make link option in the Navigation menu establishes connections. Users enter text by clicking and typing in a frame.

In Linkway's FOLDERS, the procedures for creating buttons and other objects appeal to the novice who is led to do the right thing. The user creates an object and fills in information--text, graphics, or destination--as prompted. Prompting, without a customizable option to turn the facility off, can annoy expert users.

LinkWay has a simple paint program called LWPaint with limited drawing capabilities. In addition, pictures created with IBM Storyboard Plus [1] can be imported directly. Graphic objects imported from other sources must be converted to the LWPaint format using LWCapture. All graphic objects are internal to the file. Guide lack internal graphics capability, but supports the importation of graphic elements through the MS-Windows Clipboard and has sizing and editing capability.

To save space, a Guide graphic file can be made an external link, thereby, reducing document size and increasing performance. This is a consideration if speed is an issue. To move or resize text and graphics, Guide uses the clipping frame attached to the object. LinkWay requires a similar procedure but with more steps involved. In Guide, commonly used text or graphic objects can be stored in a glossary and reused in any frame. LinkWay does not have a similar feature.

**Text Search and Replace**
The FIND option, an unsophisticated feature in LinkWay, searches for a FOLDER name, field name, and search string. In a successful

| File | Edit | Search | Navigate | Display | Format | Font | Make | Window |
|---|---|---|---|---|---|---|---|---|
| New | Undo | Find | BackTrack | Show Ruler | Show Elements | System | Expansion Button | Close All |
| Open | Cut | Change | Top Level | Freeze | Push to Back | Terminal | Reference Button | Cascade |
| Close | Copy | Find | Expand All | Show Symbols | Pull to Front | Symbol | Note Button | Current File |
| Save | Paste | Find Again | First Frame | Set Display | Lock Diagram | Helv | Command Button | |
| Save As | Clear | Find Objects | Previous Frame | Text Larger | Restore Size | Courier | Expansion | |
| Revert Content | Place | Find Links | Next Frame | Text Smaller | Insert Invisible | Tms Rmn | Reference Point | |
| Revert Window | Insert Frame | | Last Frame | Set Palette | Element Info | Roman | Definition | |
| Page Setup | Delete Frame | | Frames | Set Doc Options | Diagram Grid | Script | Start A Link | |
| Print | Cut Frame | | Definitions Window | Set Doc Color | | Modern | Connect Link | |
| Print All | Copy Frame | | | Set Obj Styles | | | Group | |
| Set Prog Opts | Glossary | | | Set Obj Defaults | | | Set Attributes | |
| Exit | | | | Enforce Protection | | | Unmake | |
| About Guide | | | | Set Protection | | | | |

*Note: Some menus change when objects are selected

**Table 2**
Guide Menu Bar and Pull-Down Menus

search, FIND displays the PAGE containing the object. In addition, the find option can be incorporated as a button. Guide has a much more powerful *Find* option with parameters for case sensitivity, wild cards, and logical connectives. Furthermore, the user can specify documents, both linked and unlinked, and directories to search. A completed search displays a list of objects containing the specified search string. Then, the user can select an object and query its properties or go directly to the frame that contains the object. Although there is no replace feature in LinkWay, the user can use FIND to identify the string, and make the correction by typing over the original.

**Navigation**

The ability to list a set of objects with their links is a helpful feature in Guide. In large documents, a list of links is useful in checking the existence or the integrity of links and in assessing whether other objects maintain links to an object identified for deletion. (Sorely missed in LinkWay is a comparable management feature.) A list of links can be used to create an index of all objects in the document. By clicking on any object in the index, one can reach the destination in a link. Since links can have names, Guide supports name links.

Guide maintains a record of the last 100 objects the user has traversed. But, this does not include movement between frames. Therefore, skipping through frames without following links will not register in the backtrack record. Guide allows users to select four levels of backtracking, including references, replacements, and notes. LinkWay maintains a record of the last 10 pages traversed with the retrace option allowing backtracking.

In Guide, users can specify behavioral attributes to an object. This feature is useful when navigating through the document, for it provides special effects, displays position, and documents position. LinkWay displays only the *Page* of the target object in a search.

**Summary**

Guide has more functionality than LinkWay (see Table 3), however, its interface is less intuitive to people unfamiliar with the object action paradigm.

Guide permits exportation and importation of objects, editing of objects, and, like LinkWay, printing the entire document. Users can edit LinkWay objects, but the functionality for importation and exportation is restricted to basic text and graphic objects. LinkWay's interface is more suitable for beginners.

Guide has features to list link names, create an index list, and has an extensive range of document display formatting commands. With respect to the latter, LinkWay can set background or foreground colors only.

Guide's search and replace capabilities are very powerful, while LinkWay's are primitive. In addition, Guide has a freeze option to test the buttons. Nevertheless, LinkWay, has better facilities for switching between author and browse mode. Furthermore, LinkWay has a stand-alone browse mode. In contrast, Guide needs the Guide Reader and Windows to run a Guide application on another computer.

Collaboration between authors is not possible, and access to their distributed databases is impractical due to data consistency issues, that is, there is no program to check that changes made by different authors doesn't destroy existing work. Both hypertext programs lack sophisticated features like exportation of mazes of links and nodes. The navigation map provided by Guide traces objects. To what extent this helps the user is questionable. Confronting the user is the need to visualize where in the document the specific objects to be altered are located.

Guide and LinkWay give us inexpensive ways to create hypertext on-line help, on-line manuals, and to create instructional interfaces to laserdiscs. For projects involving large amounts of text, LinkWay offers the potential for accessing CD-ROM. However, people who are unfamiliar with hypermedia concepts can benefit from starting with LinkWay and then migrating to Guide or remaining with Linkway and added M-Motion to increase the functionality of LinkWay.

| | Guide 3.0 | LinkWay 2.01 |
|---|---|---|
| **Accelerator Keys** | y | n |
| **Script Languages/Commands** | y | y |
| **XCMD** | y | y |
| **Store Text & Graphics in a Library** | y | n |
| **Stand-Alone Applications** | n | n |
| **Author Collaboration** | n | n |
| **Text and Graphics Import** | | |
| ASCII | y | y |
| PCX | y | n |
| TIFF | y | n |
| **Paint and Draw Features** | | |
| Cut-and-paste | y | y |
| Clip art included | y | y |
| **Link Features** | | |
| Local Links | y | y |
| Remote Links | n | n |
| Replace | y | n |
| Text Pop-up | y | y |
| Graphic Pop-up | y | y |
| **Navigation** | | |
| Backtrack | y | y |
| One Level | y | y |
| Multiple | y | n |
| **Go To** | | |
| First Frame/First Page | y | y |
| Previous Frame/Previous Page | y | y |
| Next Frame/Next Page | y | y |
| Last Frame/Last Page | y | y |
| Any Frames/Any Page | y | y |
| Any Document | y | y |
| **Search Options** | | |
| Case Sensitive | y | n |
| WildCards | y | n |
| And/Or | y | n |
| Linked Documents | y | y |
| DefinitionWindows | y | y |
| Expansion Buttons | y | y |

**Table 3**
Abbreviated List of System Features

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Selected Formal Papers From the

# Special Interest Group for Interactive Video-Audio (SIGIVA)

# DIGITAL AUDIO IN MULTIMEDIA INSTRUCTION

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**Abstract**
The literature implies a trend towards an increased use of interactive multimedia technologies for instruction. The increased availability of moderate cost, good quality, digital audio computer cards and computers with built-in audio capability has enabled trainers and educators to realize the potential of random access audio for multimedia applications.

In this paper, the author discusses the use of digital audio in computer programs, outlines considerations for recording digital audio, and offers design guidelines for implementation of audio in multimedia instruction.

**Introduction**
Until recently, most computer-based training (CBT) programs concentrated on the visual presentation mode to the exclusion of the auditory mode because of hardware constraints. In fact, many textbook authors that purport to teach the design and development of CBT fail to even mention the auditory channel and certainly do not focus on its potential.

The advent of the Macintosh computer with audio capability and the increased availability of moderate cost, good quality digital audio cards for IBM-PC compatible computers have enabled trainers and educators to realize the potential of random access audio for CBT and other multimedia applications. Few guidelines, however, exist for the implementation of digital audio with computer instruction.

**Overview of Digital Audio**
At its inception in the 1960s, audio in CBT was utilized primarily as a monotonous feature (such as a beep or a buzz) for inappropriate input by the computer user. As software and hardware improved, audio in the form of music was added for reinforcement of correct answers as well as to fill the dead space created by slow access times to various program options.

With the advancement of interactive videodisc (IVD) technology, widespread use of audio became feasible. In this format, audio was used to provide spoken instructions, include sound effects, create scenarios, explain concepts, and prescribe remediation (Pratt & Trainor, 1990). However, audio on laser videodiscs has some constraints. Videodisc production is expensive and audio is "tied" to a particular video segment. In addition, once mastered, the video and audio cannot be changed or relocated on the disc.

The introduction of digital audio in 1982 created circumstances necessary for effective integration of synchronized, random audio into multimedia instruction. Modern digital audio computer cards enable multimedia developers to record, store, edit, and play back segments of audio. "Access to the segments is rapid (on the order of milliseconds), and the amount of information controlled is large (on the order of hours)" (Davis, 1989, p. 1). Control of these segments through computer software programs is precise and reliable.

In order for a computer to have the capability to produce speech, hardware capable of producing and amplifying necessary sounds must be present. For some computers (like the new Macintosh), hardware is built into the computer; for other computers, an add-on board (card) and peripheral voice box are required. In most cases, speech cards are not interchangeable; therefore, different speech cards might be needed to run various speech programs on the same computer. These hardware considerations definitely have had a negative impact on the use of audio.

Currently, there are three methods employed to produce computerized speech: (1) text-to-speech synthesis, (2) linear predictive coding, and (3) digitized sound. Methods vary tremendously in quality, cost, applications, and hardware requirements.

The most memory-efficient approach to computerized speech is text-to-speech synthesis. In this approach, language is defined as a fixed set of sounds, and computer algorithms are used to "pronounce" printed text into spoken output without human interaction of any kind (Greene, Logan & Pisoni, 1986). Because text-to-speech synthesis works with a set number of sounds and algorithms, it does not require a great deal of computer memory.

Text-to-speech sound is ideal for "talking" word processors that can "read" anything that is typed in. Most speech cards for Apple II computers provide text-to-speech capabilities, and many software applications for this technology are targeted toward small children. The disadvantage of the text-to-speech synthesis method is that it is very unnatural and mechanical sounding. This is a particular problem in educational settings where realistic speech "could aid considerably in the language development process" (Salpeter, 1988, p. 32).

A second approach to computer speech is Linear Predictive Coding (LPC). This method begins with a human voice recording that is then digitized and compressed. A special speech synthesis chip is required to reconstruct words. The memory required by LPC speech is minimal compared to less compressed digitized sound and the quality is not as realistic; however, LPC speech is considerably easier to understand than words produced by a text-to-speech synthesizer. Many audio cards (especially for Apple II computers) offer LPC capabilities, but applications are limited to programs using a controlled vocabulary.

The best quality of computerized speech is produced by digitizing with a technique similar to that used for creating digital audio recordings on compact discs. This technology is extremely realistic and natural sounding, and its educational potential is enormous. Digitized sounds are recorded (with the use of a digital audio card) and stored as files on either a computer disk or compact disc. Files can then be controlled by a computer program, retrieved, and played instantly.

There are, however, major roadblocks to the integration of digital audio. The primary problem is that the process of storing digitized sounds requires an enormous amount of disk space. In addition, developers must now be concerned with both the dynamic range and frequency of sounds and their resultant effects on the computer memory requirements.

**Frequency and Dynamic Ranges**

The human ear can detect sounds ranging in frequency of 25 Hertz to over 16,000 Hertz (16 KHz). In addition, the ear can handle volumes (dynamic ranges) from one decibel (1 db) to 120 decibels; but duplicating huge variations of frequencies and volumes is a problem for a digital audio system. Davis (1989) outlined frequency and dynamic ranges provided by various systems in Table 1.

Because files generated by audio are proportional to the frequency range and dynamic range of the recording, these factors must be constrained to keep files to a manageable size. Most audio cards, therefore, limit the dynamic range to about 40 dB. When recording audio files, care must be taken to keep the amplitude of the digitized signal within the range of the audio card or distortion will occur.

The limitation of the frequency range is not as critical as the dynamic range. Even though the human ear can detect sounds ranging from 25 Hz to 16 KHz, most sounds necessary for a multimedia program fall within a much smaller range. For example, the majority of audio energy in human speech falls within the range of 200 Hz to 2500 Hz (Davis, 1989). Therefore, transmissions that focus on the human voice, such as telephone, AM radio, and multimedia programs, can be limited to 4 KHz (see Table 1).

Another challenge encountered when digitizing sound is that the rate at which a signal is sampled (sampling rate) must be twice the highest frequency required; if a 4 KHz frequency is desired, the audio must be recorded at 8 KHz. Selecting an optimal sampling rate usually involves a trade-off (the higher the sampling rate, the more natural the speech, but the more computer storage space

| AUDIO SYSTEM | DYNAMIC RANGE | FREQUENCY RANGE |
|---|---|---|
| Telephone | 35 dB | 100 Hz to 4 KHz |
| AM Radio | 45 dB | 40 Hz to 4 KHz |
| FM Radio | 60 dB | 20 Hz to 16 KHz |
| Good records | 70 dB | 20 Hz to 22 KHz |
| Compact Discs | 95 dB | 20 Hz to 22 KHz |
| Digital Audio (PC) | (variable) | 20 Hz to (variable) |
| Human ear | 120 dB | 25 Hz to 16 KHz |

TABLE 1 DYNAMIC RANGES AND FREQUENCY RANGES

| 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 |

TABLE 2 SAMPLING RATE AND STORAGE

| COMPANY | RATE | CONTACT | DATE |
|---|---|---|---|
| Regency, Inc. | 7-8 KHz. | Richard Davis | 8/30/90 |
| Interactive Mult. Indus. Assoc. | 7-8 KHz. | David McFarling | 8/24/90 |
| MetaMedia | 8 KHz. | Robert Hamlin | 8/24/90 |
| Institute of Simulation & Training | 12 KHz. | Peter Kincaid | 9/24/90 |
| WICAT | 12 KHz. | James Olson | 9/03/90 |
| Analysis & Technology | 12 KHz. | Hugh Fisher | 9/15/90 |

TABLE 3 RECOMMENDED SAMPLING RATES FOR AUDIO

required). A typical one-hour multimedia course can require many megabytes of storage for audio. Table 2 represents the trade-off involved in the sampling rate/storage (Schmidt, 1989):

Results of an informal survey conducted to determine sampling rates being used for multimedia revealed that the majority of development is being recorded between 7 and 12 KHz. Table 3 presents sampling rates recommended by companies contacted.

**Recording Audio**
Most audio used for multimedia is recorded with an IBM (or compatible) or a Macintosh computer. In the IBM realm, many different audio record/playback cards are available at a reasonable price (such as the Sound Blaster card). Most cards offer a limited range of different sampling rates (such as 8, 12 or 16 KHz). It is important to ensure that a card used to record sounds is compatible with the card used for playback.

For several years, Macintosh computers contained a built-in digital-to-analog converter to play recorded music and speech; however, in order to record sounds, a peripheral, such as a MacRecorder by Farallon, was required. The latest Macintosh computers (Macintosh LC and II si) offer both recording and playback ability.

The process of recording digital audio is very similar to recording with a cassette recorder -- except that the controls on are the computer monitor rather than the tape recorder. Most audio cards allow input from a line source (a pre-amp, tape-recorder, or microphone amplifier). An RCA phono connector is generally included, providing interconnection with common audio equipment. There are two methods for recording audio--tape transfer or direct record.

In the tape transfer technique, audio is recorded first onto a tape and then transfered to the computer. The advantage of this method is that the recording and editing can take place in a quite room -- away from noise generated by the disk drive, computer fan, etc. The taped information is then transfered directly to the computer from the tape recorder.

Another alternative is to record the audio directly to the computer by using a microphone or microphone amplifier attached to the computer. This method is quicker and eliminates the need to use a tape recorder; however, it is less flexible and more prone to excess noise.

After the audio is recorded, it is easy to "play" it with the software program provided with the audio card or peripheral. To replace the file, simply record again using the same file name. It is also relatively easy to access digital audio from authoring systems, such as HyperCard, LinkWay or TenCORE. If an authoring program does not include drivers for a particular audio card, it can generally be accessed through DOS.

**Guidelines for Using Digital Audio in Multimedia Instruction**

Based on experience with digital audio in both the IBM and Macintosh worlds, the following guidelines are offered:

- Balance the quality of audio sources. It is generally best not to mix high quality analog recordings with low quality digital recordings in the same lesson.
- Separate spoken phrases with a short silence (about 1/2 second). Adding a short silence helps to make sequences sound less choppy and unnatural.
- Develop on baseline hardware. Digital audio files are loaded into RAM before they are played. If your delivery hardware has less RAM than the development hardware, you may lose some of the audio.
- Use a professional narrator. Professional voices can help to control the recording level and can add interest and emphasis to narration. In most cases, the cost is well worth the added expense.
- Keep narration short. Approximately seven seconds is recommended as a maximum for a single piece of narration. Chunking is just as important for presenting audio information as it is for textual information.
- Include visual cues. Some learners are very uncomfortable with strictly audio information.
- Avoid synchronization. Because of the variable time that it takes to load audio files into RAM and play them, it is very difficult to synchronize effectively with digital files.
- Include a "repeat audio" option. In most authoring systems, it is easy to include an option that will repeat the audio segment for the learner, without having to branch back to the previous screen.
- Include an "interrupt audio" option. An option that allows the user to proceed without listening to the entire audio sequence is also desirable. This feature is especially important if the lesson is used for review purposes.

**Conclusion**

The hardware and software tools necessary to integrate digital audio into multimedia applications are now readily available. Preliminary studies in the field indicate that audio in digital format can be an effective tool for enhancing instruction (Barron, 1991; Torgensen, Waters, Cohen & Torgesen, 1988; Weiner, 1991). Instructional designers and developers can incorporate this technology to deliver the best possible multimedia instruction.

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# HIGHLY INTERACTIVE PROGRAMS WITH VIDEO FOR LEARNING LANGUAGES

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**ABSTRACT**
This paper discusses strategies for achieving high quality interactions in multimedia materials, especially those for language learning with video. We also describe our design process for highly interactive learning material. The major emphasis is on pedagogical approaches, rather than technical details.

Our Understanding Spoken Japanese Project at the University of California, Irvine, is an example of a system developed with the strategies given in this paper. The support for this project comes from the Nippon Television Network Cultural Society, Tokyo, Japan.

The techniques in this paper are usable in all language learning. We give examples from the learning of English as a second language.

**INTRODUCTION**
This paper describes strategies for highly interactive software for helping students to comprehend spoken languages, using video excerpts chosen for language features. This paper is based on an earlier paper describing our current project,

Understanding Spoken Japanese [Yoshii, 1991]. The ideas in this paper, though, apply to learning any language, not just Japanese.

In the systems we envision, both computers and video are involved. The video is completely under the control of the program. The typical hardware is a personal computer, with either a laserdisc or a CD-ROM; some situations may use both. But this paper will have little concern with such technical details. Our interest is in the pedagogical issues.

The key phrase is "highly interactive." The student does NOT spend extended periods reading text, looking at video, or otherwise not participating actively in the learning experience. Further, the student does not move at random through the program. The program is aware of the student's progress, and adapts to each individual's capabilities, guiding students through learning materials as appropriate to their individual levels.

Later sections give fuller details on the term "highly interactive." We do not regard most interactive video as highly interactive, including material for learning languages.

**COMPUTERS AND LEARNING LANGUAGES**
The use of interactive technology in learning languages is one of the oldest uses of the computer in instructional situations. The German course developed by IBM in the 1960s was an early example of interactive learning material. Soon after this Patrick Suppes at Stanford University developed several full computer-based courses in languages, including a course in Armenian.

Although these early attempts were at the full-course level, recent attempts have been only fragments of materials for traditional courses. While funding has existed for developing non-interactive courses, such as video courses (French in Action [Capretz, 1987], for example), no funding has gone to developing full, highly interactive courses, as far as we know. One might say that we have moved backwards in our scale of coverage.

The early full language courses did not use video, because the laser recording technologies were not available. But since the development of laserdisc and CD-ROM players the technology has been available. The value of sound and video for learning a language has long been recognized, well before the use of computers or laserdiscs. So it is not surprising that new possibilities are being explored now --- although not, as far as we know, at the full course level. This paper does not attempt to review these developments; it focuses on pedagogical strategies that may be useful in such material. (For a list of computer-aided language learning materials and videodiscs, see [Vance, 1986] and [Rubin, 1990].)

Unfortunately much work today uses what we consider weak interaction. The next section considers weak and strong interaction types.

## HIGHLY INTERACTIVE LEARNING MATERIAL

The term "interactive" is often used in describing technologically advanced learning units. But much of this material is only minimally interactive, as measured by the criteria we describe.

Interaction is not a "yes" or "no" question. We must discuss the degree and the quality of the interaction. One of us has discussed the interaction spectrum in other papers [Bork, 1979, Bork, 1987].

First we describe strategies that limit the quality of interaction. Then we describe strategies which limit the frequency of interaction. They are poor pedagogical choices in learning or training.

Unfortunately these poor strategies are often used with interactive language learning video. There could be at least two reasons for this:

- Since video can only display, it is inherently non-interactive. Linear video developers, given even the slightest bit of interaction, discover a facility they never had before. Hence they become excited, even though the degree of interaction is slight compared to what is possible. Often they have no idea of the full possibilities.

- Being accustomed to lecturing, to multiple choice and textbooks. teachers continue to design courses that use these formats. Although the latest developments in language teaching [Krashen, 1983] emphasize frequent conversational interactions with the students, classroom techniques have not yet reached interactive video courses.

We will conclude this section with strategies leading to interaction high in both frequency and quality. Some of these features are general, but some refer directly to learning languages.

## ONE-SIDED INTERACTIONS

The strategies listed here could lead to frequent interactions in learning material; but the very limited amount of the information about student learning, and its low quality, prevent them from being called "highly interactive" strategies.

### Multiple Choice

Multiple choice is a major example of low quality interaction. Multiple choice does not correspond to the real world: in most situations many possibilities are available. A mechanic about to repair your car's transmission has more than four possible choices.

Multiple choice is a poor way of determining whether anyone has a capability or not, except in the rare situations that have few possibilities to begin with. Because of the broad variety of features in languages, numerous errors and misconceptions, and varying degrees of comprehension, can be expected in answers to any non-trivial question. Adequate analysis of language comprehension is beyond the scope of multiple choice. As its popular student name, "multiple guess," suggests, students often guess randomly, hardly trying to solve the problem. Self-reliance is essential if language comprehension skills are to be acquired.

Despite these failings, many systems continue to use multiple choice because of assumed difficulties of comprehensive analysis of student response. We, in our work, find such analysis to be a tractable problem.

### Student-Chosen Paths

Some learning systems present the student with the list of items to be explored, but they make little attempt to direct the student, and no attempt to find out if the student is learning anything, or what learning problems the student has. Lacking this information, the system can offer no individualized help, leaving the student to choose some path through the material, without direction. A critical aspect of learning is determining how the student is progressing, and using that information to make subsequent pedagogical choices. Computer-based learning material provides wonderful opportunities for this. But they are seldom realized.

This strategy is often implemented using hypermedia tools. Examples are Brown University's hypermedia courses, and those described in [Underwood, 1989]. Each screen may have many words tha' can be triggered for more information, or may have navigation buttons and icons leading to other parts of the program.

For example, in a language-learning program, there may be parts which give the video in whole or in part; translations (or transcriptions) of lines in the video; reviews of the lesson; quizzes; and on-line dictionaries. The student decides which parts to visit, and when. The program, knowing nothing of the student's capabilities, is allowing random choices.

Although there is little empirical information, we believe the confused history of a student's passage through an unguided environment makes it difficult to assess the student's progress and problems, as needed to determine and provide the necessary help. The mixture of the two strategies is needed to achieve guided exploration. We hold that both freedom and discipline are needed in learning environments, and that without both, the student will not achieve the best learning.

## INFREQUENT INTERACTIONS

The strategies listed here limit the frequency of interactions, leading to a passive learning situation. As a result, even with some high-quality interactions, the amount of information gathered from the student is limited.

### Passive Video

Video-based language courses often show long video segments to the students before they have any interaction with the medium or a human teacher. This tends to exclude students from the activity, since they cannot concentrate on extended presentations in an unfamiliar language. We found that many students who helped evaluate our Understanding Spoken Japanese system disliked presentation of videos containing more than several sentences, where they remained passive and uninvolved. Too much information in the video leaves the student uncertain on which of it he or she is supposed to concentrate.

Some interactive video systems choose first to present the video passively, followed by interactions and remedial scenes. But we prefer to bring students to comprehend the whole story, if they so desire, through a sequence of interactions dealing with appropriate excerpts. Naturally, different students gain better comprehension from differently chosen excerpts, of differing lengths and in differing orders.

### Lecturing

Although lecturing is a form of presentation with no individualization and little or no interaction, it is nevertheless often seen in many technology-based learning systems.

Lecturing often takes the form of long textual explanations, perhaps entire paragraphs of text, intended to be read passively. It also tends to include vocabulary lists; grammar rules; and translations (and transcriptions) of speech from the video.

Computer-based materials should maximize the advantage of personal, individualized sessions, as commonly used by private tutors. We should take full advantage of their individual nature, not relying on methods created to handle large audiences.

## HIGHLY INTERACTIVE STRATEGIES

In contrast to the strategies already listed, the ones now described keep material highly interactive. These allow the system to collect information about the student's progress, and use it to assist the student. Also, the frequent use of these strategies in the material keep the student engaged and concentrating.

### Overall Organization

One way to achieve a high quality of interactivity is to organize the learning material as a carefully designed series of exercises of different types, centered on short video excerpts that demonstrate language objectives. In each exercise each student response should be analyzed, and individualized help sequences provided which make use of additional material (speech, pictures, etc.) beyond the video itself.

The major components of this organization are:

- **Guided Exploration**
  The general strategy for moving through the series of exercises is for the program to decide presentation order, based on its analysis of the student's progress. In certain places, the student may be allowed to decide:
  - the order for independent exercises;
  - whether to retry a prior, related exercise;

- whether to repeat the video or audio that was played as the basis of the current question.

- **Interaction and Video Excerpts**
  Many exercises may start with a short video (visual, audio, or both), demonstrating a learning objective; the video should typically be under a minute. Subsequent interactions will be based on it.

  Even when the whole video is made available, the student should have some control over the video, rather than being obliged to wait until it has played out. In material working on spoken language comprehension, using short excerpts for the video presentation reduces any need for subtitles and vocabulary lists. Subtitles can be useful where the student shows great comprehension difficulties. This lets the student concentrate on listening and comprehending, rather than on reading.

- **Individualized Help, Not Lecturing**
  The series of exercises should be designed to lead the student to discovering language elements without long explanations. A student having continual difficulty with some point should receive increasing levels of help.

  When the student cannot get through an exercise successfully, a short, immediately relevant explanation should be offered, supplemented by additional audio and visual material. Then further questions should check the student's understanding.

  The text on the screen, in either language, should be brief, no more than a few lines. It should be presented at a speed that lets the student read it as it appears. The sparse use of text helps to avoid lectures on the screen, and it lets the student read the text thoroughly, rather than starting to scan it, as tends to happen with, for example, newspapers.

- **Different Levels for Different Students**
  A program should analyze the student's progress and problems based on the numerous interactions with the student, and determine what level is appropriate. The program should supply various tracks or paths of differing complexities, and both judge on which path the student should start, and whether, at various points along each track, another track would be more appropriate.

  We want the program to respond appropriately to a wide variety of student answers. Within any exercise, we should allow a great variety of answers, analyzing a great breadth of difficulties.

**Types of Exercises**
There should be a variety of ways for the student to interact, to motivate the student further, and to accomodate different types of information needed about the student's progress. Furthermore, different aspects of the language being learned require different types of exercise.

For each type of exercise to be described below, we give an example from learning English as a second language. We will focus on the English articles, which are stated to be the most difficult feature in learning English [Covitt, 1976].

- **FREE-FORM ENTRY:**
  The approach most similar to a conversation between a tutor and the student is a textual answer in response to a question, in either English or the language being learned.

  No format should be imposed on the entry. Reasonable misspellings, including phonetic spellings, for each exercise should be determined and accepted.

  Questions could explore different aspects of language learning, such as listening comprehension, sentence construction, and vocabulary. Subject matter may come from either:
  - the video just seen;
  - examples beyond the video.

  **FOR EXAMPLE:**
  The program shows a video in which a girl's cat gets lost. The girl goes looking for it, and she asks "Have you seen a cat?".
  - The program asks the student to reproduce the girl's question as she phrased it.

- Anticipated answers include: the completely correct answer; paraphrases of it; ungrammatical renderings of it; mishearings and misspellings of the words; and different meanings, possibly arising from incorrect article usage.
- For incorrect articles used in the response, the program asks the student to pay attention to the article, possibly by replaying the video, or by playing additional audio that emphasizes the noun phrase. The program gives hints by referring to the context in which the girl chose the article. It also confirms the correct answer by describing why the particular article should or should not be used, again referring to the context.

- **ROLE PLAYING**

Free-form entry may also be used in role-playing exercises. Here, rather than answering questions, the student enters one side of a conversation, or even initiates it under the lesson's guidance. The conversation would usually be with some character simulated by the lesson, usually on the basis of characters already seen in the video. Questions can either by written or spoken. At present, answers can only be written.

Playing a role gives the student an opportunity to practice conversations. This cannot be achieved with such simplistic strategies as multiple choice questions.

**FOR EXAMPLE:**

The program sets up a small story visually. The simulated character comes into a room and asks questions about another family member (it is assumed that the character and the student live in the same house). The student must respond to those questions, using the correct English articles for the context.

- "Where did Mary go?": a correct answer would be "To THE beach."
- "Which towel did she take with her?": a correct answer would be "THE red one."

We look forward to technology letting students speak, with the program having full analytic capabilities. This will further increase interactivity.

- **ICONS and BUTTONS**

Buttons are useful in letting the student choose objects on the screen.

**FOR EXAMPLE:**

The student clicks on items described by a particular use of articles in a particular context. This would let the student show understanding of individual articles by taking the appropriate actions. Example instructions to the student are:

- "SHOW ME THE APPLES",
- "SHOW ME AN APPLE",
- "INDICATE THE WHITE HOUSE IN WASHINGTON",
- "POINT TO A WHITE HOUSE."

Conversely, one can supply word buttons so the student can construct sentences to cause an action when the sentence makes sense.

**FOR EXAMPLE:**

With many objects shown on the screen, the student presses buttons to construct such sentences as "Show me the green house on the pond." The program responds to meaningful sentences by highlighting the specified object or objects -- in this case, the single green house on the pond. The program responds to meaningless sentences by asking for clarification. For example, if several green houses were on the pond when the student created this sentence, the program would ask which of them was meant.

Buttons limit the number of "trivial" errors or paraphrases the student can make with component words, leading to more reliable analysis of answers. This approach is similar to "scrambled sentence" exercises, but the student is able to get immediate results by seeing the action described by the student's sentence, or hearing the sentence. The choice of actions, requiring the student's understanding, has immediate visible consequences in a nearly physical world.

**• VIDEO EXERCISES**

The student can be asked to manipulate the video. For example, students can be asked to identify a specified word or phrase spoken in the video. This can be done by pressing a key or a button as the phrase is heard.

The student can recognize a word or phrase within the normal stream of sound, where the student may not be expecting it, rather than as an isolated example spoken specifically for student identification.

Varieties of this exercise include:
- finding all occurrences of a specified word or phrase;
- finding all such occurrences that have a common meaning, where other occurrences may have different meanings
- finding variations on a specified phrase.

**FOR EXAMPLE:**

To help the student pay closer attention to articles as they are spoken, play a video, and ask the student to press the space bar every time an English article is heard. At each point, ask the student to identify the article, and explain why it is used in that context.

We expect imaginative design by excellent language teachers to produce more varieties.

Usually the video would be started for the student. It may be restarted if an adequate number of occurrences have not yet been identified.

One variation is to give the student buttons to move the video to any desired position, where it will resume play; so the student controls the finding of the phrase. This method can be used not only for audio, but for visual information on culture related to the language.

Finally, a component of each lesson can be free-play, with full video control given to the student. The student may replay all parts of the video as often as desired. This gives an opportunity to place what they have just acquired back in its context, and to exercise their hearing as much as they feel they need.

**PEDAGOGICAL DESIGN PROCESS**

How does one generate highly interactive material for learning languages, based on the strategies just discussed? The key part of the project is the PEDAGOGICAL DESIGN of the learning material, by skilled teachers of the language being taught.

The following points are the major aspects to consider in design:

The selection of the best possible teachers is critical.
- The teachers selected should be involved, on a daily basis, with the students to whom the units are directed.
- The teachers should LIKE students.
- The teachers should like interactive approaches to learning. They should work frequently individually with students.
- The teachers should like conversational and communicative approaches to language learning.
- The teachers should be interested in improving present learning environments.
- The teachers should be aware of likely student problems in learning the language.
- The teachers do not need any previous experience with computers and interactive video.
- Teachers should come from a wide geographical distribution.

Organization of design sessions is critical.
- A typical design session is one week.
- Several groups will usually work simultaneously.
- Designers should work in groups of about four people.
- Designers must be present for the full session.
- Written material should be available in advance to the designers, outlining the task and describing important points.

Other participants may be useful.
- In addition to several teachers, a design group might involve a linguist, who can supply broader language information, useful for anticipating, categorizing, and analyzing likely answers the students may give.
- A person already experienced in

designing for interactive media can stimulate the imaginative use of the media, and guide teachers in the use of highly interactive strategies.

- No programmers should be involved in the design groups, as the discussion should focus on pedagogy.

Designers need to understand something about group dynamics.

- Teachers will have little experience with such intense group work.
- The week's work should start with a brief introduction to group dynamics.
- Designers should expect conflict within the group.
- Designers should try to reach compromises quickly.
- Designers should not be distracted by technical details.

A design session produces a pedagogical design document.

- Designers make ALL pedagogical decisions. For a typical exercise, the designers should specify:
  - the video excerpt it uses, and whether sound, video, or both are to be used;
  - question or instruction given to the student;
  - all additional sound needed in both languages;
  - all special facilities (such as video translation)
  - all pictures (photographs, graphics) to be shown
  - nature of exercise, including how student is to answer (or otherwise take part)
  - anticipated answer categories;
  - responses, help sequences for each category, paths to take, further video to use, etc.

- Designers need a methodology for recording all results. The methodology should focus on interaction. The format of the design we use is the script, a technique which has been in use at Irvine for over twenty years. It diagrams the flow of the whole lesson in pedagogical terms, creating a specification which is easily implemented by a programmer. The notion is to have a tactic which the teachers can pick up very quickly, and which they think of as the process of working with individual students. Because of the multiple tracks and complicated help sequence loops, an overview flow chart should be recorded at the same time, to indicate the connections among the exercises and between tracks.

**FINAL COMMENTS**

This paper has discussed:

- The need for high quality interactions in language learning.
- Strategies for obtaining high quality interaction.
- A design process that leads to highly interactive learning material.

The strategies recommended in this paper have all been used for our Understanding Spoken Japanese system [Yoshii, 1991]. This highly interactive system promotes the student's conversational ability through exposure to genuine

conversational Japanese. Comprehension of the whole video is a possible goal, but not mandatory.

The target audience is American high school and college students. Business or industry may also find it useful. The system assumes no particular text or other reference works. It can best be described as an independent, individualized supplement to other types of instruction.

Ten lessons, taking about twenty hours of student time, have now been created. The development of a second ten lessons for more advanced students is beginning. This project is one of the most substantial collections of highly interactive video material so far produced, in any subject area.

We are planning to design and implement a system for teaching English articles to students of English as a second language.

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# ACCESSING DATABASES FROM AN IBM INFOWINDOW COMPUTER-BASED VIDEO INSTRUCTION PROGRAM USING "C" LANGUAGE PROCEDURES

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**Abstract**
The presentation describes and demonstrates methods of accessing databases from an IBM InfoWindow computer-based video instruction (CBVI) program. "C" language procedures are used with IBM's IWPS authoring system, an IBM PS/2 Model 70 microcomputer with InfoWindow touch display and a Pioneer LD-V6200A laser disc player. Segments of a CBVI program are used to illustrate database access (for example, learners' demographic data) and storage of data for future use.

**Introduction**
The paper describes methods of accessing databases from an IBM InfoWindow computer-based video instruction (CBVI) program. "C" language procedures are used. The impetus for the topic began in 1989 when a computer-based video instruction (CBVI) program was developed for a research project on learner control options (Hassett, 1991).

Phillips' work supports the implementation of tracking students' progress for CBVI/DB (1991, pp. 12, 41). Therefore, following the project, it was determined that problems with accessing databases needed to be addressed if evaluation of individuals' learning was to be readily attainable for the user. Terms used are defined as follows: author is the creator of the CBVI program; user is the instructor/trainer; learner is the student/employee; presentation is a CBVI program; application is multiple presentations linked together; events are segments in a presentation; elements are actions in an event; and CBVI/DB is a computer-based video instruction pgram with a relational database.

The project presentation on spiritual care of the patient had been authored using IBM's InfoWindow Presentation System (IWPS ), Level 051A (International Business Machines Corporation [IBM], 1989a; IBM, 1989b). Computer-based research tools were included as part of the instructional design (Hassett, 1990). Four problems with data access surfaced while using the project presentation: a) learners were asked to input demographic data items that existed in on-site information systems; b) data files were created for individual learners and could not be easily aggregated; c) modifying presentation data was time consuming (e.g., changing pretest items); and d) data required for statistical analyses had to be manually gathered.

Because of project time constraints (eight weeks for creation of complete presentation), individual learners' data was printed as stored in IWPS log (trace activity) files. This data was then tabulated manually and input to a spreadsheet or sent for data analysis via electronic files created from the tabulations. The frustration of manually tabulating pages of data, much of which were stored electronically, prompted an in-depth look at the four problems.

To resolve the immediate problem of aggregating learner data, a standalone "C" program was written to extract data from the IWPS system files (variable and variable index). The "C" program was called by the presentation at the end of each learner session storing the data in a separate aggregate file. This solved only one problem and additional file conversion was still required. A more comprehensive solution was needed. Possibilities identified were to: a) download learners' demographic data from the on-site information system into character-delimited files using a standard data base management system (DBMS) format, such as dBASE IV; b) store CBVI data in an accessible format, using a traditional or conventional DBMS, and thereby facilitate statistical analyses; c) aggregate learner demographic data and CBVI data as needed, via traditional or conventional DBMS; and d) store test items and other presentation data in character format in a file, rather than using storage in the presentation graphics library.

It was decided that the traditional file processing approach would be abandoned in favor of a formal database approach. The presentation was completely redesigned to accommodate the new database requirements. A rapid prototyping approach was used

(Hassett, forthcoming). This demonstration will show the results of that endeavor. Database Organization of data in a database is crucial to ease of maintaining integrity of data and ease of use. Databases are integrated collections of automated data files related to one another to support a common purpose (Stevens, 1991, p. 8). They include what are commonly known as metadata and structure. Database management systems (DBMSs) provide the capability to manage and manipulate the data; standard query languages can access the data.

All real world things are related to other things by relationships. The ability to represent things and maintain the relationships between/among these things is an important feature of a database system. Database systems can be based on a number of database models. Most agree that the third normal form (3NF) relational model is the model that one should aim for, to provide a system that has a good maintenance profile. Translation from this model to any working DBMS is easily possible.

**Relational Model**

There are three major advantages to the relational approach. First, compared to other database models, only the relational model is based on certain mathematical disciplines: set theory and predicate logic (Date, 1990, p. 13). The relational model requires that the relations be normalized. There is a solid body of theory (dependency theory) to support this process (Date, 1990, p. 36 ). Databases that are based on normalized relations (i.e., 3NF) guarantee against certain types of deletion, insertion and update anomalies. Second, relational databases provide a simple user-interface. Files are perceived by the user as tables (and nothing but tables); and tables are very simple and familiar structures. Relational operators such as the Structured Query Language (SQL) SELECT and UPDATE operators allow users to simply specify what they want to do, without knowing how it has to be done at the programming level. Third, the relational model is widely used and is well supported by vendors.

In a relational database, things and relationship are both represented by flat files. Thus, relational database files have no parent files and no children files. Each record in a file is uniquely described by a key consisting of one or more data elements . Files in a relational database system are related by using data elements. For example, a person's social security number in one file may be linked to another file that also has that data element. In this demonstration, a relational database designed to support the CBVI system will be used. That database is in 3NF.

**Tools**

Most CBVI authoring languages provide some means of storing data. They do not, however, tend to provide the author or user with database support. This is true of IWPS, which requires a programmer to write the code necessary to access databases. dBASE IV (a traditional or conventional DBMS) was chosen for this demonstration for three reasons: it supports the relational model, it provides a subset of SQL and it is widely available. dBASE IV is not necessarily the best DBMS but is the most popular. Most microcomputer applications software, such as a spreadsheet, will import and export dBASE IV files. SQL is an English-like database language that operates on data entirely as logical sets called relations, or tables (Ashton- Tate Corporation, 1988, p. 7-1; Learning SQL, 1991, p. 1). SQL is a standard for mainframe, minicomputer and microcomputer database system programs. SQL is intended to be used by audiences ranging from computer professionals to end users. A number of popular DBMS software packages now include the SQL language.

**Design Goals**

The following goals were determined for the demonstration database: -store pertinent data in an accessible format, -minimize redundant data, -minimize the number of relations (files), and -normalize relations (i.e., 3NF). The first goal is obvious; that is, one must have the capability of storing all pertinent data in the database. The demonstration uses dBASE IV (a traditional or conventional DBMS) for accessibility. Some data must be extracted from the on-line information system and stored. The second and third goals eliminate redundant data and keep the number of relations (files) in the database to a minimum. The fourth goal normalizes relations; this minimizes update and deletion problems. The demonstration has six relations. IBM InfoWindow and IWPS Computer-based video instruction (CBVI) is often referred to as interactive video. Miller, Reeve-Dusenberry and Sayers defne interactive video as follows: The fusion of video and computer technology: a video program and a computer program running in tandem under the control of the learner. In interactive video, the user's actions, choices, and decisions genuinely affect the way in which the program unfolds (1988).

CBVI programs are commonly interactive only with the learner. The author of the CBVI program defines the values to be used and/or generated by the program in terms of interaction with the learner. [The term values is used, rather than data, because the user does not have access to "values" in the CBVI program.]

CBVI is used in the context of other systems that use and produce data that are sensitive to the presentation (context-sensitive). An IBM PS/2 Model 70 microcomputer is used for the demonstration, with an IBM InfoWindow touch display and a Pioneer LD-V6200A laser disc player. The IWPS Version 1.0 Level 51a was upgraded to Level 56 for this demonstration. Level 56 provides a number of new features, including support for IBM's M-Motion.

**IWPS Editor and Interpreter**
The IWPS Editor, used to author CBVI, is application independent. That is, the author has considerable flexibility in developing presentations. However, the user's control over data used and generated by the presentation is limited. The Editor is used to develop (author) interactive videodisc presentations (IBM, 1989a).

The Interpreter (InfoWindow Presentation Interpreter [IPI]) is used for developing and running presentations (IBM, 1989b). It is a runtime standalone program. When editing a presentation, authors have access to programming languages through: (a) user exits, (b) IPI "hook routines", or (c) calls to separately executable programs. Programming modules or programs must be coded and compiled. User exits and IPI "hook routines" must be linked to the IWPS Interpreter prior to editing. Several languages are supported by IWPS. Microsoft "C" is used exclusively for this demonstration.

**IWPS "C" Program Language Support**
User procedures written in "C" language can access selected IWPS system files (IBM, 1989). After the project, therefore, "C " language procedures were written and tested (Harbison & Steele, 1991; Microsoft C: 1990a, 1990b, 1990c). The term "procedure" is used in its generic sense. "C" is a procedure-oriented language that has all the constructs associated with structured programming; for example, if-then-else (Pugh, 1985, p. 1). In "C", however, a function is the equivalent to a subroutine or function in Fortran, or a function or procedure in Pascal (Kernighan & Ritchie, 1988, p. 24).

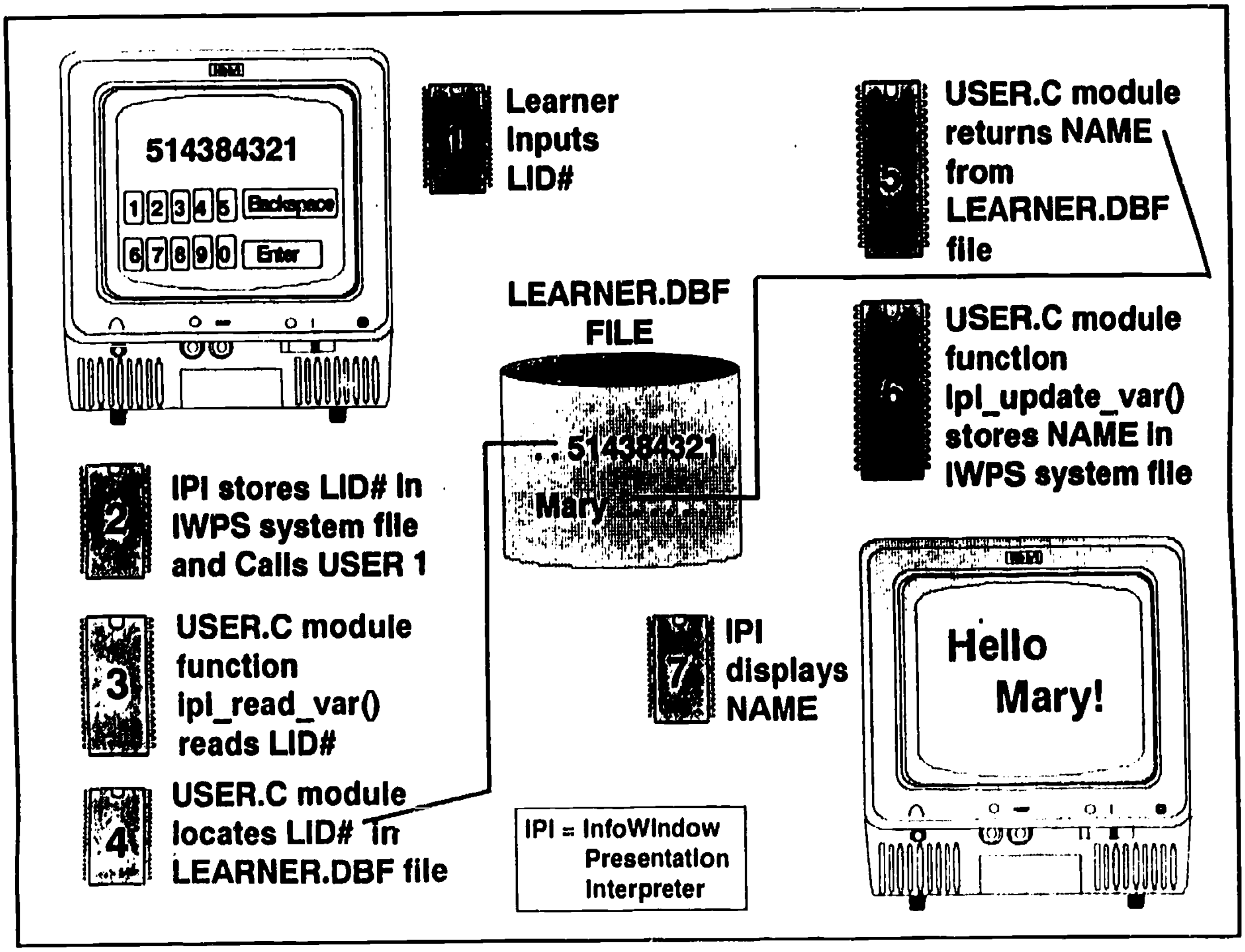


Figure 1. IWPS Presentation with User Exit.

"C" procedures made it possible to retrieve and store data in traditional or conventional database format. These procedures will be shared during the demonstration and illustrations will be provided via segments of the demonstration CBVI/DB program. A CD-ROM programmer's library was used for reference and sample code programming support (Microsoft programmer's library, 1991). SQL was used for relational database manipulation and control (Learning SQL, 1991).

User exits. User Exits provide variability during the execution of an event. A library of "C" functions is provided to use as calls from user procedures (IBM MultiMedia Solutions, 1990, pp. 23-45). Variables defined in the presentation during development can be accessed at runtime using "C" functions. The "C" functions used to read and write to database files were: ipi_read_var(), ipi_update_var(), and ipi_set_ind(). These functions are coded in "C" modules and linked to the Interpreter. Figure 1 depicts an IWPS diagram for a user exit: the learner inputs her learner ID on the InfoWindow touch display and the IPI accesses her first name via "C" procedures and displays her name in a hello screen.

IPI hooks. The IPI "Hook Routines" are pre-defined "C" function names that are called by the Interpreter at appropriate times during the running of the presentation. For example, the event_start() function will cause a given action to take place at the beginning of every event in the presentation. These functions are coded in "C" modules and linked to the Interpreter.

Standalone programs. Separate programs can be written and called by the IWPS Interpreter. When such a program is called, control of the presentation is given to that program. When that program terminates, control is returned to the Interpreter. These programs do not have access to presentation variables but can access data automatically stored in files by the Interpreter.

**CBVI/DB Application**

The environment in which a CBVI program is used determines what kind of database access can be provided. Both sophistication of the user and availability of technology are important factors for a CBVI/DB application.

A team approach was used to develop the CBVI/DB demonstration application. The basic requirements were defined. Then, in parallel, the Programmer/Analyst developed the database system while the Instructional Designer/Author rapid prototyped the presentations. The team approach was necessary because the variable names and types used by the programmer in the user exits were first declared by the author in the presentation events and vice versa. The goal was the final application; however, at the day-to-day level there was a complex set of interwoven factors to manage: personnel, resources, schedules, budgets, documentation, and ideas (Bergman & Moore, 1990, p. 25). The team approach worked well.

**Requirements**

Database requirements (Figure 2) were identified as: (a) user demographics, (b) instructional management, (c) research resou rce, and (d) presentation control.

[Insert Fig. 2 about here]

**User demographics.** Identification numbers are used for the user and for the learner. The Subject Information Form (SIF) tool (Hassett, 1989c) collected five areas of learner demographic data in the project. This tool was adapted to a new, similar tool for the demonstration: the Learner Information Form (LIF).

**Instructional management.** Identification numbers are used for the user and for the learner. Presentation time spent by the learner is stored. For example, time data can be used to plan scheduling of future computer laboratory activity. Reports are generated from the demonstration database; these include selected demographics, presentation time spent and test scores.

**Presentation control.** The CBVI project was used for research on learner control options (Hassett, 1989d; Hassett, 1991). Changes in the project presentation were difficult to make. Therefore, each presentation for the demonstration is assigned an identification number. Time stamps are collected and stored. The Screening Pretest (SP) tool (Hassett, 1989b) can now be altered by the user. For example, SP items can be altered, added or deleted, and the number of randomly selected items can be changed, such as from five items to ten.

**Research resource.** Data important to research were added to the CBVI/DB. Identification numbers for the user and for the learner are

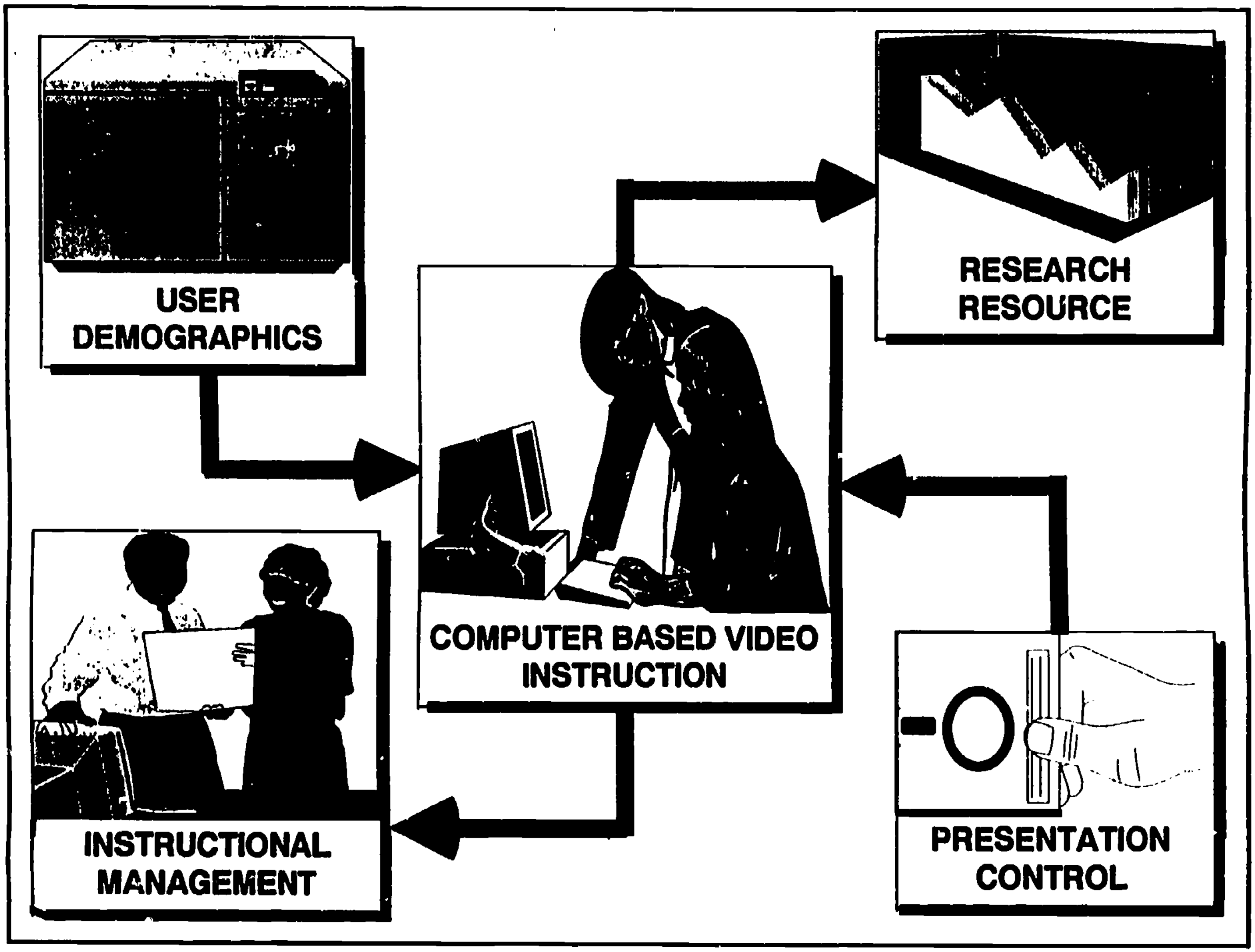


Figure 2. Database Requirements.

used. The four CBVI project tools are used in the same form or as revised: (a) the SIF tool (Hassett, 1989c) was revised to LIF for learner demographic data; (b) the Screening Pretest (Hassett, 1989b) for baseline learner knowledge prior to the CBVI; (c) the Embedded Content Questions (ECQ) tool for assessing knowledge acquisition (Hassett, 1989d); and (d) The computer-based ARS tool (Hassett, 1989a) for measuring attitudes toward the CBVI program. Kelly, Pascarella, Terenzini, and Chapman developed the Adjective Rating Scale (ARS), a public domain paper and pencil tool that measures attitudes toward courses and programs (1976). Other learner responses added to the database for research purposes are learner control choices. Therefore, examples of research resource activity available through the CBVI/DB include: -assessment of learner control choices; -comparison of Screening Pretest baseline data with learners' scores on the ECQ; -study of learner attitudes toward CBVI; and -study of presentation time spent by learners.

**Design and Development**

The Entity-Relationship (ER) model is used in the database design. The ER model is closer to the user's perception of data and is not meant to describe the way in which data will be stored in the computer. Figure 3 depicts an ER diagram of the demonstration CBVI/DB. The entities are: user, course, presentation, learner, test, and evaluation. The entity relationships and attributes are depicted in the diagram (Fig. 3). An object-oriented database design, such as described by Huang and Unger (1988), will be used with the relational model in the future.

**Modular Approach.** With the modular approach, an application is divided into multiple presentations. Each presentation performs a cohesive function. IWPS supports

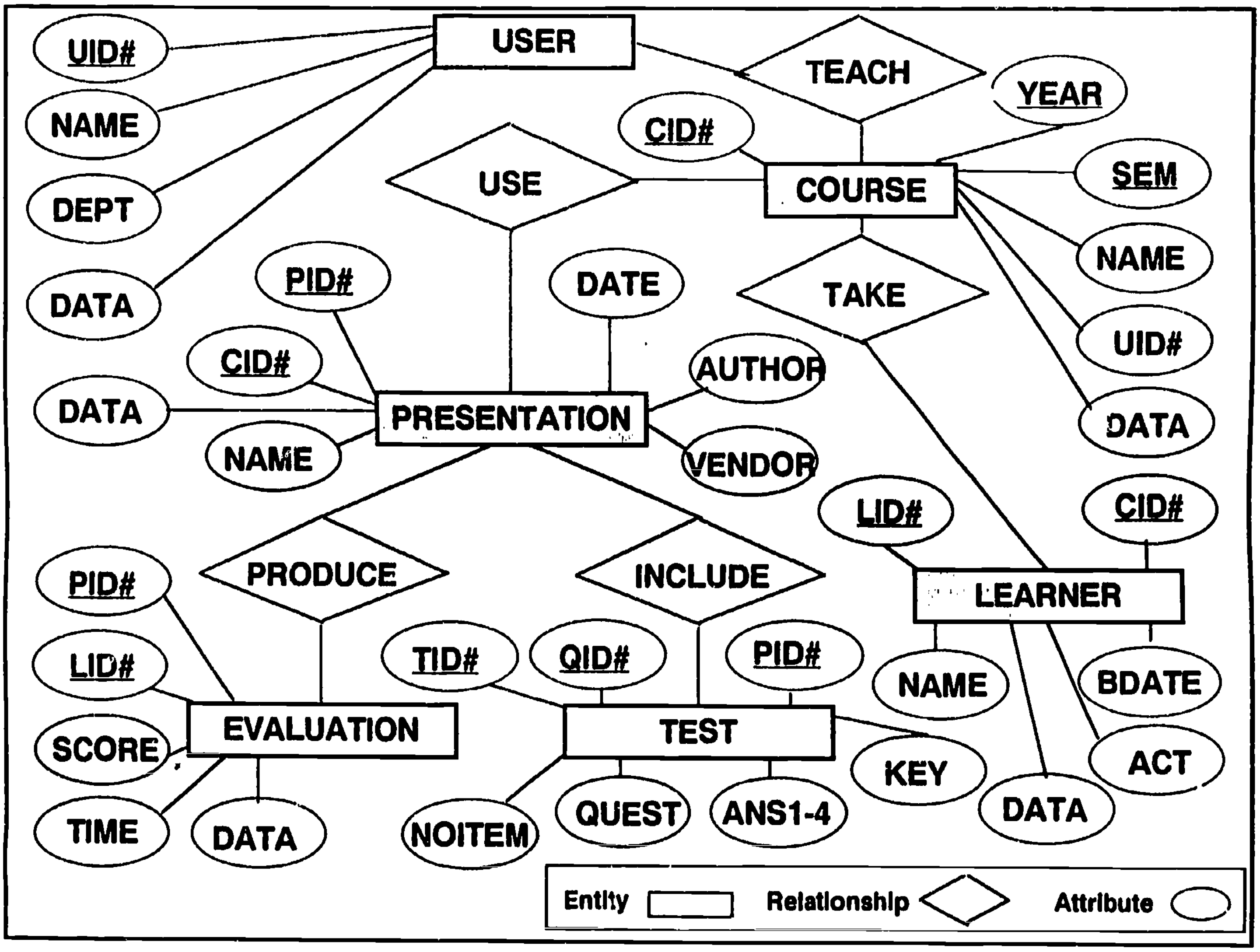


**Figure 3. Entity-Relationship (ER) Diagram for a CBVI/DB.**

this approach by allowing a presentation to be called from within an event of another presentation (IBM, 1986a). Adding the database to the demonstration (i.e., the CBVI/DB) makes using multiple presentations simpler. The database provides data independence, thus eliminating the need to collect data from several program-dependent files. Figure 4 illustrates how one may use multiple presentations with IWPS and a CBVI/DB.

Defining and Querying the Database. Sample dBASE IV SQL statements used to create the six relations in the database will be demonstrated. The relations declared through the CREATE TABLE are called base relations. These relations will be created and stored as files by dBASE IV. Base relations are distinguished from virtual relations created through the CREATE VIEW statement. A virtual relation may or may not correspond to an actual file.

SQL does not provide a way of specifying key CREATE TABLE command. This must be done using the CREATE INDEX command.

The demonstration will include a sample query of the relations in the database.

ToolBook (v. 1.5) will be used to build a front end for the CBVI/DB. This will allow the user to maintain data in its original form so it can still be accessed by other programs (Asymetrix Corporation, 1991, p. 19). The ToolBook front end (book) will be used to demonstrate the flexibility of the database.

**Implementation**

A Typical Learner Session and a Typical User Session will be demonstrated, based upon the CBVI/DB depicted in Figure 4. dBASE IV will be

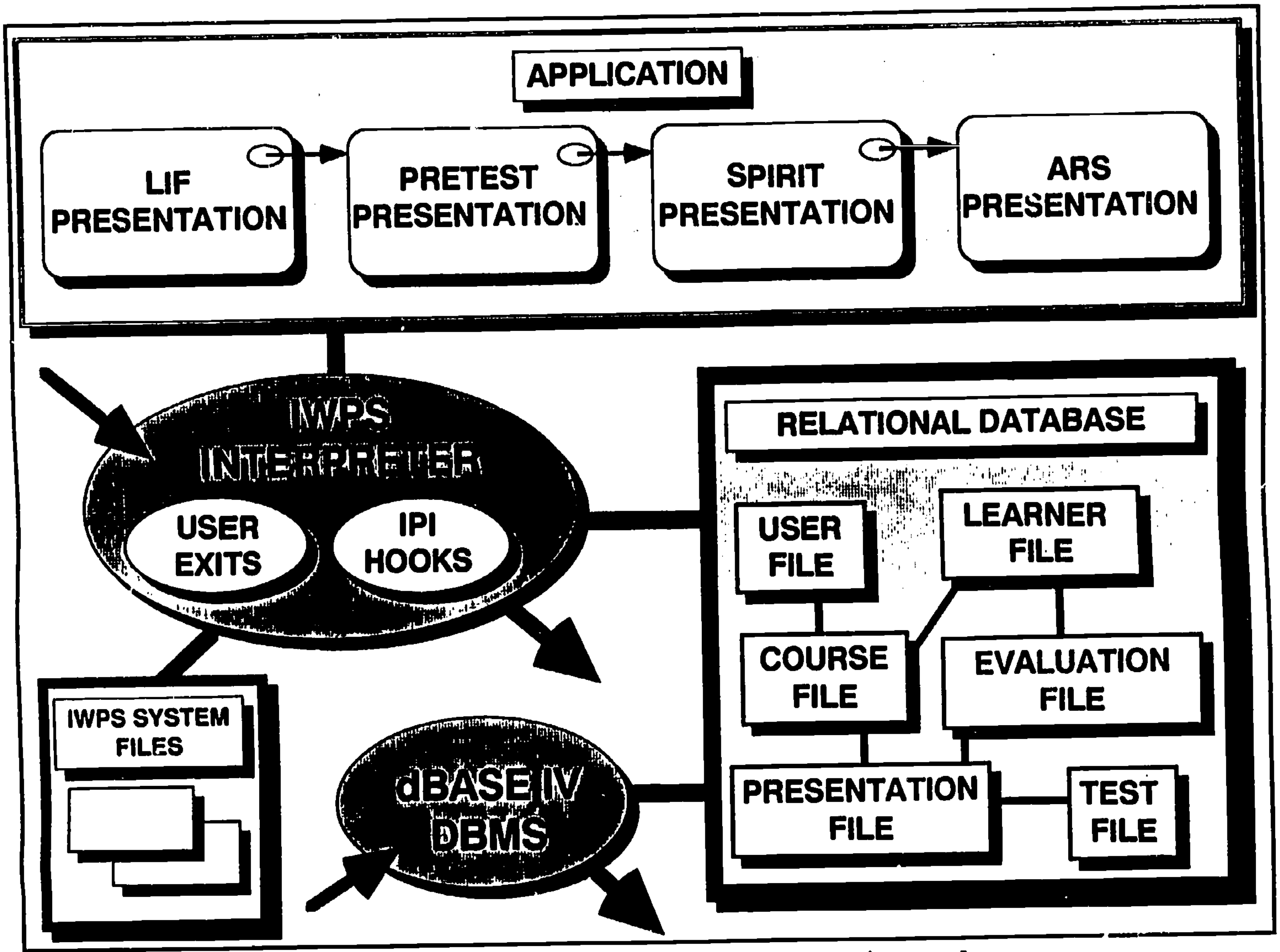


**Figure 4. Computer-Based Video Instruction/Database.**

used as the DBMS. The demonstration will show an application that uses procedures written in "C" that provides access to relational database files. The demonstration will illustrate database access, report generation and storage of data for future use.

**Conclusions**

Users need automated access to learners' data. Problems with accessing databases in CBVI were addressed. Methods of accessing databases from an IBM InfoWindow computer-based video instruction (CBVI) program using "C" language procedures were described: a CBVI/DB. Later, object oriented design (Huang & Unger, 1988) and statistics capability should be added to the applications.

Researchers have investigated prediction of success in courses. For example, Becker and Unger's study created and validated a tool to predict success in an introductory programming course (1983). A tool such as this could be computer-based and used to predict success prior to learners' initiating a set of CBVI/DB presentations, for a given course. Further research is needed in this area. The CBVI/DB will be tested in research environments.

The use of databases with CBVI ought to be promoted to increase the types of use that involve evaluation of learners' responses. An "open architecture" philosophy is needed to make this work easily portable to other environments. More flexibility should be provided to users about presentation control data. More research is needed to better understand what the next generation of programs should look like. User demographic data is important for research, instructional management and presentation control.

Providing easy access to the data necessary for course management should be an integral part of the CBVI design (i.e., the creation of CBV I/DB).

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# COMPUTER-ASSISTED LANGUAGE LEARNING (CALL) THROUGH THE LENS OF ELABORATION THEORY

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**Abstract**
Many theories have been developed about learning and retention. In this paper we shall discuss an independently arrived at synthesis of existing learning theories embedded in an original Intermediate Hebrew Computer Assisted Instruction (IAV /CAI) project. The latter was the outcome of a cooperative agreement between the U.S. Government and Brigham Young University. Elaboration theory, a modern instructional development strategy which uses existing cognitive principles, will be referred to in connection with the structural format of the IAV/CAI project.

Points of contact will be discussed between many of the theoretical issues and their practical application to real problems in CBT development. Several diagrams and flowcharts are included to simulate some of the actual computer interface screens and to graphically illustrate the nature of the lesson design.

**Introduction**
With the advent of technology, learning has taken a new twist. Courses no longer need to be developed strictly on paper. Computer Assisted Instruction (CAI) is a multidimensional, fascinating medium which, when used properly, has been known to enhance student motivation and desire to stay with the course. We believe that a design based on a synthesis of modern learning theories can enhance long-term retention of the material.

Below, we will describe an original Interactive Video Computer Assisted Instruction (IAV/CAI) Hebrew language courseware package, highlighting computer learning interface features and the language-learning methodology used. Finally, using the instructional design strategy known as Elaboration Theory, we will show how computer-assisted instruction based on an independently arrived at synthesis of modern learning theories can create a state-of-the-art language learning tool.

First, the courseware package. In 1982 Brigham Young University (BYU) and the U.S. Department of Defense collaborated to produce three interactive videodisc language instruction projects. This interactive video was achieved through video materials that were mastered on laser disc and incorporated in computer assisted instruction (CAI) courseware (via video disc player) for the learner to interact with. One side of a laser disc holds 54,000 frames or one half hour of video material. Each laser disc has two audio tracks. In the Hebrew language project we used track two for the recording of a **m**ore **c**arefully **e**nunciated **a**udio (MCEA) mode.

The programming was done at BYU, while the subject matter experts (SMEs) from the Department of Defense designed and developed every aspect of the course, including the selection of video materials and their copyright releases, the recording of the MCEA, the structure and plan of each lesson and the actual coding of hundreds of screen design sheets (Knisbacher, 1987). All these projects consisted of an initial prototype course and a follow-on, more sophisticated "phase II." All the packages were intended for language learning. The entire project took six years to complete. The authoring tool was Courseware Design System (CDS) with Courseware Design Language (CDL) for the fine-tuning. A video overlay board (the MIC 2000 by Learncom) was used to project the video on the same computer screen used to present lesson text and graphics. A Zenith AT 248 (an upgrade from the prototype) was the master engine driving the process.

In phase II of the intermediate level colloquial Hebrew courseware, another component was added, the Instavox (from the Latin for "instant voice"). The latter is a rapid access analog audio device that was used for the recording of cultural notes, idioms, expressions, and the Advanced Level Total Comprehension Test, all on a rather clumsy 14" floppy disk. Today's digital technology is far more compact and transportable (see diagram on figure 1 ).

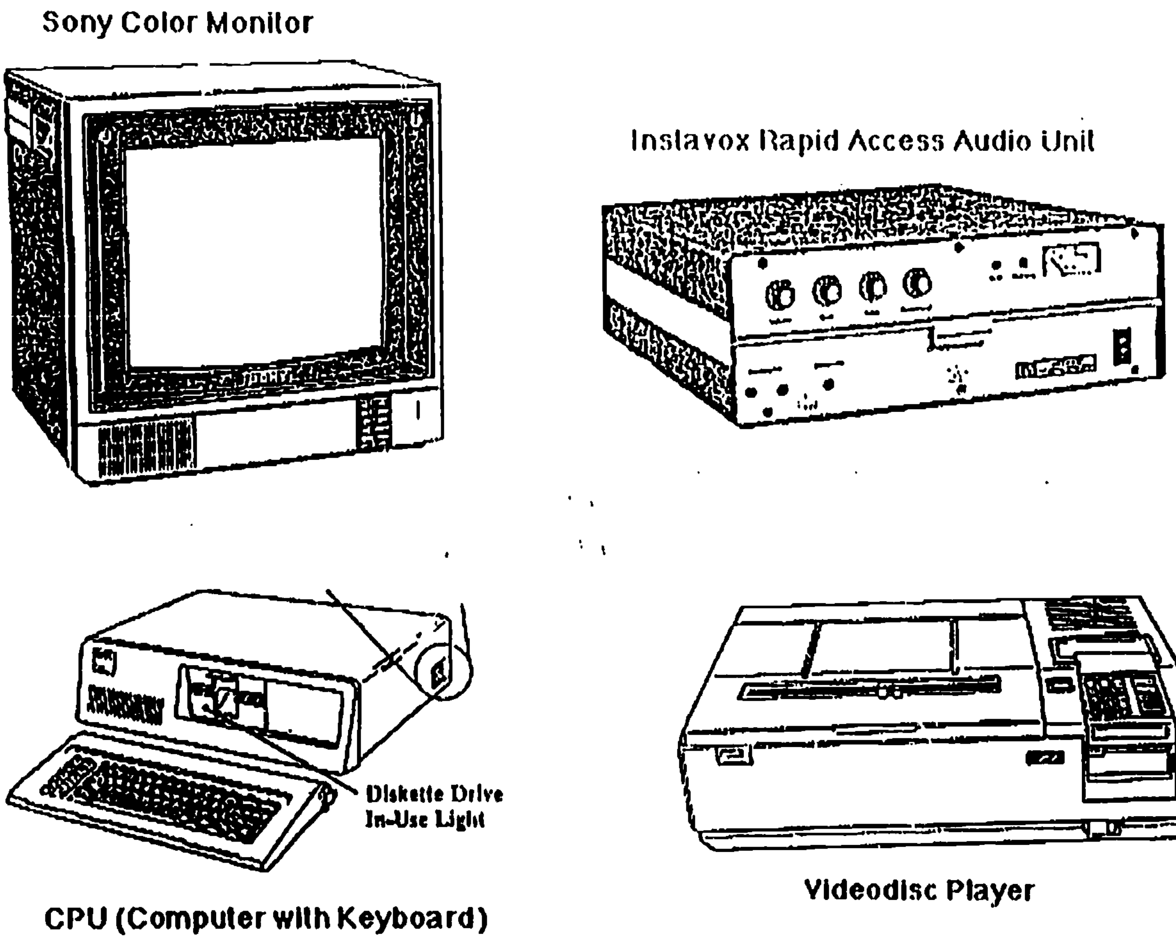



Figure 1

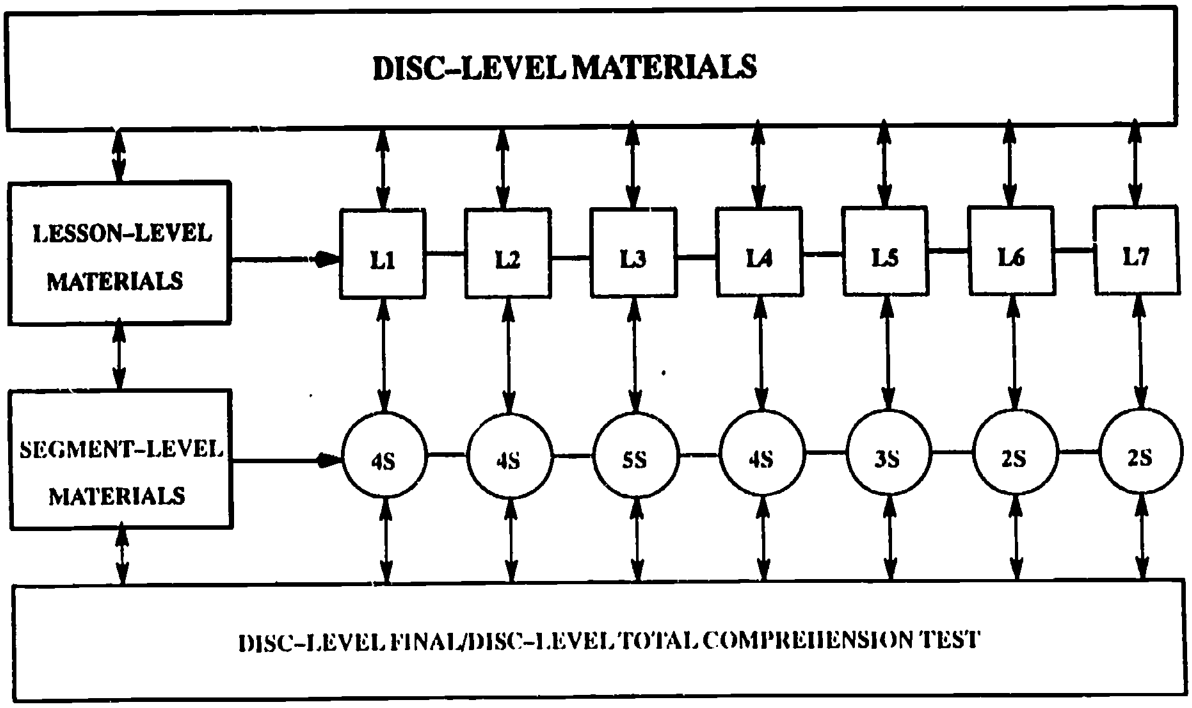



Figure 2 Course Map

Language Acquisition and IAV/CAI Design Aspects Designing IAV/CAI is not a simple endeavor: It is a multifaceted process. First, there is the actual CAI aspect, which is quite different from normal platform instruction development. One cannot just take a paper course and encode it into the computer. It is too expensive and time-consuming a medium to be just a page turner. It should contain ample remediation material and multiple branching flexibility. Another essential consideration is the aesthetic appearance of each screen (page) presented to the learner. Since reading a computer screen is more difficult than a printed page, care should be taken not to overcrowd it, to use upper and lower case letters and to leave ample space between lines of text. Related pieces of information (page numbers, content title, student options menu, feedback, etc.), must appear in their allocated place on the screen cosistently. And finally, in addition to screen color selection, there is the language aspect and related methodology.

A CAI course can be designed to supplement existing, regular classroom instruction, or to support self-paced learning (in stand-alone mode). The addition of video to CAI opens up new avenues for the exploration of CAI-based teaching effectiveness. "A picture is worth 1,000 words" is more than a cliche. Video not only makes learning livelier, but also clarifies and puts the point across faster. This is especially true of language learning, where a gesture or facial expression may help a person understand the context even without knowing the meaning of each individual word.

Dr. Janet Murray (1989) author of the Athena language project at MIT, sums up the benefit of interactive video in the teaching of foreign language as follows: "Interactive video can provide the student with a sense of immersion that no other technology can duplicate, as the students are surrounded by a multiplicity of language sources--video, stills, audio, graphics, texts,--allowing them to see, hear, and read the language simultaneously. This variety of language as it exists within the visual, social, and cultural world, allows for immersion in the truest sense of the word."

Phase II of the Hebrew IAV/CAI is strictly an Intermediate-Level Colloquial Hebrew course and can be used as enhancement to existing platform instruction, or in stand-alone mode. It is based on a sitcom from the Israeli TV series "Close Relatives," somewhat comparable to our "Family Ties." Only comedy was used here because it is so closely tied to colloquial language.

Contextual methodology is the language instruction approach of choice in this project. Current language instruction theory focuses on real language (as opposed to the made-up sentences that one finds in so many text books). In keeping with that idea, everything in Phase II is prompted by actual usage in the video, i.e., by real live language. The learner is encouraged to listen to a whole string of vocabulary items in context, rather than to focus on a single word. The advantage ofhis approach should be obvious.

Our overall computer-assisted foreign language acquisition philosophy is very much in tune with the thinking of noted educator Michel DeBloois (1983) who states that courseware authoring for videodisc requires "multidimensional thinking and advanced design tools." In attempting to provide as many tools as possible to enhance the learning experience, several features were programmed and incorporated into the project. These include, among others, the ability to watch the video and/or listen to an utterance as often as the learner wishes, using both audio tracks alternately. Where problems remain, a transcript of the audio can be requested along with the English translation and/or of the Hebrew-English vocabulary list (word bank). All of these are always available from a student options menu at the touch of a function key to make the program as user-friendly as possible. Of course, backing out of any activity whatsoever and switching to another is a constant option. There are very few "system control" features, i.e., instructor-controlled activities. For example, the learner may not be allowed to answer a question more than once while in "test mode" or may be encouraged to complete a transcription exercise prior to having access to the entire text. These restrictions, however, are few and far between. Rather, "student control" predominates, thus making the learner master of his* own destiny.

**Elaboration Theory** Having talked about our hardware configuration and language acquisition philosophy, let us look at the overall design strategy and the tools used to implement it.

Elaboration theory is a macrolevel strategy and structure for the development of instructional design. Based upon the work of Reigeluth and colleagues (1979, 1980, 1982, 1983, etc.), it advocates that instruction be developed the way knowledge is arranged in memory, i.e., hierarchically.

Elaboration theory embraces well-established cognitive approaches to learning and memorization a la Gagne. However, elaboration theory recognizes other relationships among the various content types. Although it is relatively new, elaboration theory shows marked increase in the ability to learn concepts, which in turn, promotes better transfer of concepts and their classification, leading to the application level. Elaboration theory begins at the application level, proceeding down and back to the entry point at the top.

Elaboration theory and Norman's Web theory (1983) have a common denominator: both hold that "memory is a network of interrelated id eas" leading to the duplication of the theory in practice.

*Note that for the purpose of simplicity, the learner will be referred to as "he" or "him."

The instructional design of elaboration theory advocates the need to:

a.state the overall ideas within the general content (procedures, concepts or principles)
b.use epitomes to present the simplest, most essential ideas to show their application in the larger picture
c.relate these ideas to things familiar to the student through previous learning (use of analogies)
d.break up the general content into more elaborate detail (from the general to the particular)
e.repeat the above process in reverse--from the detailed to the general
f.let the learner determine the sequence of information

Lesson strategies according to elaborative theory should:

g.present ideas in simple to complex sequence, after presenting the general structure
h.use Gagne's prerequisite knowledge, i.e., always teach those behaviors that become a foundation for the rest of the content
i.use summaries, practices items and examples
j.synthesize instruction at the end of the lesson by relating new ideas to previously learned information
k.make instruction relevant through the use of analogies (relates to previous learner experience)
l.provide hints on chunking, organization, synonyms and antonyms in order to teach cognitive strategies (this can be included as part of the overall instructional strategy)
m.let the learner control the mode, sequence, and learning strategy of instruction

Reigeluth has used the analogy of the "zoom lens in a camera." He suggested first presenting the learner with the overall picture (without going into detail), then zooming in by breaking the large picture into its component parts and relating them to one another. Finally, summarizers and synthesizers are used to move the learner to the general picture, once again.

If all of these steps are followed, the assumption is that learners will develop better understanding of the materials, gain more stable knowledge and thus strengthen their long-term memory.

In conclusion, the designer should organize the learning material into groups of related tasks/concepts/ideas, establishing a relationship amongst the various content items, which are then arranged into hierarchies with the lesson's epitome at the top. Summarizers and synthesizers are arranged to reflect the exact content interrelationship and, finally, cognitive strategies and their placement within the general scheme of things.

While elaboration theory seems to inform the overall philosophy used for the instructional design and development of the Hebrew IAV/CAI, Operant Conditioning (Skinner's learning machine) is also represented, i.e., active learner participation , feedback and reinforcement, presentation of small segments using the "building block" approach, etc.

**How does all this tie into the IAV/CAI project?**
Video Disc-Level Activities After a thorough content analysis based on elaboration theory principles was conducted, the overall content was arranged hierarchically, and all the concepts and principles were identified. A three-way division was decided upon consisting of disc, lesson and segment level materials. Within each of the above, prerequisites precede more complex structures, becoming the foundation for new learning and the glue for cumulative learning.

This Disc-Level Activities portion of the course presents the general structure, as per strategies suggested by elaboration theory. At this level there is no specific detail. The intent is to give the learner an overview, a point of departure, before the smaller parts are presented in the next level.

Within disc side one of phase II (see Course Map figure 2) is a completely fleshed-out course, consisting of seven lessons which break down into twenty-four segments that we shall describe below (see Disc Level Menu figure 3). These amount to 160 hours of student/computer time.

Typically, the constraints of normal platform instruction make it very difficult to address a variety of entry levels. The computer is an excellent tool for solving that problem. There are three distinct entry levels in the course, each interrelating with the other, each with a stand-alone capability. Less confident students may wish to enter the course at lesson or segment-level. On the other hand, the very strong student may wish to learn at disc-level.

A newcomer to the program will most likely want to see the Glossary. Here he is introduced to the sitcom actors, an advanced grammar organizer, a complete listing of idioms with their English translation, along with culture notes and their translation; all this, lesson-by-lesson. In fact, the grammar, though an integral part of the course, can be accessed as a separate entity to be used as reinforcement for a grammar review course.

At this point, the learner will be encouraged to see the "big picture," namely, to watch the entire half hour of video uninterrupted . He may repeat this effort with cultural notes and/or idiomatic expressions.

Now, in the best tradition of CAI, the learner has, among other options, the choice of taking a diagnostic test to see if he is ready to take the final test and bypass this disc side. If he passes that test with a score of 90% or better, he qualifies for the final exam without further ado. If he then passes the final with a score of 80% or better, he gets credit for the course and may continue with another disc side. The diagnostic test requirement is deliberately higher than the final, since most learners will benefit from the intensive review provided in the body of the course.

If, after viewing the half-hour comedy, the learner takes the diagnostic test and fails, the Computer Managed Instruction (CMI) "advisor" will instruct him to drop down to at least lesson level and suggest what lessons to do on the basis of questions missed. This approach has been claimed to be more effective than unmediated learner control.

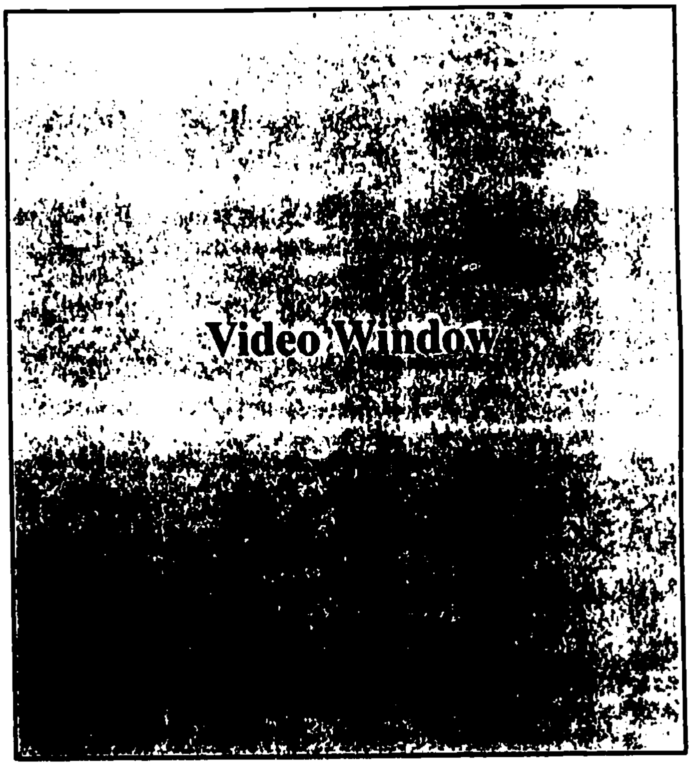
Cognitive psychology stresses the importance of making connections between previous knowledge and new learning. It is easier to adapt learning to learner needs when the learner's background is well-known than when a randomly formed group is involved and learner backgrounds are not well-defined. Adaptive learning programs could help solve the problem, but they are too costly to develop. However, although learner-control CAI is more cost-effective than adaptive programs, one does not know if the average learner possesses the know-how to select the proper remediation materials for his particular needs. Specifically, when a learning task is particularly difficult, the learner may simply opt to get out and go on to another task. Several studies conducted on the subject--Hanse, Ross & Rakow (1977), Tennyson & Rothen (1977), Steinberg (1977), Hannafin (1984), and Ross & Morrison (1989)--have discovered that "uncontrolled" learner-control, does not improve performance.

## Disc–Level Menu

- Disc Video
- Disc Video (with culture notes)
- Disc Video (with idioms)
- Glossary (advanced organizer)
- Diagnostic Test
- Disc–Level Final Test
- Advanced Level
  Total comprehension Test
- Lesson–Level Materials
- Grammar Module*
- Help
- Quit

Figure 3

**English Explanation**




**Student Options:**

| |
|---|
| video audio (in context) video (in context) Instavox F7 (EXIT) |

Figure 4

**English Explanation**


**Student Options:**

| |
|---|
| video audio (in context) video (in context) Instavox F7 (EXIT) |

Figure 5

# Lesson–Level Menu

- Lesson Video
- Lesson Video (with culture notes)
- Lesson Video (with idioms)
- Diagnostic Test
- Lesson–Level Final Test
- Lesson–Level Material
- Lesson Segments
  - Segment one
  - Segment two
  - Segment three
  - Segment four
- Word Games
- Final Test
- Help
- Quit

Figure 6

In a research study investigating two instructional design variables related to concept learning, Tennyson (1980) suggests computer- managed advisement as remediation for some of the learner-controlled instruction strategies. Results showed that students under course advisement performed better than those under strict learner control conditions, and more efficiently and timely than the adaptive control group.

Our design puts great emphasis on learner navigation, preference and control. However, if the approach does not agree with every learner, or if, due to this approach, a learner cannot pass the test, CMI will step in to advise him as to the best avenue to pursue.

If upon failing the disc level diagnostic test, the learner decides to change his approach completely and instead of a top to bottom approach, go directly to segment level, the system is flexible enough to allow this to happen.

In addition, to challenge the advanced student, there is an advanced-level total listening comprehension test available on Instavox. This is a recorded listening comprehension test consisting of an analysis of the sitcom and its actors by male and female native speakers. The initial recording was done without a script (to maintain language spontaneity) in rapid-fire Hebrew, dialogue style. Because opinion is involved, the language level here is at least three plus (editorial-type, on the government scale). A series of test items follows each recorded segment. The directions for the test are also

aural. The learner is instructed in the target language to select or type in an answer as the need arises.

It should be noted here that all tests (lesson and disc level) are automatically graded and the scores maintained for the instructor . The computer also keeps tabs on how many times the student attempts each question of the segment level exercises (not graded so as to be non-threatening). In other words, phase II goes beyond CAI into the realm of CMI.

The learner may request assistance at any level. He can review, skip or terminate the video at will. There is variable access to the cultural and idiomatic expressions. If the learner so chooses, he may have the video stop automatically at each point where a commented cultural point or idiomatic expression occurs. The screen will shrink into a window (see figures 4 and 5) zooming in on the face of the speaker. Outside the window, the text of the comment will appear, and then the comment will be heard. In fact there are two different windows, a round one for the idiomatic expressions and a square one for the cultural notes. After requesting and obtaining the necessary assistance, the learner is returned automatically to the starting point where HELP was first requested.

**Lesson-Level Activities** At lesson level the learner can repeat the above process by first viewing the lesson video portion with all the trimmings (see lesson level menu figure 6). Once again, he may take the diagnostic and, if he passes it with an acceptable score, he may go on to take the lesson-final test and continue with the next lesson. All the lessons use epitomes and tie into one another and into the larger structure or picture. The examples chosen to illustrate a point are usually related to scenes familiar to the learner (analogies) in order to facilitate comprehension and transfer.

Here the general thrust is from the general to the particular, and back to the general. The student is encouraged to participate, creating an atmosphere of active learning. Ample feedback exists along with hints and guidance to help the learner, while minimizing the frustration level. HELP and QUIT function keys can be put to good use at any time and from any point in the program.

If the learner fails any diagnostic test at lesson level, he is instructed to drop down to segment level and do those activities relevant to the missed portion of the test before taking the final exam. In fact, if at disc level the learner attempted to take that level's diagnostic and was dropped to lesson level, he must pass every lesson-level final before attempting to take the disc-level final test. The reasoning here is that lesson level finals are used as progress tests; since the overall final test is comprehensive, it is important for the student to show readiness to continue on.

Word review is another feature built into each lesson at menu level. The learner may get here either after having completed all the segments of a lesson, or after or before taking the lesson test. Since these games are not graded except through CMI control, it is a suggested exercise, but not a mandatory one. The review is in computer-games format (varying from lesson to lesson). There is a concentration game, (a classify-type game), and listening to the Hebrew track to find a match to an English utterance projected on the screen (all done contextually).

**Segment-Level Activities.** Segment-level activities all relate to the short video cuts at that level. In other words, the half hour sitcom was divided first into contextual portions 2-3 minutes long, which we called lessons. Following that, each lesson was divided further into so-called segments--small, palatable contextual portions, lasting anywhere from 30 seconds to a little over one minute. Although the design is flexible, the approach at each level of instruction is always from the general to the simplest idea represented, and then back up to the most complex. The segment level is the most elaborate of the three levels, taking the learner on a voyage through the intricacies of Modern Hebrew colloquial language. IAV/CAI design principles dictate the need for elaborating on a small segment of video at a time. This approach satisfies the criteria of Skinner's learning machine, i.e., presenting the student with one small portion at a time and using each preceding block as antecedent learning for the next, etc. Gagne's (1984) learning hierarchies approach is used throughout, with every level of instruction a prerequisite to the next.

There are no tests at this level; however, lesson level tests cover every bit of what was learned at segment-level. Here again, a very close relationship exists both horizontally and vertically among the various levels of instruction.

Pribram (1962) believes that reinforcement should be structured to fit the learning situation. This program allows the learner to structure reinforcement to fit his learning style. While in learning mode at segment level, the student can view the video in any of the aforementioned ways, or request to see a written Hebrew transcript of the audio track (see segment-level menu). Here, too, the learner can listen to the whole transcript, or to a single utterance in either normal mode or MCEA. From this screen there is also access to the English transcript, word bank, idioms and culture notes (see figure 7). with or without video, or to linguistic tutorials. The latter deal with grammatically irregular vocabulary items, all in context and through analogies. A distinction and cross-comparison is made between colloquial language and grammatically correct language (roughly, the linguistic distinction between descriptive and prescriptive approaches).

It is at segment level, and through the transcript, that the grammar review tutorials may be accessed. Here the student will find three levels of learning and reinforcement. Again, elaboration theory is reflected. The grammar items are "chunked" together by subject, with additional examples added, for a built-in cognitive strategy. Every grammar item begins with a prediction question, designed to introduce the learner to the subject without much detail. Defined concepts are introduced, and the learner is asked to discriminate and classify them. The program then shifts to a more elaborate explanation through analogy and examples. Additional practice is available at the press of a key, and the learner can demonstrate the rule ( a la Gagne) if he is ready. (See grammar rule flow chart figure 8) None of the above is forced on the learner, who can decide what he wants or needs to learn and what he already knows, before making a selection. However, it should be emphasized again that the tests are very thorough, and although an attempt is made not to overtest, the terminal objectives are all covered. In fact, the final test is properly representative of every lesson-level test.

The random access capability of the laser disc is particularly valuable in the various practice materials designed to increase comprehension. After viewing the entire segment video, the learner can choose to do exercises. During any exercise at segment level he may repeatedly watch just that smaller portion of video that is contextually related to the question he is working on.

# Segment–Level Menu

- Lesson Video
- Segment Video
  - with vocabulary
  - with culture notes
  - with idioms
- Transcript
  - with audio (normal/MCEA)
  - video (full/segment)
  - with special vocabulary
  - with culture notes
  - with idioms
  - with grammar notes
  - English translation
- Practice Materials
- Word Bank
- Help
- Quit

Figure 7

Various approaches are used to enhance the learning process, including prediction questions designed to spark curiosity, hypothesis learning, viewing video without the sound track, and listening without the video. A favorite with learners at all levels seems to be a type of prediction exercise which starts with a word list in the order of its appearance in the video. In association with multiple-choice questions, this helps the learner to construct the plot. Other exercise types are matching, CLOZE (Fill in the Blanks, Gagne's "verbal skills"), scrambled sentences (Gagne's "demonstrate the rule"), word chaining, transcription, multiple choice questions, true or false, gisting, indicate the speaker, etc.

Steinberg (1984) talks about games, drills, and simulations. She suggests that the courseware designer keep the number of items short, and if the learners are likely to require additional practice on certain sets of items, there is a need to design a variety of formats. In this IAV/CAI project each of the previously listed drill types changes format if presented more than once.

It should be noted that feedback is an important part of any CAI package. Not only is there extensive feedback for wrong answers--hints, instructions to watch or listen to a given segment again, etc.--but there is also positive reinforcement for correct answers. Not just a "Nice work!" kind of comment, but an explanation as to why the answer is correct. Not every correct choice reflects knowledge on the part of the learner; at times it may be due to a lucky guess, in which case an explanation is due.

With every item of the video sound track analyzable down to the individual utterance, with tutorials on almost every aspect of the grammar and with exercises to reinforce every point related to content, the segment level provides remediation and glue for even the weakest learner, while preparing everyone to pass the disc-level final.

**Concluding Remarks** In this article we have attempted to expose the reader to the endless possibilities of combining learning theories and proper design strategies with exciting multimedia to create intricate student-computer interactions.

Interactive courseware will reflect the creativity of the seasoned pedagogue who designs it. Geoffrey R. Hope, Heimy F. Taylor, and James P. Pusack (1984) describe computer assisted instruction as follows: "Many of the positive feelings CAI frequently engenders can be traced to a single factor: the computer's liveliness. While the screen may present nothing more in terms of content than a workbook does, by having each item pop up as though from nowhere, and by responding in some way to the student's answer, the program

## Learning A Language Rule

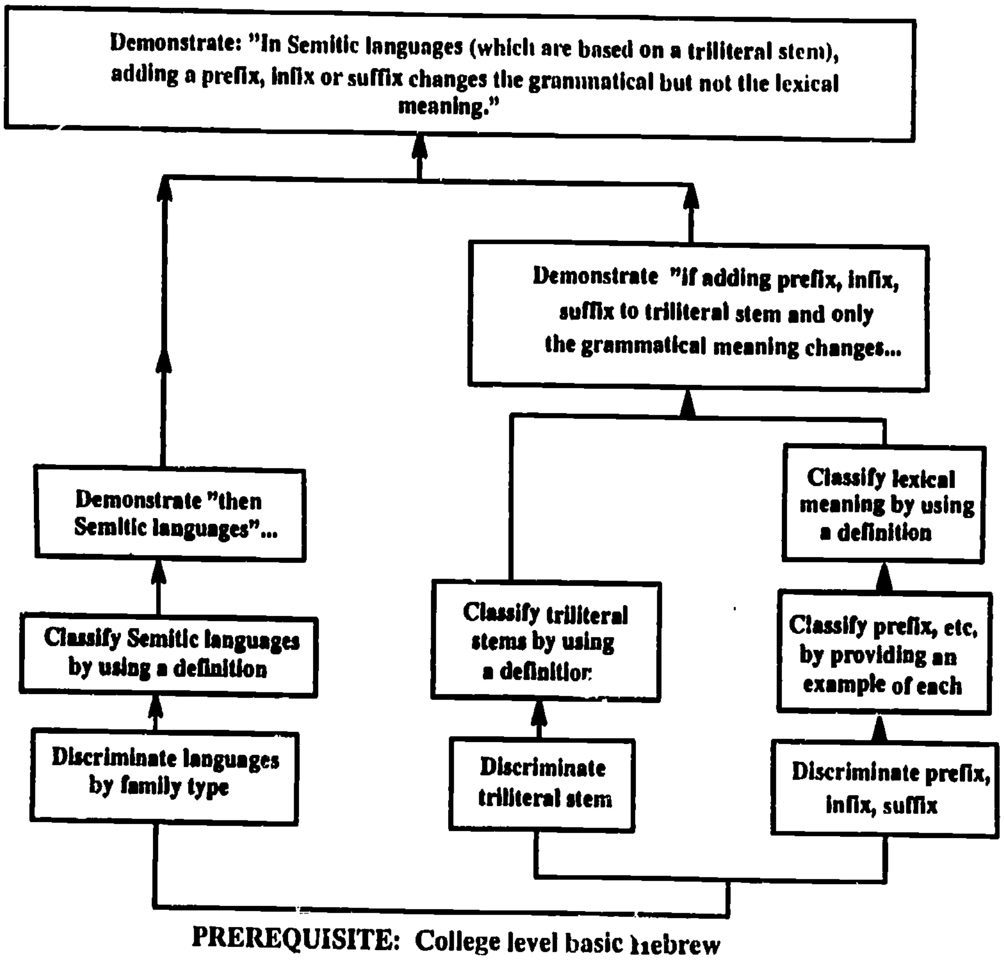



Figure 8

transforms o⁴ :erwise inert exercises into active materials. Language study is particularly well-suited to a dynamic context like this; some of the mind-numbing effects of written language exercises are changed in to lively and engaging qualities by the computer. The computer allows one-on-one interaction. The amount of control over events is shared fairly equally between student and machine: the computer asks the questions and has the answers; the student decides when to turn it on and off, which material to work one, and how fast to go. Students rarely have such power over their teachers. Teachers rarely seem as patient."

In just a few years this technology has progressed so far that one can only imagine what the future will bring. But one thing can be stated with fair assurance: No matter how much technological progress we make, we shall still have to come back to the "unprogrammed" Homo sapiens to teach computers to behave more intelligently and help technology take another leap forward.

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# DEVELOPING AN INTERACTIVE MULTIMEDIA NETWORK FOR DISTANCE EDUCATION

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**Abstract**
This paper describes the present and anticipated development of interactive multimedia networks which enable users to share computer-based instructional resources, locally and at a distance. A multimedia computer-based network can also enhance the effectiveness of interactive television instruction in distance education. Both local area and wide area multimedia networks have their own specialized hardware, software, and operational problems. However, problems of system implementation and cost are less significant than problems of instructional design and preparing materials and teachers.

**Introduction**
A increasingly common form of interactive multimedia instruction is one in which an individual or group of students interact with content and technology at an "instructional workstation" (Rhodes & Doss, 1989-90). Linking the workstations in a network configuration enables users to share computer-based instructional resources. These resources can be made available to teachers and students through a local area network (LAN) and can also be incorporated into a wide area network (WAN) for distance education.

In an interactive multimedia network, users at one workstation share hard-ware and software resources with users at other workstations. For example they can share video materials on tape and disc, text and visual data bases and compressed and full-motion video on CD-ROM, as well as standard and custom CAI and CBT programs. The media can be used for individualized, self-paced instruction or as a aid in teacher-directed instruction.

For distance education, interaction between students and teachers over a network can be facilitated through a telephone link with a minimum of added expense. When two-way interactive television is added to the instructional network, students and teachers can communicate with each other "face-to-face."

**Local Area Network Configuration**

**Hardware**
In the local area network we now have configured at Illinois State University, the principal workstation/file server consists of a Zenith 386-16Mhz microcomputer with 4Mb RAM, 40Mb hard disk, two floppy drives, VGA monitor and mouse. A Panasonic video monitor, Pioneer laser disc player, Panasonic VCR, NEC CD-ROM player, modem, and printer are peripherals. A fax machine will be added as budget permits.

The Panasonic VCR is connected to the micro-computer through an interface board and cabling supplied by BCD Associates, though future plans call for conversion to an NEC VCR with a serial port connection. The laser disc player is connected by cable to the microcomputer serial port. Two 8088 microcomputers, a Columbia and a Zenith, each with a 640Kb RAM, VGA monitor and Amdek video monitor, serve as "remote" stations. The remotes are now connected to the principal workstation by twisted-pair, shielded cables; the video and audio components, by standard A/V cables.

**Software**
A windowing program, Quarterdeck System's DESQview with QEMM 386 (version 5.1) enables users to control the multiple devices. QEMM 386 is a memory manager which converts extended memory to useable expanded memory. Multiple windows in DESQview, each containing a different program, can be used to control devices in

the system. For example, a CAI program which sets up a problem to be solved can appear in one window; in a second, a program which gives the user control over both video tape recorder and laser disc player; in a third, the access program for a CD-ROM encyclopedia. Through a time-sharing technique, DESQview is able to maintain execution of programs in all windows simultaneously.

The network itself is an ARCNET Local Area Network. It uses a token passing bus topology and LANtastic software from Artisoft, Inc. LANtastic is Network Basic Input Output System (NETBIOS) compatible. As such, it conforms to the Open Systems Interconnection (OSI) model for the transport layer, session layer, and presentation layer. At present, computer data are transmitted over a high grade dual twisted pair cable with shielding; sound and pictures are transmitted over standard audio and video metal cable.

We intended to use the NETBIOS program, "The Network Eye," also by Artisoft, Inc., to permit sharing across the network of the hard drives, floppy drives, serial ports, parallel ports, modem, printer, laser disc, VCR, and CD-ROM. However, we have found that many of these peripheral devices can not be shared across the network with Network Eye or other standard LAN software. The "Network Eye" software also does not transport graphic images because it is written to require minimum RAM (30Kb for a master; 6Kb for a workstation).

We have written custom programs in "C" language to permit a direct interface with the NETBIOS. In this way, screens composed of both text and graphics can be captured on the server and passed to remote stations. Keyboard combinations used by DESQview and LANtastic which create interference (such as those employing the "Alt" key) are also rearranged. NETBIOS has become the defacto industry standard and is implemented in all major networks. Through using a standard interface, the custom programs can be transported to other networks.

**Network Operation**

Any of the computers in the local network can monitor and/or control (a "Master") or be monitored and/or controlled (a "Workstation"). These terms describe network functions, not hardware functions: a network fileserver is a Master in "The Network Eye" terminology if it is used to monitor or control a remote computer.

Monitoring and being monitored can occur simultaneously. For example, students at one computer can control peripherals at a second computer while being monitored by a teacher at a third computer. In addition to the monitor and control options, each Workstation still has the capability to perform other operations requiring network resources, such as printing a document on a network printer.

Access to control or monitor a remote microcomputer is determined by a system of passwords. Passwords for different levels of access or control are specified on the command line as the software at a Workstation is loaded and intialized.

A Master can display windows that may be "sized" and moved anywhere on the Master screen. It is thus possible to view (and control) four Workstations simultaneously by placing a Workstation's screen into a window and moving the window to one corner of the Master's screen. Text can also be "cut and pasted" among any Workstations displayed on a Master's screen. These options greatly increase the possibilities for multimedia instruction.

**Instructional Designs**

However, conventional instructional designs in the "presentation - recitation" format will not be sufficient to use the resources of an interactive multimedia instructional network. An alternative is teaching which emphasizes knowledge development rather than information acquisition; problem/task-centered learning rather than teacher-centered presentations. Teacher to student and student to student interactions will be "transactive," through and with the various media, rather than merely reactive (Rhodes and Azbell, 1985). Students may work individually or in small groups at an instructional workstation instead of at rows of desks.

When the interactive multimedia instructional network is used for individualized instruction, a student at a remote terminal can use any of the devices available at a central location. As an example, the courseware design will give the student a task to accomplish: e.g, determine the optimum mix of vegetables and planting procedures in order to maximize yield in a given plot. The student can then access information from a variety of sources at a central site -- video tape, video disc, CD-ROM, CAI -- to accomplish the task.

By monitoring the student's progress, a teacher at another location can provide help if the student is having difficulty or requests assistance. The teacher can monitor the student on the computer screen and communicate through the network, and/or over a telephone connection.

For teacher-directed instruction, a teacher can lead individuals or small groups at remote terminals through an instructional sequence. For instance, if the students are to study a topic in ecology, a teacher can provide the information in a predetermined sequence through computer text, video tape, video disc, and/or CD-ROM. Communications with students can again be done through the network or telephone lines.

## Multimedia Interactive Television

### Conventional interactive television

Computer-based multimedia instruction also has the potential to affect significantly the ways interactive television may be used for distance education. From an instructional perspective, interactive television teaching technology for distance education today can be compared with the automotive industry of 100 years ago. Inventors then were able to combine the technology of the time in new ways, but still thought of their work in conventional terms. Hence they developed the "steam-powered horseless carriage" as an innovative form of transportation. It was some years before they could design an automobile which made good use of the internal combustion engine and did not simply reproduce the basic features of horse-drawn vehicles.

In much the same way, distance educators are now prone to use 20th century technology to reproduce the school and college classroom of the 19th century and give the result an "education in the 21st century" label. The actual teaching itself is conventional classroom practice extended over a wider geographical area. The conception of teaching employed has not kept pace with the opportunities afforded by the technology.

Most written descriptions and live demonstrations of two-way video/audio television in educational applications reveal that instruction retains the traditional "presentation - recitation" form (Czech, 1989; Hannu, 1990; Ward, 1990). The teacher can now see students on a video monitor, but the setting still closely resembles the traditional high school and college classroom. The teacher talks, asks questions of students, or respond to student questions should there be any. Interaction takes the form of verbal exchanges. This approach differs from the standard single-teacher classroom or lecture hall only in that the teacher is not physically present.

### Interactive multimedia wide area network

Computer-based multimedia instruction, however, is an alternative to the conventional conception of television teaching. This alternative employs computer-based instruction as the centerpiece for an instructional system which extends the "electronic classroom" to distance education. The local area instructional network is expanded to form a wide area network. As in a local area network, the wide area network will also include computers, CD-ROM and other types of optical data storage, video tape recorders, video disc players, and facsimile transceivers.

The technology is now available for transmitting high quality pictures, voice, and data over wide area network. "T-3" telecommunications service, with a bandwidth of 54Mbps, using fiber optics cable is the transmission medium of choice. While this bandwidth is technically below the level required for complete "full-motion" video, the service does provide video transmission quality that appears to the viewer as indistinguishable from full-motion. Coder-decoder devices ("codecs") select, compress, transmit, and then expand that portion of the video signal essential to realistic viewing. Data and voice transmission are essentially unaffected. Combining microwave transmission for audio and video signals with high quality telephone lines for data transmission is another possibility.

Since the "electronic classrooms" in a wide area network can function as workrooms or laboratories as well as a standard classrooms, the conventional presentation-recitation methods of teaching is inadequate to take full advantage of the available resources. Unlike conventional television teaching where the teacher often acts as resident expert and TV personality, the teacher in a multimedia wide area network needs to serve as model, manager, and mentor. Instructional designs will need to reflect the same type of changes required in the local area multimedia network.

### Problems and Resolutions

Interactive instructional network development is not without problems, but we believe the problems are amenable to resolution.

### Technical

The most serious technical problems we have found are those related to improvements in network and instructional resources. Hardware, especially that related to CD-ROM capabilities, is changing rapidly. With the advent of rapid search VCRs, video tape is becoming a more attractive interactive medium. Each software upgrade usually includes more features, uses more disk space, and often makes subtle undocumented changes in operation.

These improvements, especially the latter type, may impede the work of the network. Earlier versions of Grolier's CD-ROM encyclopedia, for example, could be integrated into the network with relatively little difficulty; the latest version, with very useful graphics, has been a challenge. Upgrades in DESQview and LANtastic have a similar history. But overcoming these technical difficulties does have a marked positive effect on the improved performance of the network.

**Cost**

The first questions usually raised about establishing a local or wide area multi-media instructional network are related to cost. Those costs, however, are a function of the hardware and software already available. Since there is no requirement for dedicated computers or video equipment, existing hardware can be adapted for network use. If purchased new, the hardware for a principal workstation/file server can be obtained for no more than \$10,000; a remote station can be outfitted for under \$1200. The Lantastic Starter Kit (including cards, cable, and software) is priced at about \$400 for two stations with \$225 for each additional station). DESQview with memory manager and utilities is priced at about \$230.

The cost of a wide area network is obviously much greater. These costs will vary according to distance, financing arrangements, and other local factors, but cooperation among educational institutions, telecommunications companies, and electronic suppliers can now result in a more favorable cost-benefit analysis. Two years ago, costs appeared to be prohibitive, but that situation is rapidly changing.

In at least one instance, the yearly cost to a five school consortium for leasing the facilities needed for "classroom door" to "classroom door" data, video, and television transmission has been quoted as about the same as the cost of employing a first-year teacher and less than purchasing a school bus. Television equipment is not inexpensive, but many price levels are available.

**Teachers and Materials**

With the rapidly increasing interest in multimediated instruction, computer, video, and CD-ROM materials are becoming more widely available. To be effective, however, instructional materials must be adapted to the educational context in which they will be used, and accepted by the teachers who will use them. As one part of a resolution to this problem, we offer at Illinois State an extended summer workshop on the development of interactive multimedia materials. In this workshop the participants are able to make a start in learning how to adapt existing instructional materials to the interactive network format, should they choose to do so.

A more serious long-term problem is teacher preparation. The potential of multimedia interactive television can not be realized unless teachers have the knowledge, skills, and materials to make use of the technology. The knowledge and skills required for teaching with a multimedia interactive local or wide area network setting are beyond those which classroom teachers or university instructors can now reasonably be expected to have. Many of our colleagues in the schools and higher education are still struggling with incorporating computers into their working lives, to say nothing of CD-ROMs and video discs. This is the classic problem of technological capability exceeding human capability to employ it. We have no ready solution, but we continue to raise the issue with teacher educators.

**Summary**

In summary, we believe a computer-based instructional multimedia network has significant educational advantages for teachers and students. When integrated with two-way television, such a network can also provide a truly proactive instructional system for distance learning. Both local and wide area networks can increase the productivity and reduce the cost of interactive multimedia instruction, thereby increasing its potential to positively effect educational change. Teachers must be prepared to implement these networks, however, before such change can be realized.

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# MICAL: AN INTERACTIVE MULTIMEDIA RESEARCH PROJECT IN COMPUTER SCIENCE

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**ABSTRACT**
This paper details an ongoing research plan MICAL for the effective design and implementation of multimedia interactive computer aided learning (MICAL) in computer science. MICAL includes four progressive stages; Phase 1 : Utilization of barcode controlled video; Phase II : Development of selected multimedia workstations. Phase III : Incorporation of expert system interfaces to the Level III applications, and Phase IV : Transfer of these applications to a microcomputer-based local area network.

This plan is tailored to enhance the instructional efficacy of the Department of Computer Science and the quality of information delivery systems at Western Kentucky University.

**OVERVIEW**
The advent of multimedia technology is changing the design and implementation of instructional delivery systems in both the corporate and academic environments. Using only a piece of chalk and a chalkboard has been equated to using "one stone age implement on top of another stone age implement " (Sneiderman, 1990). The proper blend of graphics, video, audio, and computer technologies has created a new "Virtual Reality" and "Visualization" for learning environments. Producing prototypes of a single user multimedia system is a step in the right direction, but it does not meet the needs of university lecture classes of forty or more students, or the needs of participants who require more time to master conceptual learning. The purpose of the MICAL research plan is to refine, develop, and disseminate effective video-based multimedia systems for a wide range of students in a computer science department. The target audience at Western Kentucky University ranges from advanced graduate students in computer science to multiple sections of first time computer users. The delivery systems will be utilized in the regular classroom, the department laboratories, and eventually the university laboratories. Common software and hardware platform(s) will be effected so that software/hardware implementations can be utilized, not just by the Computer Science department, but the entire university campus.

The main body of this paper discusses the four planned phases for the MICAL endeavor. The sections are as follows:

Phase 1: Portable Barcode Controlled Videodisk Systems
Phase II : Level III Videodisk Stations
Phase III: Expert System Interfaces for Workstations
Phase IV : Local Area Networks for Video-based

**Workstations**
The design constraints, environmental factors, and research questions for each phase will be highlighted in the rest of the paper.

**PHASE I: Portable Barcode Controlled Videodisk Systems**
The initial start of MICAL is to select those existing videodisks most appropriate to computer science instruction and to incorporate their utilization in the standard lecture class of twenty to fifty students. The first phase does not include in- house production of videodisks (even though this is possible) due to the time, cost, and man hours of such an endeavor. The target audience for the initial stage is not undergraduate or graduates in computer science, but the literacy students in an introductory course in computer technology. The reason for this selection is the expanding enrollment in this required course (CS145). Currently there are multiple sections of thirty-five students per semester who learn an introduction to microcomputer packages, programming, and social issues of technology. With limited resources and facilities, this heterogeneous lecture-oriented environment is the initial target audience.

The system selected for this scenario is a videodisk player with barcode controls for the instructor. The videodisk player (with Level III capability) is managed by scanning barcode symbols from a textual page to control the videodisc. Hence, the instructor is in complete control of the sequencing of the presentation. The system with its attached color monitor is mounted on a portable cart to permit easy portage to different classrooms.

The videodisks utilized are those consistent with the course syllabus: history of computers, introduction to telecommunications, hardware design, human factors, and applications. Videodisks on microcomputer packages, other than DOS, are not utilized because of the potential change in versions of these software packages. The barcode development process includes searching for frame numbers of video sequences with a hand control, printing barcode representation of videodisk instructions and frame numbers, and merging the barcode symbols with appropriate textual instructions using a wordprocessor.

The lesson is created in consultation with the instructor, and refinements, changes, and resequencing are easily handled with a wordprocessor and barcode software.

Research questions include: Which video topics are most successful in this selected environment?; Why?; What human interface factors affect the instructor's utilization of this media system?; Can the software development cycle for this technique be easily transported to the instructor?; and Is there any correlation between the video topic and the learning style of the student? Finding answers to these questions is the main goal of Phase I along with the acceptance of the videodisk as another teaching tool for the professor.

**PHASE II:**

Once videodisks have been utilized and integrated into selected classrooms, the most effective ones will be ported to Level III workstations. The computer control will be either a Zenith 80336 and/or a Macintosh IIS: This is consistent with the supported hardware platforms in the Computer Science department and consistent with the Zenith platform in campus-wide laboratories at Western Kentucky University. The software utilized will be HyperCard-like packages which include Windows 3.0, Toolbook, and/or Authorware. Even though the initial development for Level III Videodisk stations will follow a Zenith platform, the Macintosh will be incorporated.

Since the Computer Science department has a Zenith/lcd display system in each classroom, a videodisk under computer control is viable. Both barcode and microcomputer controlled systems will be placed in the laboratories to supplement classroom instruction and promote individualized learning. Videodisk topics will expand to undergraduate and/or graduate components. Programming, software engineering, JCL, database, architecture, and similar topics will be included. Since many computer related topics are now being stored on compact disc read only memory (CD-ROM), this technology will be merged into the multi-media stand alone stations. Research directions will include software development for the multimedia components, effective graphical interfaces, appropriate help/testing components, and possible correlations between learning outcomes and participant learning styles. The effective incorporation of the microcomputer with video, overlay graphics, and CD-ROM will be the primary objective of Phase II (Pigford, 85),(Pigford, 84).

**PHASE III:**

Phase II development of MICAL will be extended to expert system interfaces or expert front ends to the multimedia video workstations. An expert system is a software program that emulates the intelligence of a human expert in a narrow domain of expertise. An expert system will be used to control the interface to the video station, to diagnose students errors, to control sequencing in instruction and, in general, emulate the behavior of a master teacher with students in computer science. Video topics used for expert system development will be drawn from those topics which have proven to be most beneficial and efficacious in Phase I and II.

The software tools for expert system development must be incorporated with the authoring tools for the video workstation. Possible software solutions include VP-Expert, 1St Class, EXSYS, and Guru. VP-Expert is a viable candidate because of its integrability with existing software libraries (Pigford, 1990). Adding expert system interfaces and components will help to increase the efficiency and utility of the learning workstation, but the domain (video content) will tend to be narrower in scope (Baur, 1988).

The relevant research issues in this phase are designing intelligent user interfaces, establishing relevant knowledge bases for selected domains, testing the expert systems, and integrating the various software components of the multimedia workstation (Devolder, 1989), (Ting, 1988). Transforming the video workstation into an intelligent tutoring system is the central goal of Phase III.

## PHASE IV: LOCAL AREA NETWORKS FOR VIDEO WORKSTATIONS

Phase IV of the research plan involves the expansion of the delivery system from essentially a single-user mode to a multiple-user mode. This extension will be accomplished by the use of multiple workstations connected with a local area network. The extension creates new problems. If the multimedia sources include a videodisk, then only a single user can use the material at one time. Hence, the concept of multiple users cannot be implemented.

Second, if the multimedia Source includes a CD-ROM, there are severe limitations. A CD-ROM System is not capable of reproducing full-motion video and has a limited capacity relative to the storage of still frames.

These limitations are caused by the fact that the storage of digital images (voice) takes a great deal of memory which is not the case with video stored on a video disk which is in analog format. The amount of storage needed for full-motion video sequences is so great that it is currently not possible, even at high transfer rates, to move the images fast enough across a network to be able to reproduce them at a playback rate of 30 images per second, a rate that is required for full-motion video.

The purpose of the phase is to study and implement techniques that will permit the use of a local area network. A promising solution to the aforementioned problems is digital video interactive (DVI) which is under development, but the solution is still some time away.

Successful completion of this phase will enable students enrolled in Computer Science classes at Western Kentucky University to use the systems developed in phases II and III of the project in a networked environment that will be cost effective (Lidard, 1990).

## SUMMARY

This paper outlines a four phase research plan MICAL for developing multimedia workstation for the Department of Computer Science at Western Kentucky University. The goal of the research effort is to improve the quality of instruction for different levels of students in computer science. The software and hardware platforms are designed to be ported to the university environment. The four phases involve the use of portable barcode videodisk configurations, Level III development, expert system interfaces, and transfer to local area networks. Constraints, environmental factors, and research questions for each of the four phases have been discussed. The research plan follows the usual "re-evaluate and change" spiral found in the traditional software development process. A time frame of three years is expected, depending on the hardware/software developments for a networked implementation of the system.

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Selected Formal Papers From the

# Special Interest Group for PILOT (SIGPILOT)

# AUTHORING SOFTWARE SELECTION

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**Abstract**
A comparison of the different types of authoring software included analysis of costs of use, programming abilities, ease of use, quality of resulting courseware, and usefulness across a wide variety of subject disciplines. Determining the actual costs of using authoring software was exceptionally difficulty due to the wide variety of fees associated with use of this software. TenCORE was rated best in terms of use, programming abilities, and courseware quality. PCD3 and ACT-III were the most user friendly. PC/PILOT was the least experience to operate.

**Introduction**
I have been involved in courseware production on Apple II's and Commodore 64's since 1982, but it is only since 1988 that I have been involved in the authoring of courseware for MS-DOS machines when I received a grant to evaluate a number of different types of authoring software.

**Purpose**
The primary purpose of the project was to evaluate a number of authoring languages and authoring systems to determine which were the best for use in authoring courseware in a variety of subject areas at the post-secondary level.

**Evaluation**
The evaluation was to take account of a number of factors including,

a. cost (including purchase price, annual licensing fee, maintenance fee, etc.)
b. hardware requirements (for both authoring and student use)
c. ease of use and operation
d. usefulness across a wide variety of subject disciplines
e. quality of resulting courseware.

**Criteria for selection of authoring software**
These are the criteria used for the initial selection of authoring software.

1. must run on IBM-compatible computers
2. must require no more than 512K RAM, and use either one or two 5.25" 360K floppy drives, and/or hard disk, or any combination
3. must incorporate both colour and graphics
4. must use the EGA graphics standard
5. should not cost more than $2500 (Canadian)
6. should be readily obtainable.

**Identification of authoring software**
The first step was to review the research literature to identify authoring software and any available reviews. Our search indicated that there was no single list of all the commercially available authoring software, and so we had to rely on a number of sources (Barker and Singh, 1982; Kearsley, 1982; Burger, 1986; Barker, 1987; Tyre 1988, 1989). Even a more recent list (Greenfield, 1990) lists only 34 and this omits a number of quite well known and still commercially available authoring software.

**Reviews of authoring software**
The literature includes many articles which review authoring software, but often these are technical reviews focusing on programming abilities with no attempt to produce courseware, or use it with the intended target audience, the instructors. Very rarely is there a mention of the actual cost of using courseware generated with the software. Some authors have reviewed software as regards its potential usefulness to a particular subject discipline. Two types of authoring software which were often mentioned in the literature were PC/PILOT and TenCORE, with the latter receiving the better reviews. Identifying potential authoring software, then, is still very much a shot in the dark approach.

**Method**
Since 5 different aspects of authoring software were to be evaluated, five different methods were used, one for each aspect.

**Cost**
This information was obtained directly from the manufacturers of the software.

**Hardware**
This information was obtained from the manufacturers or their publications.

**Ease of use/programming abilities**
Initially it was planned to evaluate seven different types of software, and, with all the work involved, it was decided to hire students to learn how to use the software, and to create example courseware. Each student was first to learn to use PC/PILOT, the language with which I was most familiar, and then to learn the use of two further tools. In this way we could compare the software using PC/PILOT as the common factor.

**Usefulness across a wide variety of subject disciplines**

**Quality of resulting courseware**
A number of instructors agreed to develop short lessons for programming with each type of authoring software. Each was asked to develop a sample lesson using as many different programming techniques as they thought would be routinely used in their subject area e.g. colour, graphics, animation, super- and sub-scripts and the like. Once the courseware had been developed each author would then be asked to evaluate the usefulness of each programmed version to that subject area, and to rate its quality.

**Results**
The project was originally designed to run 4 months, but within the first few weeks a number of major problems were encountered which caused the project period to be extended. Some of these problems are listed in Table 1 and are referred to as implementation problems. As a result we returned one tool, MICROINSTRUCTOR, for a full refund, and in its place ordered a further three products.

All the authoring software eventually used in the project is listed here in Table 2.

**Hardware requirements**
Even though the hardware requirements had been checked with the manufacturer prior to ordering the software a number of problems were encountered with RAM requirements, type of diskette on which the software was supplied (720K 3.5",360K 5.25", 1.2M 5.25"), and peripherals (graphics tablet etc.).

| **SOFTWARE** | **PROBLEMS** |
|---|---|
| AUTOOL* | required additional hardware/peripherals. (Matrox card; multisync monitor; 640K RAM) |
| CSR Trainer | set up problems - proper procedures missing from manual; company had to be contacted for correct procedures. |
| Microinstructor | diskettes would not run on IBM-compatibles. Software returned for full refund. |
| PCD3 | software took almost 3 months to arrive, and lacked necessary set-up disks when it did. Obtaining this disk required phone calls to 3 different North American cities and the disks were not obtained for another month. |
| PC/PILOT | quick delivery and no problems. |
| TenCORE | prompt delivery and no problems. |
| VITAL | required additional hardware - a second monochrome monitor in addition to the EGA monitor. Manual and diskette versions did not coincide and both had to be replaced. Graphics tablet driver didn't work - multiple replacements also didn't work. |

Table 1 Problems Encountered in implementing the software

* now called HyperTRAINTable 2

**Software evaluated:**

•ACT-III (Informatics Group, Inc., West Hartford, Connecticut)
•CSR-Trainer 4000 (Computer Systems Research Inc., Avon, Connecticut)
•GUIDE (Owl International Inc., Bellevue, Washington)
•HyperTRAIN (Hofbauer Information Systems, Dallas, Texas)
•Microinstructor (C.V. Mosby Ltd., St. Louis, Missouri)
•Micro NATAL (Softwords, Victoria, British Columbia)
•PCD3 (Control Data Corporation, Minneapolis, Minnesota)
•PC/PILOT (Washington Computer Services, Bellingham, Washington)
•Smalltalk/V (Digitalk Inc., Los Angeles, California)
•TenCORE (Computer Teaching Corporation, Champaign, Illinois)
•VITAL (Com:port International, Ottawa, Ontario)

Table 2

Student Programmers Rating of Authoring Software

| Software | Rating | Comments |
|---|---|---|
| ACT-III | 4.0 | Would be 7 or more if included ega graphics, looping and arrays |
| CSR Trainer | 3.5 | |
| GUIDE | 0.0 | |
| HyperTRAIN | 3.0 | |
| Microinstructor | n/a | |
| Micro NATAL | 2.0 | For experienced programmers would be 5.5 |
| PCD3 | 9.0 | |
| PC/PILOT | 6.0 | |
| Smalltalk/V | 2.0 | For experienced programmers would be 8.0 |
| TenCORE | 10.0 | |
| VITAL | 2.0 | |

Table 3

**Ease of use/programming abilities**
The original plan of students evaluating 2 types of software in addition to PC/PILOT became impossible to continue with because of the problems which were encountered. It was decided, therefore, to create a series of stages through which the software had to pass. If software did not successfully pass a stage, then its use in the project was terminated at that point. These stages were:

1. setting up
2. learning how to use software
3. determining programming abilities
4. programming example courseware

Once students had learned to use the software they were then asked to rate it. In determining this rating the students took account of the purpose of the project which was to identify software which could be used by novice computer users. The ratings are shown in Table 3. Clearly TenCORE and PCD3 had the highest ratings. It should be noted that this evaluation was conducted without knowledge of the individual programming requirements of the sample lessons.

**Usefulness across a wide variety of subject disciplines** and **Courseware quality**
Only four of the different types of authoring software were successfully used to programme all six of the sample lessons. Of these only PC/PILOT and TenCORE produced all 6 sample lessons. PCD3 could only be used to programme courseware in Biology, Chemistry and Psychology, and ACT-III only in Biology.

Each author was then asked to review the resulting courseware and state whether each version was acceptable, and if more than one was acceptable, to rate them in order of preference. The results are shown in Table 4.

Author Rating of Courseware Quality

| Subject Area | Software | | |
|---|---|---|---|
| | PCD3 | PC/PILOT | TenCORE |
| Biology | *3 | *1 | *2 |
| Chemistry | *3 | *2 | *1 |
| English | - | *2 | *1 |
| Mathematics | - | *2 | *1 |
| Physics | - | *2 | *1 |
| Psychology | *3 | *2 | *1 |

1 = First; 2 = Second; 3 = Third; * = Acceptable

Table 4

All the created courseware was of an acceptable standard. In all cases but one TenCORE was rated as best, with PC/PILOT second and PCD3 third. However authors felt that PC/PILOT's standard font was easier to read than TenCORE's, while PC/PILOT could not display custom characters in EGA mode. Each author commented on PCD3's long loading time and its requirement for two floppy drives or a hard drive.

**Cost**

Estimating the cost of using authoring software would seem to be a straightforward task, but, unfortunately, this turned out to be one of the most difficult aspects of the evaluation. The advertised purchase price of an authoring tool is rarely, if ever, the actual cost of using that tool, since many firms charge a variety of different fees for the authoring of courseware, and actually using it with students. The various costs which may be associated with the use of authoring software are as follows.

1. authoring fee
2. authoring options
3. additional hardware/peripherals
4. student use fee
5. distribution fee
6. commercial distribution license
7. annual maintenance fee
8. training fee

The authoring fee is the one most often advertised as the price of authoring software. Often, however, this fee covers only the use of the software on one single authoring machine. Multiple authors on the same campus would usually need to purchase a site license or obtain multiple copies of the software.

Some of the software also offer options or enhancements which are additional to the base price. PC/PILOT, for example, offers an Advanced Features Library (AFL), and TenCORE offered TenCORE Assistant, an authoring system overlay for TenCORE. Several also offer the option of using a third party graphics package such as PC Paintbrush.

Some may require the purchase of additional hardware or peripherals, and even though these are not strictly speaking authoring software requirements, account should be taken of them in calculating the cost of use.

A number of companies charge a separate fee for student use of courseware created with their authoring software. CSR Trainer 4000, for example, charged $95 per workstation. Yet others charge for the use of this courseware off-site. TenCORE, for example, charged a perpetual fee of $1200 per item of courseware used off-site. There may also be fees for commercial distribution of courseware created with authoring software.

Some companies charge an annual maintenance fee for the use of their products. This fee may be a fixed amount or a percentage of the total fees for the software. The maintenance fee usually allows the purchaser to obtain free software and documentation updates, and phone support.

A number of companies offer training sessions in the use of their products. TenCORE offers both on- and off-site expert training in the use of their products.

In order to estimate the possible costs of using authoring software it was decided to cost out the use of authoring software under a number of different scenarios as shown here.

**Scenario #1**

One authoring machine producing courseware only to be run on 5 student machines on the same campus.

**Scenario #2**
One authoring machine producing 10 items of courseware to be run on 5 student machines on the same campus, and also to be used on (i.e. distributed to) 100 student machines at 10 other sites.

**Scenario #3**
10 authoring machines producing 10 items of courseware to be run on 50 student machines on the same campus, and also to be used on (i.e. distributed to) 100 student machines at 10 other sites.

The estimated costs for the leading four authoring tools are shown in Table 5. Among the four leading contenders it is clear that PC/PILOT is the least costly of the four for each scenario, followed by ACT-III. TenCORE's price increases enormously for multiple author use and off-site use.

Table 5

Estimated Costs of Using Authoring Software Under 3 Different Sets of Scenarios (All prices converted to Canadian dollars; US - 1.18C$)

| Software | Scenario 1 | Scenario 2 | Scenario 3 | Notes |
|---|---|---|---|---|
| ACT-III | 584 | 4,673 | 4,673 | No student use or distribution fees. No annual maintenance fee. |
| AUTOOL[1] | 3,108 | 3,108 | 19,328 | Prices include student use fees. Annual maintenance fee of 12%. |
| CSR Trainer | 2,304 | 10,491 | 26,122 | Students use fees on and off-site. Annual maintenance fee of 15%. |
| GUIDE | 673 | >673[2] | >2,891[2] | Distribution fees and student use fees not specified. |
| Micro NATAL | 1,495 | 6,495[3] | 9,995 | Fee for interpreters on off-campus machines. Annual maintenance fee of 15%. |
| PCD3[6] | 14,535 | 14,535 | 22,500 | No student use, or distribution fees. No annual maintenance fee. Authoring costs include training, hot-line support, software and documentation updates. |
| PC/PILOT | 189 (->873)[4] | 189 (-> 873)[4] | 1,888 | No student use or distribution fees. No annual maintenance fee. |
| Smalltalk/V | >83 | >83[5] | >649[5] | Distribution fees, not yet set. No annual maintenance fee. |
| TenCORE | 2,938 | 17,771 | 31,825 | Distribution fee of $1200 per product (one time only fee). Maintenance fee of $570. |
| VITAL | 2,220 | ≃2,820 | ≃22,800 | No student use fees. Distribution fee of about $5 per disk. Maintenance fee of 20%. |

1 now caller HyperTRAIN
2 these are minimal since the applicable fees were not specified.
3 interpreter fee varies from $50 to $150 each.
4 higher price includes authoring aids which are deemed essential.
5 appropriate fees not yet fixed by manufacturer.
6 when PCD3 was originally purchased it cost $300 (US). As a result of changes within Control Data, the prices have risen astronomically!

Table 5

**Conclusions**

The original purpose of the project was to identify authoring software which could be used by individual instructors in a variety of subject areas at the post-secondary level. We have concluded that unfortunately it is not advisable for a novice computer user to use MS-DOS authoring software on his/her own. The potential author should have a working knowledge of an IBM-type computer, and be familiar with MS-DOS operations as well as a programming language such as BASIC. The potential author may also need technical expertise to set up some of the software and to attach peripherals. The author also needs to be acquainted with the types of problems which may be encountered in identifying, ordering and implementing authoring software.

Ideally, therefore, authoring should be a co-operative effort involving subject experts, programmers, instructional designers, and graphic artists. Unfortunately, however, in many institutions authoring will remain the preserve of interested instructors, who will have to produce courseware without much in the way of back-up facilities and support.

As regards the actual software evaluated TenCORE was rated the best in terms of use, programming abilities and quality of courseware produced, and together with PC/PILOT, was successfully used to produce all 6 sample lessons. PC/PILOT, however, was much less expensive to operate under a number of different scenarios. No start up problems were experienced with either of these. PCD3 and ACT-III were rated as very user friendly and easier for a novice to use than either PC/PILOT or TenCORE. Both PC/PILOT and TenCORE are well established authoring software and are frequently mentioned in the research literature.

It should be noted that the shortcomings of much of the authoring software can be overcome by the use of external subroutines written in programming languages such as BASIC and PASCAL. ACT-III, PC/PILOT and TenCORE, for example, all allow the use of such programming subroutines.

Even though most authoring software provides special graphics editors, we found it more useful to produce graphics with a third party graphics package such as PC/Paintbrush or Paintshow Plus. Both PC/PILOT and TenCORE are set up to allow the use of PC/Paintbrush, and ACT-III actually uses PC/Paintbrush as its own graphics editor. The use of PC/Paintbrush also allows the transfer of graphics between the three types of software. A handscanner, such as Logitech's, can be used with such graphics packages to enter graphics more easily.

At the beginning of the project we decided to evaluate the usefulness of the authoring software for a number of subject areas by seeing if each type of software could be successfully used to programme all the requirements of six different subject area sample lessons. At the end of the project it became apparent that even courseware in the same subject area may require the use of quite different programming techniques. Rather than deciding which software should be used to programme a particular subject lesson on the basis of subject area alone, the courseware developer should identify the programming techniques necessary for the work, and then identify the authoring software which can handle all these requirements. Some of the more important programming/authoring requirements identified in this study are shown in Table 6.

It should be noted that new authoring software is continually coming onto the market (e.g. cT, Linkway) while established software is being upgraded. It should also be noted that there are now authoring overlay systems for both PC/PILOT and TenCORE, namely PROPI and TenCORE Producer, and both seem to be highly rated in the literature (e.g. Fisher, 1989).

**Footnote**

As a result of our project findings we have obtained a site license for PC/PILOT and now use it as our principal authoring software. We distribute copies to interested instructors, and also offer a limited authoring service using Computer Science majors, who do the programming under the guidance of myself and an assistant. We also have ACT-III and cT available for use by instructors although neither are supported by us at present. We have also bought a BBC-BASIC converter used by a chemist to bring BBC courseware into the MS-DOS environment.

We use PC/Paintbrush 4.0 as our main graphics editor and also use a Logitech handscanner. PCX is also available to enter graphics into normally non-graphic oriented programming languages. At present we have developed some 16 Biology programmes and one each in English and Mathematics. PC/PILOT is also being used to develop computer/videodisc programmes in Physics.

Authoring/Programming Requirements

1. Answer handling routines (multiple choice, answer precision)
2. Ability to accept long answer strings
3. Handling mathematical calculations
4. Alternate character sets
5. Proper super/subscripts
6. Advanced programming abilities (dimensioning, variables, loops, for/next subroutines)
7. Graphic/text split screens
8. Colour (CGA, EGA, VGA)
9. Complex graphics (i.e., free-hand drawing)
10. Animation
11. 3 dimensional objects
12. Number of simultaneous colours (4, 16, 32, etc.)
13. Alternative text fonts
14. Rotation of objects
15. Use of external graphics packages
16. Ability to scan in text, graphics
17. Ability to move out of authoring software into another programming environment (e.g., Pascal, C)
18. Ability to print out material for students
19. Ability to interface with video
20. Ability for student to edit text on screen
21. CML option

Table 6

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# DEVELOPING CBT COURSES FOR END-USER TRAINING

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**Abstract**
Training end-users of computer systems has always been a major application of CBT. Nevertheless, creating CBT in parallel with system development or for systems subject to frequent change has proved difficult. This is due in part to current development methods, both the programming tools used and the design techniques governing them. CIRCUS is a mix of design philosophy and programming toolkit, building on prototyping techniques, which provides an environment for the creation of flexible, easily-updated courseware with substantial time and cost savings. In addition to proving its worth in its original application area of end-user training, CIRCUS has turned out to be an effective method of developing multi-lingual courseware and portable courses for different hardware configurations

Training end-users of Information Technology (IT) systems was one of the earliest, and remains one of the most fruitful, application areas for computer-based training (CBT). In training terms the medium's suitability is obvious: a simulation of the system can be offered to the trainee in which carefully structured experimentation may be carried out in an environment where mistakes can safely be made and corrected and where real data are not at risk.

The commercial benefits are equally clear. An organisation introducing new computer systems has a large training need thrust upon it. Many people need to be trained in a short period of time and these staff are likely to be scattered over several different sites in different regions, perhaps even in different countries. The cost of taking trainers to remote sites, or bringing trainees to central classrooms, makes distance learning a worthwhile option. In some instances it may be possible to use the real computer system for training but often this is not so. For example, use of live data may not be practicable or users may need to be trained ahead of system completion so that they will be proficient and productive from day one. Even where training databases are proposed as part of the system, experience shows that when development schedules begin to strain, the training component is usually the first victim and the period between the projected availability of the system for training purposes and the "go-live" date becomes ever shorter. This is only the practical problem. There remains the question of whether it is wise to offer the trainee a full simulation of a real system for training. The research into high-fidelity simulation for novice users (e.g. Alessi, 1988) may be summarised as saying that an accurate representation allows the trainee to become as lost and bewildered as would be the case in real-life. However, despite CBT's inherent suitability for end-user training there are significant problems in its implementation which have discouraged even greater use.

If a CBT course is to be ready ahead of the arrival of a new computer system or a major upgrade, the course's design must be based on the "real" system specification. Unfortunately, these fixed specifications have a habit of changing dramatically during the life of a project. When this happens, the simulation of the system in a CBT package has to change also: a process which is both time-consuming and expensive. Until now that has simply been accepted and the received wisdom has been not to try to develop CBT for unstable systems.

There are cases, though, when the problem cannot be side-stepped. There may not be time to develop a CBT course between the date the computer system becomes stable and its implementation. On other occasions there may still be a huge training need before the final release of the software. In these cases there is no choice but to develop a CBT course in parallel with the creation of the real system.

Probably because commissioners of CBT have stuck to the 'don't develop CBT for an unstable system' maxim, little thought has gone in to how CBT software should be designed for situations where changing system specifications must to be tracked during course development. Yet the notion underlying the demand for stability is absurd. Why should the resources required to modify a superficial simulation of a system be anything like as great as those required to change fundamental system elements such as database structures, networking protocols or access methods?

Even when the computer system for which training is to be provided is stable, the time required to create CBT courses by traditional methods is often too long for a course to be available by the time the real system is implemented. Estimates of the ratio of hours of development time to course duration vary enormously from 70:1 to 1000:1 (Jay, Bernstein and Gunderson, 1987, Sampath and Quaine, 1990, Friedler and Shabo, 1991) with a commonly quoted figure in the UK of 275:1.

For many commercial training applications this figure is simply too high. The most common approach to reducing development times is to search for an authoring system to simplify course creation. The costs in terms of lost flexibility incurred by using such a system are well known (Merrill, 1985). Although authoring systems whose primary purpose is the development of training for users of computer systems exist, a 'silver bullet' approach is likely to be especially unsatisfactory in this application area. The simulation capabilities, let alone the instructional strategies, required for training senior managers how to use a graphically-based Decision Support System are very different to those required for instructing experienced data entry clerks in the operation of a mainframe-based customer service database.

Another possible solution is using a self-developed code generator (Bryant, 1990) to automate routine features used throughout a particular project. This has its attractions but, when it becomes simply a series of templates for different screen types, it is nothing more than a user-designed authoring system. If it is to have a life beyond one project its design is likely to be as limiting as a commercially produced authoring system but, given the development effort, at a far higher cost.

The problem is not simply one of the availability of suitable programming tools: it is the whole role of programming in the courseware development cycle. Most Instructional Systems Design (ISD) approaches emphasise instructional design at the expense of development. Indeed it seems CBT software development always lags several years behind general purpose computing. Advances in software engineering, knowledge representation or object-oriented programming have made little mark in CBT. A few worthwhile attempts to highlight the importance of the programming side of CBT have appeared (Janossy, 1986, Wey Chen and Shen, 1989,) but on the whole, CBT authoring tools seem to encourage unstructured program design and coding. (Think how many so-called authoring languages do not even support subroutines.)

In CBT courses to train end users of computer systems there seem to be two extremes. In courses developed with simpler types of authoring package, system screens tend to be represented by static images with accompanying text and little or no simulation of the computer system. This is hugely unsatisfactory from the training point of view as it offers little more to the trainee than what is available in a well written manual. Alternatively, in courses written in more complex authoring languages or general-purpose programming languages, the simulation of the system screens and the functions of the live system are not distinguishable in the code from the pedagogic element. This has no adverse affect on the quality of training but, if the real system is modified by the removal of one compulsory input field, the changes required to make the CBT reflect this can be complex and time consuming.

A series of CBT development projects for different clients to train users in the operation of various custom-built computer applications highlighted these problems and provided the impetus for CIRCUS. There was, and remains, a determination not to create a new authoring system or language whether as a fully-fledged product or as an in-house code generator. Staff already had much experience in developing successful CBT solutions for end-user training so the quality of training was already there: the concentration would be on reducing development times and allowing courses to be modified more quickly. This meant building on existing working practices, particularly the technique of instructional prototyping, and re-evaluating the role of programming in courseware creation. It is this background, and the fact that it evolved through use in several different projects, which makes CIRCUS something of a hybrid: part design philosophy, part programming toolkit and part 'the way we do things here'. As such, it is hoped that it is general enough for others involved in the development of CBT for end-user training, to adapt to their own methods of working and their own preferred authoring or programming languages.

**CIRCUS and its place in Prototyping**

Abandoning the ISD method of development can reduce course development time and instructional prototyping, a specialised application of incremental system development, (MacKenzie, 1990a) is one approach. The experiments with CIRCUS to date have been carried out with this method of development. The prototyping strategy deals with the entire design/development/ project management process: CIRCUS is concerned solely with the structure of the courseware code. CIRCUS could also be used with traditional ISD methods where the main objective is to provide a course which can be maintained easily after its first release. However, the benefits achieved in terms of faster user approval, more rigorous testing and, consequently, faster and cheaper development, which was the initial objective, have commended the prototyping route in projects carried out so far.

The development to course duration ratio for IT-related courses developed using instructional prototyping lies between 70 and 160:1 (MacKenzie, 1990b). Significant development time improvements for the creation of most courseware by this method accrue for a number of reasons (MacKenzie, 1987). The most important benefit in using instructional prototyping for courses involving simulation of IT systems is the constant availability of prototypes for formative evaluation throughout the project. Subject-matter experts unlikely to be able to approve traditional paper-based course designs, either because of demands on their time or because of the design's inherent incomprehensibility, have working courses the accuracy of which they may verify quickly and easily. This allows changes to be made as early as possible in development when they are considerably cheaper (for an analysis of the cost differences in software changes at different project stages, see Boehm, 1976).

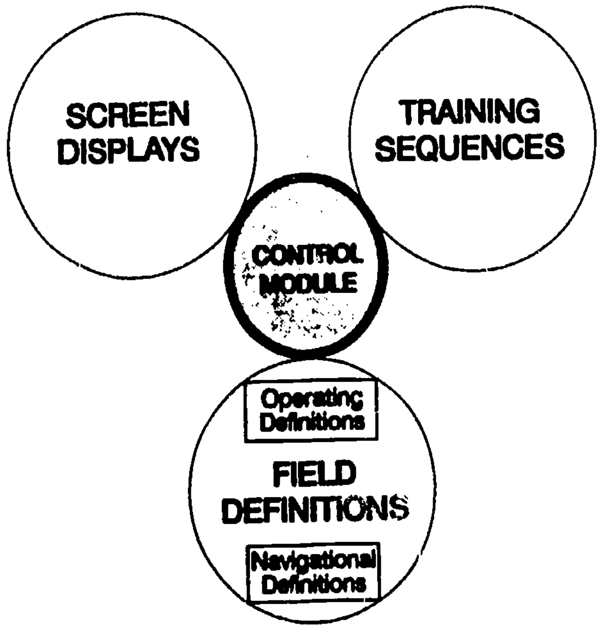
Prototypes are flexible. A key requirement is that prototypes be modified according to the comments of trainers, subject matter experts, instructional technologists, supervisors and potential trainees among the project participants. This may happen in a project no matter what method of working is adopted but CIRCUS provides an environment which affords cost-effective flexibility. A modular toolkit approach allows changes to the course, and in particular the system simulation elements, to be made simply. System changes are, therefore, quickly reflected in the CBT.

In addition to the rapid reflection of real system changes in the courseware, there is another benefit of prototype creation. The specification documents for the IT system will often represent several man-years effort but not only will there be ideas which seemed reasonable in the design document but look less good in a working model (Wasserman and Shewmake, 1985), but given an example of how a finished product will look, users' perceptions of requirements will frequently alter. A prototype CBT course concentrating on the simulation of system functions and the user interface may well be the first real product a user of a potential system sees. Changes in specification are far easier to spot at this stage than in the period of reviewing paper-based designs. Just as course changes are cheaper to make at this stage, system modifications are also considerably less expensive. Instructional prototypes in IT system training are not just a means of eliciting comment on the CBT course: they also offer a way of influencing design and development of the IT system itself.

**The Principle of CIRCUS**

CIRCUS is a series of techniques which enables the prototypes described above to be created, and whenever necessary modified, quickly. As was pointed out in the introduction, CBT courseware involving simulation of IT systems generally does not separate the system element from the training element. This can make course modifications necessitated by changes in the computer system extremely cumbersome. As part of the preliminary fieldwork a course which had been written in an authoring language which did not allow the use of subroutines (Trainer 4000) was examined from the point of view of the modifications necessary were an extra input field to be added to the live system. In the relevant course section, about twenty minutes of study time, sixty eight changes had to be made to the code. It was estimated that if the course had been written in a conventional way in a more structured language such as PC/Pilot or TenCORE, around twenty to thirty code changes would still have been required.

Where languages allow course creation with external editors, global change commands and internal macros may reduce the physical effort of making changes to the code. This is, however, likely to be complicated by embedded colour and highlighting commands or by the




| Section | Purpose | Components |
|---|---|---|
| Screen Displays | Graphic representations | Passive overlays |
| Field Definitions | Input field descriptors | Navigational definitions<br>Event markers<br>Operating definitions<br>Operating variables |
| Training sequences | Explanation | Text, graphics, animation |
| Control | Co-ordination | Subroutine calls<br>Setting of<br>Operating variables<br>Event markers |

Figure 1 The CIRCUS model divisions

conjunction of tutorial text with system screens. In addition to the effort of changing the code in many places, a large demand is placed on project time by the new testing required.

CIRCUS aims to reduce the number of changes in the CBT caused by a change to the real system. The basic idea is to keep the system and the instructional elements separate with pointers from one to the other. The system information is divided into screen displays and field definitions and the training element constitutes a third section. The "connections" between the three elements are defined in the central control module. This format is illustrated in Figure 1.

**Screen displays**
The screen display portion of a course contains definitions of the system screens as they appear to a system user. These are passive overlays with no distinction between fields: input, output or mixed fields are simply left as blanks.

**Field definitions**
This section contains definitions of input fields for each screen: field name, screen co-ordinates, input field length, any type checking done within the field, the keys which allow movement to the next or previous field, the names of those fields. These definitions could be coded explicitly for each field. However, the first CIRCUS toolkit implemented in PC/Pilot uses a shorthand. So called operating variables are set in each field definition which are passed to Pilot subroutines. For example, on the first project where CIRCUS was used, the real computer system used 80x24 text screens with a mixture of fields. Filling an input field meant the cursor automatically jumped to the next field. Attempting to input data in an output field caused an error tone to be sounded but required the TAB key to be pressed before the cursor moved on. The CBT version of this

involved setting variables mlth to 8, jkey to 9 and num to 1. The subroutines in the control module use these to determine that the maximum length of input is eight characters and so adjusts the input window accordingly. Only numeric characters are to be accepted and, once the field is full or the tab key (ASCII value 9) has been pressed, the cursor will automatically jump to the start of the next field. This, in CIRCUS terminology is called an operating definition.

In addition to the detailed operating definition there is also a higher level field description, the navigational definition. This describes a particular screen in terms of a list of the fields used on a screen in the order they would be completed. Within this definition there is space for event markers. These are checks for author-specified conditions such as 'field traversed three times by trainee without inputting anything' or 'non-numeric input attempted' or a test for a specific input. The use of these is described in the Implementation section below.

**Training**

The training portion in CIRCUS contains the purely explanatory parts of a CBT course. These may be graphics, animation sequences or blocks of text. They may be individually labelled items, such as a textual explanation of how to complete a particular field, or quite long sequences explaining, say, the operation of TAB and BACKTAB keys, with branching instructions limited to that particular sequence. (It is very important for the modular nature of CIRCUS development and the ease of debugging and testing that the blocks of training material are self contained and do not contain references to other blocks.)

**Control Module**

This section is the driver for the whole course. Screen overlays are called from here with pointers to the training elements to be used with them. The field definitions to be used with each screen are specified. If a section of a course is to be a very close approximation to the real system, as in a mastery test, whole screen field definitions are called using the navigational definitions described above with the appropriate event markers primed to afford the specified help or remediation when triggered.

A purely tutorial part of the course would probably use only an operating definition often with some of the operating variables turned off. This is called along with the appropriate teaching material portion.

**The Implementation of CIRCUS**

CIRCUS was originally conceived simply as a development method and so capable of being used with a wide variety of languages. In-house use of it at DMC has, however, led to a large number of supporting routines being developed in PC/Pilot.

There were two reasons for this choice. The power and flexibility of PC/Pilot make it a very suitable choice for creating complex simulations of IT systems and so it had already become something of a house standard for this type of course. Secondly, the language uses a so-called execute indirect statement which allows a string to be executed as a language command. For example, an event marker might be of the form adpas>3, a counter noting that a certain field had been passed more than three times, and a teaching segment marked with the label *INT1. These components can be combined in a string of the form rec$="u(adpas>3):INT1". Executing the rec$ string as a command means that when the condition in the event marker has been fulfilled, the teaching segment is called as a subroutine. This language feature, equivalent to having subroutines to which addresses, variables or conditions may be passed, is of immense value in adding automation to the toolkit.

**The Impact on Development Times**

The first project on which CIRCUS was used was a PC-based CBT course to train end users of an enquiry logging and tracking system used in a large UK bank. The logging system was developed in COBOL and ran on networked PCs. Trainees had neither knowledge of previous manual procedures used in the bank nor had they prior computing experience. There was a three phase implementation of the live system with significant changes with each release. CBT had to be available for users of each release. The live system was menu-driven with eight menu options. Complexity varied between four and thirty-two

fields per screen, most of these both input and output fields. The average time to complete a transaction on the live system is around five minutes.

The first information available to the CBT developers was a draft functional specification of 6the real system. From this a prototype course was constructed with PC/Pilot showing how a system simulation would operate and

| | Approximate length of material developed in minutes of trainee study time | Development ratio (hours development to hours of course) | Main CIRCUS-related activities |
|---|---|---|---|
| Phase I | 60 | 140:1 | Building routines, screen displays and field defs. |
| Phase II | 20 | 90:1 | Changing navigational definitions, training sequences and event markers. |
| Phase III | 30 | 64:1 | Changing operating definitions. Constructing new exercises from existing definitions. Adding new training seqs. |

Table 1 Development Time Ratios for Courseware created unsing CIRCUS

how data entry would be taught. This was achieved and made available to bank trainers and subject matter experts within five days. In addition to producing a design template on which non-CBT specialists could offer meaningful comments, the prototype illustrated a number of inconsistencies within the functional specification itself and a number of features were clarified and user requests passed back to system developers.

The CBT development continued in parallel with system developments which went through three pre-release software versions. A two-hour CBT course using a mixture of text-based system screens and EGA graphic images, of which training on system use constituted around one hour's worth of material was ready at the time the system went live. The development time for this section was around 140 man hours. This is fast compared to industry standards but was in line with the developers' expected ratios for such a course created using instructional prototyping and with a stable system specification (MacKenzie, 1990b). Given the fact that the specification was not stable and the large number of changes to the system being simulated, CIRCUS certainly kept development time, and consequently cost, down. Although the actual saving for this stage is not directly quantifiable, the method's benefits become clearer in the versions produced for the second and third phases. The development times required are summarised in Table 1.

The second phase of the software involved major task changes in the way the real system was used. Division of work in the processing centres meant trainees now no longer completed many of the fields they were taught to complete in Phase I; other fields were added and the format of some was altered. Different ways of completing input fields largely meant changes to navigational definitions and to event markers. Around twenty minutes of changed material in the course required thirty man-hours.

Phase III involved the addition of two completely new menu options. Although the use of these on the real system did not involve much data input, the menu from which they were accessed changed and would have involved a large number of cosmetic changes in a non-structured course. Similarly, screen appearances changed appreciably as did the allocation of function keys and field structures. Changes for this release, therefore, involved mainly changes to operating definitions. As the live system was now stable, client trainers requested a mastery test consisting of an exact reproduction of the system with trainees expected to complete a full data entry transaction with 'real' messages for tasks completed correctly and appropriate remediation when it was felt that stored answers deviated too far from correct working practice. The toolkit of operating and navigational definitions already assembled allowed this, and the system changes, to be completed very rapidly. Approximately thirty minutes of new course were created in thirty-two hours and delivered within a week.

**Concluding Remarks**

The first project proved the worth of CIRCUS as a strategy. We have gone part of the way to implementing it as a PC/Pilot toolkit but this is a matter of convenience rather than a requirement: the techniques of partitioning courses in this way can be used with many languages and can, no doubt, be used with development strategies other than instructional prototyping. The motivation for developing these techniques came from a need to produce CBT for rapidly changing computer systems but there have been two important 'spin-offs'.

It was felt initially that CIRCUS could be applied only to CBT for computer systems where the course followed the same structure as the real system. However, separating text, graphic overlays and user input and co-ordinating them from a control module has been beneficial in other types of course: firstly courses designed to run with a variety of graphic cards where the appropriate images and fonts are called depending on what the delivery system has available and, secondly, in multilingual courseware. A course developed with English, French, German, Italian and Spanish versions was created using the CIRCUS methodology. By keeping text separate (including all text used to caption graphics) and treating pattern matching sequences for student input as operating definitions, the translation and production of different target language versions was speeded considerably.

A benefit exists outside the training area also. The rapid prototyping afforded by CIRCUS allows real system designs to be understood by larger numbers of staff than would be the case with system or functional specifications. Changes to users' requirements, or perceptions of requirements, are consequently identified before it is too late, and too expensive, to do something about it.

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Selected Formal Papers From the

# Special Interest Group for PLATO Users' Group (PUG)

# I NEED SOME HELP

*Leslie Smith*

How many times have you stood in front of a class and offered your best explanation of a lesson only to turn and look into a group of lost faces all bearing blank expressions? Better yet, how many times have you had to parade around the room, from student to student, offering individual assistance to each; in response to a steady chorus of "I need some help"? As educators, we have learned that no matter how thorough a job we think we have done, no matter how precise we have been, there will always be students in our class, who at the conclusion of the day's explanation of the lesson, will inevitably need some help. Many times it is the same student over and over again; however, every now and then, it is a different student, who for some reason or another, just didn't understand a particular aspect of the assignment. Finally, have you come up with a cure for the students who are absent, and when they return, they not only bother the teacher, but they bother their classmates as well?

It was with these circumstances in mind that 17 teachers from the Chicago and East St. Louis area gathered in the sweltering heat of the summer of 1990 at the University of Illinois at Urbana for two weeks of intense study for a pilot program called NovaNet. Each teacher came with one common goal: to learn a computer programming system that promised to improve the educational skills of every student in the school system. Many of us were apprehensive because we were what you would have classified as computer illiterates; and the mere sight of the monitors and keyboards struck fear in our hearts. As much as we hated to admit it, it baffled us as to how we were going to be proficient at using a system such as NovaNet into our everyday scheme of things; when we weren't even certain we could learn how to use it yet alone master it in two weeks. We were, however, willing, eager and ready not only to stick ourselves out there, but be sacrificial lambs. Yes! Sacrificial lambs. The success or failure of this experimental program depended on us and how well we could get the information across to our students. All our fears, doubts and reservations were put to rest as we gathered with a well-equipped group of professionals from CERL (Computer- based Eduation Research Laboratory), who knew the system as well as many people know their names. The staff of CERL explored every possible use of NovaNet with us, and explained how they felt it could be best used in our classroom.

The three teachers from East St. Louis Senior High School decided to incorporate the NovaNet Curriculum into our everyday curriculum as an aid. By aid, I mean we would let the students use it primarily to reemphasize major parts of the lesson or clarify points that may have been misunderstood. As the mathematics teacher, it was a welcomed relief to get the system in my school. I'm one of those teachers who tries to reach every student in the class and at some point lets him realize that he has mastered some part of the lesson; however, having 30 to 35 students per class, each on different levels, it became increasingly more difficult to do this. Many times, when the smarter students had comprehended, I'd look and see 15 to 20 puzzled looks; and if I taught until the slower students caught on, the smarter ones' minds would wander off onto other things. NovaNet solved this problem and allowed me to teach to the middle of the class without feeling guilty. The more I have used NovaNet, the more advantageous it is for me to use the system.

There are several advantages as well as disadvantages to using the NovaNet system. The system is absolutely superb for individualized instruction. The teacher can examine the various lessons in a given curriculum and with very little difficulty give each student his or her own personal prescription as it pertains to a given lesson. If the teacher does not wish to use this approach, everyone can begin in the same place, at the same time and proceed through the lesson at his own rate. This alleviates the pressure put on the slower learner to keep up and relieves the boredom gotten by the faster students when they have completed the assignment and are waiting for the teacher to go on to the next assignment. Throughout the individualized lessons, the teacher can place off-line assignments which can be used for grading purposes.

Off-line assignments are assignments

programmed into the computer by the teacher. They can be assigned pages out of a textbook, handouts from a workbook or board assignment, etc. Off-line assignments are not the only means of grading which can be implemented with NovaNet. Many of the various lessons and modules have quizzes contained within them. Also many of the lessons will give a grade based on the number of questions answered correctly. NovaNet is equipped with a testing and graphics program, which allows the teacher the freedom to create his/her own test, called Testing 1-2-3.

Testing 1-2-3 is more than a test making program. It is an excellent tool for graphic design. Many of the handouts available today were written or created using the graphics portion of Testing 1-2-3.

Another major advantage of the system is the manner in which it handles right and wrong answers. For example, after the student keys in the right answer, such words of praise as: GREAT! SUPER! O.K.! TERRIFIC! and GOOD! will appear on the screen. These phrases not only make the students feel good about themselves, but they inspire them to attempt to work more problems in the lesson. Wrong answers are followed by such expressions as: INCORRECT! NO! and TRY AGAIN!. For each wrong answer, students are given a second and in many cases a third opportunity to get the correct answer. After several wrong attempts the correct answer, along with a procedure or an explanation is automatically displayed on the screen. There is a HELP key available which will many times give directions and explanations for obtaining right answers at any point during the problem-solving portion of the lesson. Finally, wrong answers are followed by several more problems of similiar nature to give the student more practice and to reassure the student that he/she has grasped a particular concept.

Among the disadvantages is the fact that many times, the students fail to sign out correctly and a days worth of work could be momentarily lost. The students quickly find the sign-ons necessary to find the games section of the programs, and if the teacher is not doing some supervising, they will find that some students have wasted valuable time doing nothing more than playing games. Another disadvantage is that in some cases the students get frustrated because the computer may want them to be more specific than they are accustomed to being for the teacher. There are several other minor problems such as temporary shut downs and phone wire problems, but these are so few and far between that they shouldn't really matter.

Not only does the system give welcomed relief to the statement "I need some help" which came from the students, if offered me help as well. Many of the lessons are graded; therefore, it cut down on much of the paperwork I'd have after giving homework. If the lessons aren't graded, they occupy the students in a positive way and that allows me time to catch up on my other paperwork. The Student Grade Report Page, which is part of the Instructors Resource Program, allows me, at my convenience, to check grades, progress and amount of time each student has put into each lesson on any given day.

The NovaNet system has several key features that make it more complete than other computer systems. Because everything runs off everyday telephone lines, there is not a bunch of software (disk) to carry around, keep up with, and hope it doesn't get erased. The HELP button which is on the keyboard makes for easy assistance at any point in the program.

I have witnessed smiles on faces that thought math was the worst thing since strained spinach. I have seen slower learners who didn't understand the assignment spend countless hours in front of the monitor eagerly awaiting the next problem. Students who had given up on mathematics now explore areas that I would never have been able to cover in a regular classroom setting. Students who were always the ones being helped are helping each other grasp concepts and find short-cuts to problem-solving that only using this sytem could have provided. No longer do I stare into blank faces, wear out the soles of my shoes or feel as though I've let some student down. With NovaNet, no longer do I need any help!

Selected Formal Papers From the

# Special Interest Group for Theory and Research (SIGTAR)

# WORKING ALONE VS. WORKING IN TEAMS DURING COMPUTER BASED INSTRUCTION IN PUBLIC SPEAKING

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**Abstract**
This study was designed to examine the efficacy of CBI in speech education--both as a deliverer of content and a facilitator of interaction among students working as a team. Results indicated improved learner performance when participating in CBI with another student. Additional analysis revealed effects of learner attributes on the impact of team-based CBI.

**Rationale**
The advantages of computer-based instruction are well documented and far-reaching. Students with diverse preparation and abilities can proceed through computerized lessons without the anxiety of being too far behind or the boredom of being too far ahead of the rest of the class. Since CBI is self-paced, it also allows for efficient learning in that large groups of students may be exposed to virtually individualized instruction without intensive use of human instructors. Because of these advantages, CBI use is rapidly increasing in various educational arenas, from Geometry (Hativa, 1984) to English (Thompson, 1990).

It would seem large introductory courses in speech communication could also benefit from CBI, particularly in teaching public speaking mechanics. However, little evidence exists indicating CBI is being used successfully in basic speech courses (Hemphill & Standerfer, 1987).

The reason CBI is not prominent in speech education is two-fold. First, much of speech education is behavior-oriented, the object being to change how students perform some communicative task. CBI is too often viewed as a drill-and-practice tool to teach basic information, e.g., multiplication tables, vocabulary words, geographical locations, etc. This vision of CBI is falsely limited. In fact the dynamic nature of CBI makes it well-suited for speech education (Hemphill & Standerfer, 1986). Second, much of speech education is "other" oriented. Speakers do not become better by delivering speeches to a mirror, but rather by standing in front of an audience. The computer (even in its best anthropomorphic guise) is still an inanimate data processor. However, the computer can provide the speech teacher with educational advantages by serving as a model of a human communicator through "interactions" with the student. More importantly, through appropriate lesson design and task structure, the computer may serve as a facilitator of interaction among learners working in teams.

Teamwork at a computer terminal is not a new idea. Reports of how effective it might be in increasing student learning are mixed. Dossett and Hulvershorn (1983) reported that peer training via CBI can be useful in decreasing training time, although they report no significant differences in achievement among groups receiving peer instruction via CBI, individual CBI instruction, or conventional classroom instruction. Webb (1985) also found no significant differences in achievement between students working alone at a computer and students working in pairs. However, when computer-aided cooperative learning has been compared to traditional methods, some differences in recall of information have been found (Rocklin, O'Donnell, Dansereau, Lambiotte, Hythecker, & Larson, 1985). One study found that students working in teams demonstrated more and better daily work than students working alone and showed greater problem-solving skills (Johnson, Johnson, & Stanne, 1985).

Obviously, teamwork at a computer increases interaction among students. Students are required to interact on a minimal level to decide a division of labor, to indicate when each is ready to move ahead in the lesson, to decide on how to answer embedded questions, etc. If the computerized lesson is constructed with explicit instructions for student collaboration, then the interaction becomes more substantively related to the lesson.

Despite previous reports that indicate off-task (or social) interaction may interfere with completion of the task during collaborative learning (Dalton, 1990), one goal of CBI teamwork in speech education is to promote interaction beyond task accomplishment. That is, the lesson should provide the students with an opportunity to discuss the mechanics of communication as well as provide an opportunity for off-task discussions among team members. In this way the lesson, by encouraging social interaction, may promote positive communication experiences during the lesson and positive attitudes about communication in general. At the same time the lesson, by requiring task interaction, could be expected to increase the students' knowledge concerning effective communication.

However, such an interactive-intensive team-based approach may not work for all students. Webb (1985) suggested that differences in prerequisite skills may moderate results when comparing individual and team CBI achievement scores. Dalton (1990) found that team performance may be influenced by the gender of the team members and suggested existing attitudes toward the subject matter could influence achievement.

Student attitude toward the subject matter is especially critical in communication education. Not every student looks forward to the activities and exercises associated with an introductory speech course. Students vary in terms of how apprehensive they are in communication situations and their apprehension could be expected to affect their learning. Simply put, students who are highly apprehensive about public speaking will react differently to a public speaking assignment (or a computer lesson designed to explain one) than students who are not apprehensive about speaking in public. The question ultimately becomes:

To what extent does team-based public speaking CBI impact student learning and attitudes about public speaking?

## METHODOLOGY

### Subjects

The subjects for this study were 40 students enrolled in an introductory speech course. This course is a general education requirement for all degree-seeking students and requires a public speaking performance. Computer-based instruction is a regular component of this course.

Because previous research has indicated that students with high and low levels of communication apprehension respond differently to highly structured communication tasks, such as the CBI used in this study (Booth-Butterfield, 1986), subjects were screened prior to participation using the PRCA-24 (Richmond & McCroskey, 1985). The PRCA-24 contains 24 statements assessing students' apprehensions about interpersonal communication situations, group communication situations, meetings, and public speaking and results in a summed overall measure of apprehension. Only students with scores representing moderate overall apprehension were included in the study (Richmond & McCroskey, 1985).

### Independent Variable

Students were assigned to complete a CBI lesson defining and explaining seven criteria of evaluation (e.g., "Use an opening attention getter") to be used on their public speaking assignment. Twenty-two students were randomly assigned to work in pairs on the lesson. In an effort to promote interdependence between the two team members (Dalton, 1990), the team had to collaborate on seven exercises, one for each of the criteria. The lesson also included prompts before the description of each exercise to remind the subjects to work together.

The remaining 18 students were assigned to work on the lesson by themselves. The subjects in the "individual" condition completed the lesson and the exercises on their own.

### Dependent Variables

After completing the computerized lesson, subjects were required to list the seven criteria of evaluation and complete a 21-item test over the 7 criteria. Student learning was evaluated be assessing the number of criteria correctly identified and the number of test questions correctly answered. In addition, after completing the lesson, subjects filled out a five-item measure adapted from the STAI (A-State) anxiety scale (Spielberger, Gorsuch & Lushene, 1970) assessing how tense, calm, relaxed, at ease, and jittery the subject feels about an upcoming speech.

### Results

Those subjects participating in the team-based CBI were able to cite more of the seven criteria of evaluation ($x = 5.65$) than those working alone ($x = 4.41$, $t = 2.07$, $df = 38$, $p<.05$). However there were no significant differences in either test scores or attitudes about the upcoming speech.

Because the PRCA-24 assesses levels of apprehension in four different contexts, it was decided to further explore the effect of team composition on performance and attitude by examining more closely each of the four types of apprehension. Subjects were divided into two median-split groups (low and high apprehension) and separate 2 (team condition) x 2 (type of apprehension) ANOVAs were conducted for each type of apprehension. Any interaction between team condition and type of apprehension would provide evidence of an important learner characteristic that mediates the effect of teamwork on performance.

Once again, only those analyses involving the subjects' ability to list the seven criteria of evaluation correctly yielded significant findings. The only significant interaction involved group communication apprehension. Those students low in interpersonal apprehension identified significantly fewer of the criteria when working by themselves ($x = 3.22$) than those students working in teams ($x = 5.75$; $x = 5.50$) and those students high in interpersonal apprehension working by themselves ($x = 5.82$, $F = 6.72$, $df = 36$, $p<.02$).

**Discussion**

This study was designed to examine the efficacy of CBI in speech education--both as a deliverer of content and a facilitator of interaction among students. It was thought that the task-oriented discussion among teammates would produce better results on testing and social-oriented discussion would improve the students' attitude about their upcoming speech.

Partial support was found for improved learner performance when participating in CBI with another student. Students who worked in teams were able to recall more of the evaluation criteria than those who worked alone, reinforcing previous research on collaborative learning (Johnson, et al. 1985; Rocklin, et al., 1985). However, no impact on student attitude about the upcoming speech was found.

In examining the impact of specific learner attributes it was found that students low in interpersonal apprehension (meaning they are very comfortable in one-on-one situations) performed poorer than the other students when left to work by themselves. At the very least this supports Webb's (1985) and Dalton's (1990) contention that learner attributes can interact with collaborative learning. It should be remembered that only those students whose overall apprehension level was moderate participated in this study. Thus, more extreme effects may be expected with students with greater or lesser levels of apprehension.

The area of student apprehension as it relates to CBI needs to be explored more fully, especially in speech education. Teaching is a communication process and student apprehension about communicating with others will impact that process. CBI, to the extent it models or facilitates interactions with students may generate the same type of student anxiety. Thus, speech educators need to be more aware of student apprehensions before deciding to pair them with another learner.

On the other hand, CBI may prove to be an effective means of reducing anxiety within students. While research abounds in speech education concerning traditional techniques to alleviate speech anxiety, no research has been conducted to examine CBI's effectiveness in alleviating anxiety. Do students view the computer as a non-threatening, non-evaluating source of information? Can lessons be structured in such a way as to deliver content aimed at reducing anxiety while at the same time giving the student a chance to practice anxiety-reducing techniques with a partner? Will off-task discussions among highly anxious students (as opposed to the moderately anxious students participating in this study) help reduce anxiety and improve student attitudes about future communication experiences?

This study uncovers some of the potential of CBI in speech communication education, but it also suggests some exciting issues related to using CBI as a facilitator of interaction among student learners. Once again the conclusion seems to be that the use of computers in education is not in and of itself a solution to a problem. But rather, the effectiveness of CBI is dependent upon an interaction of lesson design and learner attributes.

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# GENERATIVE PROCESSING OF STRUCTURAL KNOWLEDGE IN HYPERTEXT

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**Learning and Semantic Networks**

The interrelated knowledge within semantic memory enables humans to combine ideas, infer, extrapolate or otherwise reason with the information. Learning consists of building new structures by assimilating environmental information and constructing new nodes that describe and interrelate them with existing nodes and with each other (Norman, 1976). It requires forming links between existing knowledge and new knowledge in order to comprehend information from the environment. Learning therefore may be conceived of as a reorganization of the learner's knowledge structure that results from the learner's interactions with the environment. This hypothesis has been empirically demonstrated. As a result of teaching, the learner's knowledge structure closely resembles the instructor's (Shavelson, 1974; Thro, 1978). So, learning may be conceived of as the mapping of subject matter knowledge (usually that possessed by the teacher or expert) onto the learner's knowledge structure.

Hypertext engines or structures can be designed to reflect the semantic structure of a subject matter expert (Jonassen, 1991). The research question that is implied by these assumptions is, "If the node-link structure of the hypertext reflects the semantic structure of the expert, will the expert's knowledge structure be more effectively mapped onto the novice browser?" This is the question that has been investigated in the studies described below.

**Semantic Networks for Designing Hypertext**

If we accept the suggestion that hypertext should mirror the semantic structure of an experienced performer or expert, then we need methods for mapping that semantic networks onto the hypertext. This may be accomplished by having an expert or group of experienced individuals or experts generate semantic maps using any of the techniques described above. The maps provide a node-link structure which may be mapped directly onto the hypertext. The concepts in the semantic maps comprise hypertext nodes and the relationships are in effect hypertext links. Being able to work interactively and iteratively with an expert or group of knowledgeable individuals to refine, clarify, and correct these structures should provide more meaningful and useful maps. The assumption of this method, that using semantic maps to define the structural model of a hypertext by directly mapping the expert's organization of ideas onto the hypertext, has been the subject of considerable debate (Jonassen & Mandl, 1990) and is the subject of a series of studies described below.

**Developing Graphical Browser from Semantic Maps**

The most direct way to map the expert's semantic structure onto a hypertext is to use the semantic map as a graphical browser in the hypertext. Graphical browsers are maps or graphical listings of available nodes in a hypertext. They represent a graphical interface between the user and a hypertext that is designed to reduce navigation problems within the hypertext (Jonassen, 1988). Getting lost in a large web of hypertext nodes and links is a common problem among hypertext users, so graphical browsers are developed to provide a spatial map of the organization of nodes in a hypertext. Most often, however, the arrangement or structure of nodes that are illustrated in a graphical browser is arbitrary (eg. rows and columns of nodes). The hypothesis of our recent research (Jonassen & Wang, 1990; 1991) is that by arranging the nodes in a graphical browser according to an expert's semantic map, you are explicitly conveying the organization of ideas in the expert's knowledge structure. That is, you are showing the user how the expert thinks. So, while navigating through a hypertext, the user is in effect navigating through the expert's knowledge structure. The research questions that we have pursued focus on the extent to which the semantic structure illustrated in graphical browsers actually maps onto the user's knowledge structure. To what extent will the user model or replicate that structure in their own knowledge representations?

**Methods**

In order to assess structural knowledge acquisition following various treatments, we developed three subscales of ten questions each to measure different aspects of structural knowledge: a) relationship proximity judgements, b) semantic relationships, and c) analogies. All of the structural knowledge test questions were developed to focus on relationships between important concepts contained in the hypertext. The relationship proximity judgements required that students assign a number between 1 and 9 to each of several pairs of concepts to indicate how strong a relationship they thought existed between the concepts in each pair (Diekhoff, 1983). For example:

information retrieval systems and online documentation

hypertext processing strategies and database

The semantic relationships subscale consisted of multiple choice questions that required students to identify the nature of the relationship between two concepts. These relationships were paraphrased from the hypertext knowledge base. For example:

unstructured hypertext ..... navigating hypertext

a. produces problems in
b. defines the functions of
c. counteracts the effects of
d. enabled by

Finally, the analogies subscale required students to complete 10 analogies consisting of four of the concepts from the hypertext. For example:

accessing information : index :: integrating information : ......

a. links
b. hypermaps
c. idea generator
d. multi-user access

These questions were used to assess structural knowledge acquisition. In order to provide standards for assessment, three authors and researchers in the hypertext field agreed on the answers to each of these questions. In addition to assessing structural knowledge, ten lower-order information-recall questions were developed.

**Treatments**

The hypertext that was used for all of the studies was the HyperCard version (Jonassen, Roebuck & Wang, 1990) of the book *Hypertext/Hypermedia* (Jonassen, 1989a). This hypertext is a browsing system consisting of 240 cards and 1167 links in three stacks supported by bookmarking and limited annotation capabilities. All treatments in all studies contained embedded referential links in the cards. Terms in the text were highlighted, enabling learners to immediately traverse the links. The treatments varied in terms of the types of browsers that were made available and the ways that they depicted structural information. Each of the 75 major concept nodes contained a main "related terms" card, which was the first card accessed when traversing a link to that node.

One of the weaknesses of the previous study (Jonassen & Wang, 1990) was the lack of instructional support provided the learner. Hypertext is a technology that supports information retrieval and search tasks. However, these tasks are not necessarily correlated with instruction. One of the most significant potential problems in learning from hypertext is integration of the presented information into knowledge structures (Jonassen, 1989a). Learning requires that users not only access information but also interpret it by relating it to prior knowledge.

Therefore, in this study, we attempted to provide additional instructional support by including a more generative form of treatment. Generative learning occurs when learners relate information meaningfully to prior knowledge (Wittrock, 1974). The control treatment was compared with the pop-up treatment and the generative processing treatment. In the control group, each *related terms* card provided a list of terms that are related to the concept being currently examined. This list provided links but no structural information about the nodes or links. The experimental treatments replaced these lists with a pop-up window which described the nature of the link (one of 12 different link types) being traversed. The generative treatment was similar in appearance to the pop-up window version of the same hypertext used in the previous study. However, rather than being told what the nature of the relationship was between the nodes being linked, the learners were required to classify the nature of each link themselves. The pop-up window presented 12 different link types and required the learner to determine which of the link types most accurately depicted the nature of the relationship implied by the link that they were traversing. The user had the option of returning to the previous node or moving forward to see the node they had selected as many times as necessary. Knowledge of results was provided for each selection by the user until the user selected the correct link type.

The studies involved undergraduate pre-service teachers in a teacher education program, who were assigned to learn about an important new instructional technology, hypertext, as an assignment in a pre-service instructional technology course. Students individually interacted with and studied the hypertext for one to two hours in order to acquire as much information about this new technology as possible. A monitoring program was added to the stacks to audit the learner interactions.

**Results**
As in the first study, the recall scores of the control group (no structural information provided) were higher than either of the two structural treatments. No differences between relationship proximity judgements, semantic relationships, or analogy scores occured.

In this study, we also assessed the individual difference characteristics, field independence (Hidden Figures Test) and global reading ability/vocabulary (Extended Range Vocabulary Test, both from the Kit of Factor Referenced Cognitive Tests (Ekstrom, French, & Harman, 1976)). In the control and generative treatments, field independent students performed better on the relationship judgements, but they were impeded by the pop-up version. On the semantic relationship task, the opposite occurred. Field dependent students in the pop-up version outperformed field independents while they were impeded in the control and generative groups. No significant interactions occurred on the analogy task. Nor were there any interactions of treatments with vocabulary scores.

**Discussion**
To the extent to which learners attended to the structural cues provided in the hypertexts, they did acquire some structural knowledge. The post hoc regression analyses showed that students were in fact attending to some of the structural information. The number of structural cards accessed appeared to predict structural knowledge acquisition in the form of relationship judgements in two different forms. The time spent with the structural cards suggested a relationship between accessing those cards and the level of structural knowledge acquisition. These are weak effects at best, though with longer exposure to the hypertext and the prior acquisition of hypertext processing strategies, these findings may be substantiated.

The most questionable assumption of our hypotheses, based upon the results, is that merely providing structural cues in the user interface will result in structural knowledge acquisition. The superiority of control treatment subjects, who produced the highest level of recall, is consistent with research that shows that without cueing or practice, learners tend to recall micropropositions more readily than macropropositions. The structural information clearly impeded the recall of specific facts by the students in the structural knowledge treatments. However, it did not generally result in greater structural knowledge acquisition. Merely showing learners structural relationships is probably not sufficient to result in encoding. Requiring structural knowledge outcomes, rather than orientations, is able to produce enhanced acquisition of structural knowledge though.

According to Whalley (1990), the most natural mode of studying hypertext is browsing. The question is the extent to which unconstrained browsing can support instructional goals. The data and the comments from students in these studies showed that they lacked a clear purpose for studying the hypertext. That lack of clear purpose manifested itself in consistent performance across groups, especially with the structural knowledge elements. It is becoming increasingly obvious that learning from hypertext must rely on externally imposed or mediated learning tasks -- that merely browsing through a knowledge base does not engender deep enough processing to result in meaningful learning.

Hypertexts are obvious information retrieval technologies. However, retrieval of information is not sufficient by itself to result in meaningful learning. When the goals of accessing information require deeper processing, then deeper processing is more likely to occur. However, simply browsing hypertext is not engaging enough to result in more meaningful learning. It may well be that hypertext is not be very appropriate for highly structured learning tasks, as Duchastel (1990) suggests.

Students in this study appeared, as expected, to lack hypertext processing strategies (Jonassen, 1989), which likely precluded the most effective use of the technology. Hypertext, and the greater learner control of instruction that it entails, is a novel form of instruction for these learners. The more novel the appearance of the hypertext (ie. graphical browser version), the more negatively the students reacted to it. A fair evaluation of learning from hypertext can only come from hypertext-literate learners who have developed a useful set of strategies for navigating and integrating information from hypertext.

As expected, individual differences interacted with learning from hypertext. Field independent processors generally prefer to impose their own structure on information rather than accommodate the structure that is implicit in the materials. In the second study, field independent learners were impeded by the structural information provided in completing the recall task. However, on structural knowledge outcomes, they were the only learners able to successfully use the structural cues to acquire more structural knowledge information than field dependent learners. It is likely that field independent learners are better hypertext processors, especially as the form of the hypertext becomes more referential and less overtly structured.

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# EXTERNAL EVALUATION OF POSIT

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**Abstract**
While there has been a great deal of expectation and a small amount of evidence for the benefits (Anderson, Boyle, & Reiser, 1985; Raghavan & Katz, 1989; Kurland, Granville, & MacLaughlin, 1990) of Intelligent Tutoring Systems (ITS), there is at least as much equivocating evidence (Center for the Study of Evaluation, 1986; Sleeman, Kelly, Martinak, Ward, and Moore, 1988; Sleeman, et.al., 1989; Stasz, 1988). It is my intent to present some of the findings from an external evaluation of POSIT which would add to the support. Littman and Soloway (1988) suggest that evaluation of ITS has two facets: external and internal evaluation. External evaluation addresses the question, "What is the educational impact of an ITS on students?" (p. 209). Orey, Legree, Gillis, and Bloom (1991) suggest that external evaluation may be most appropriately conducted for ITS by comparing the effectiveness of the ITS to that of human tutors and regular classroom instruction, although there are some dangers in using these groups for comparisons (Clark, 1983; Hogan, 1958; Reeves, 1986). Some effort has been extended toward defining these groups in terms of emerging constructs as observed from video tapes. This paper reviews some of the external evaluations that have been conducted on ITS architectures. It then details an evaluation of POSIT (Orey, & Burton, 1990), an ITS for the tutoring of whole number subtraction. This evaluation used the three groups: computer tutor, human tutor and regular classroom instruction. The results, although somewhat limited, indicate that there is some support for ITS systems.

**External Evaluations: What's been done**
Although over twenty ITSs have been developed, very few of these systems have been externally evaluated. Many of these systems were developed on AI workstations that cannot be used to economically distribute training. These systems were primarily designed to demonstrate the types of interactions and approaches that could be used to deliver training. The fact that these ITSs were not intended for widespread use may account for the paucity of formal evaluations.

Much ITS that is now being developed will run on microcomputers because of improvements in PC based software. These systems, although expensive to develop, have the potential to become cost-effective training systems because the computer programs will run on readily available microcomputers. However, because microcomputer based ITS remains expensive to develop, it is critical that performance data be collected to determine its effectiveness.

In the past, the developmental cost of ITS technology has been justified by the claim that this technology may approach the effectiveness of one-on-one human tutorial instruction (Anderson & Reiser, 1985). In fact, at least one source (Littman & Soloway, 1988) has suggested that ITS effectiveness will eventually surpass the effectiveness of the human tutor. This should have major implications for training and education because students who are taught by human tutors perform approximately two standard deviations better on achievement tests than students taught by traditional methods (Bloom, 1984). The demonstration that ITSs lead to similar gains in training effectiveness should also justify continued support for developing practical microcomputer based ITS.

Evaluating ITS technology with well designed research studies is critical to avoiding a repetition of the history of the evaluation of conventional computer aided instruction (CAI). Initial meta reviews of CAI studies (Kulik, Bangert & Williams, 1983; Bangert-Downs, Kulik & Kulik, 1985; Kulik, Kulik & Shwalb, 1986) supported optimistic estimates of the effectiveness of CAI and reported effect size estimates ranging from 0.25 to 0.42. However, a meta-analysis (Clark, 1985), which eliminated poorly designed studies from Kulik and Kulik's reviews, estimated a much smaller effect size for CAI effectiveness, 0.09. This later estimate underscores the importance of using sound evaluation procedures to estimate the effectiveness of microcomputer based ITS.

The impact of ITS is also ambiguous, but evaluations of systems that have a wide curricular scope seem to indicate that ITS may be a powerful instructional technique. The MACH III, Lisp ITS, and Smithtown exemplify well developed systems with wide curricular scope. All three tutors were designed for an actual training requirement and cover a large amount of course material. The MACH III supports 32 hours of Army training, the Lisp ITS covers a one semester course at Carnegie Mellon University, and Smithtown corresponds to approximately one-third of an economics course. All three of these ITSs have been favorably evaluated by the demonstration of statistically significant group differences. Furthermore, the group differences were meaningful in that each of the tutors had a substantial effect on course performance.

### *MACH III*

The MACH III ITS evaluation report includes mean and variance estimates for students taught with the ITS, versus those taught with traditional classroom instruction. The ITS was used for approximately 32 hours of instruction and the evaluation data indicate an effect size of approximately one standard deviation (Kurland, Granville, & MacLaughlin, 1990).

### *Lisp ITS*

The Lisp ITS was evaluated twice (Anderson & Reiser, 1985; Anderson, Boyle & Reiser, 1985). In the first evaluation, groups of 10 students learned Lisp with either a human tutor, the Lisp ITS, or through self instruction. During the first evaluation, the Lisp ITS covered 6 of the 16 chapters covered in the course, or 38 percent of the course. The first evaluation did not demonstrate group differences on course exams, however, time data indicate that the human tutor, ITS, and traditional instruction groups required different amounts of time, 11.4, 15, and 26.5 hours, to cover the same material.

In the second Lisp ITS evaluation, two groups of ten students learned Lisp with either the Lisp ITS or traditional classroom instruction. During this evaluation, the ITS covered 9 of the 16 chapters, or 56 percent of the course. A class exam indicated that the Lisp ITS students "performed 43 percent better than" the traditional classroom instruction group.

Unfortunately variance estimates were not reported for either Lisp ITS evaluation, thus it is not possible to estimate effect size. However, the time estimates and the classroom test scores are consistent with the 1.0 effect size estimated for the MACH III. The fact that differences were only demonstrated on the knowledge test for the second Lisp evaluation is most consistent with the assertion that ITS evaluations are more likely to be successful for better developed ITSs.

### *Smithtown*

Two Smithtown evaluations are described by Raghavan and Katz (1989). The first Smithtown evaluation demonstrated that students who worked with the tutor spent much less time, 5 hours, to learn material that required 12 hours of time for students who did not have access to the tutor. This time savings estimate is consistent with time data from the Lisp ITS evaluations.

A second evaluation study demonstrated a 15 point advantage on a course test for students who had access to Smithtown during instruction as compared to students who did not. These results are consistent with the Lisp ITS data, as well as with the 1.0 standard deviation effect size estimated for the MACH III

### Description of POSIT

POSIT is an ITS for the tutoring of whole-number subtraction. The design of this system (see, Orey & Burton, 1990, for a detailed description of the design) is based somewhat on Anderson's (1987) ACT* theory of learning. Within this theoretical orientation, it is assumed that the learning of a cognitive skill builds from declarative knowledge. In terms of subtraction, the algorithm to be learned is made of a set of declarative information. During the development of this skill, this knowledge becomes after making the Error of Omission (see Table 1 for error types) - Decrement (#1 and #2 are variables consolidated into the specific skill (in this case, proficiency with a subtraction algorithm develops). Declarative knowledge is provided to the learner in a text form when errors occur or when the learner asks for help. For example, this is a typical message that are bound during the execution of the program) "*You have to complete the borrow into the ones place by taking away one of the tens. So, the correct value for this area is #1 You typed #2 Please enter the correct value.*" Although this is a very brief description of POSIT, it should suffice for the purposes of this paper. It is also necessary to provide a short description of the participants and the method used for the collection of data for this paper.

| | |
|---|---|
| **Errors of Omission** | **Errors of Commission** |
| 1. Increment (add 10) | 5. Increment |
| 12. Decrement (subtract 1) | 4. Decrement |
| 13. Both | 11. Both |
| 7. Neither | |
| **Errors of Creation** | **Other Errors** |
| 8. smaller-from-larger | 2. Fact error |
| 10. 0-N=N | 6. Typing error |
| 9. 0-N=0 | 3. Leading 0 |
| 14. N-N=N | |
| 15. N-N=0 with regrouping from | |
| 16. M-S=0, with S>M | |

Table 1. The four error categories and instances of errors in each category (numbers are ranked according to number of occurrences).

**Data Collection**
Evaluation was conducted in the fall of 1990 in a lower middle class suburb of Michigan. The entire third grade was used. This constituted 38 possible participants. One arrived late for the study and was eliminated and a second demonstrated mastery for subtraction prior to the beginning of the study which means that a total of 36 participants were used. The average age was just over 8 years. These participants were split into three groups; human tutor, computer tutor, and regular class. This yielded 12 participants for each group. The study was conducted over a five week period and the participants spent approximately 30 minutes a day working on subtraction.

The University of Georgia, Wayne State University, Apple Computer, Inc. and Oakland Elementary School in Royal Oak, Michigan, collaborated to implement this evaluation. Both universities agreed to co-direct this project, provide technical expertise, and monitor and evaluate the program. Apple provided ten Macintosh SE's for a lab environment as well as the necessary system and utilities software.

The principal at Oakland Elementary agreed to obtain parental permission for students to participate in the POSIT program, meet with participating teachers to facilitate scheduling of students in the study, collect and record research data on a daily basis, and facilitate the exchange of data between the various sites and the University of Georgia. An integral factor was the utilization of parent volunteers to assist in implementation of this exploratory study by monitoring the various student groups involved. Most importantly, provisions were made to assure that all students in any of the three groups (tutor group (human), computer group (POSIT), and regular classroom group (large group instruction)) were able to receive some computer instruction (in other curricular areas for the non-POSIT groups).

***Groups***
There were three groups in the study: ITS, tutor, and class groups. The ITS group used the 10 Macintosh computers each with a 20 megabyte hard drive and at least 2 megabytes of RAM. POSIT was available on each machine and it constituted the instructional treatment for the ITS group. The tutor group consisted of students who were tutored by parental volunteers in the ratio of 3 tutees to 1 tutor. The last group was the regular class instruction. Because the students came from two different classes and because the current content of the math portion of these classes was not subtraction, a teacher's aid was used to perform the instructional treatment for this group. The twelve students who were selected to participate in this group would then meet together as a group with the teacher's aid. All three groups followed a mastery learning approach that required the students to complete a mastery test (on paper generated by POSIT for the tutor and the class groups and via the computer for the ITS group) with 2 or fewer errors out of 18 problems.

***Materials***
The ITS group used POSIT (Orey, & Burton, 1990). The regular class and the human tutor groups used materials that were generated by POSIT. POSIT uses as its curriculum 18 problem levels (ranging from 2-digit problems without regrouping to 4-digit problems with zeros in the tens and the hundreds place of the minuend). Ten tests were generated by POSIT which were made up of one problem from each of the 18 problem levels. These tests were used

to determine mastery. For worksheets, POSIT generated two worksheets for each of the 18 problem levels. These worksheets included 18 problems at the specified level.

### *Procedure*

Prior to the initiation of the study, all students were administered an achievement test that was generated by POSIT (in paper format) using its 18 problem levels. These tests were graded and the students were rank ordered according to these scores. Using a cluster of three, the students were randomly placed into one of the three groups. That is, the top three students on the list were randomly assigned to each of the three experimental groups. In this way, each group had one of the top three students, and the next three, and the next three, and so on.

The pretest was then used by the tutors or teacher to establish instructional progression. POSIT uses its own pretest, so on the first couple of days of the experiment the ITS group was taking another pretest. All three groups used the pretest to determine which problem level (1-18) where each student needed practice. POSIT would continue to present problems at that level until the student was able to perform correctly on three problems in a row. At that point, POSIT would go on to the next level where the student had difficulty. This process continued until all problem levels where the student had difficulty were resolved. At that point, the student was given a test for mastery. If mastery was achieved, the student was locked out of the program. If the student did not achieve mastery, this new test was used to determine which problem levels the student needed to work on.

Similarly, the tutor and class group used the pretest to determine which worksheet the student needed to work on. The student worked on the problem level that was determined from the pretest until the teacher or tutor determined that the student might continue to the next level. It should be noted here that as the students worked on these problems they received feedback from the tutors or teacher. The difference between these groups was that the teacher had twelve students while the tutors only had three. The class size was somewhat smaller than a typical class size, but the size was determined from the fact that the population from which to draw was limited to 36 students. The students in the tutor and class conditions continued through the problem levels until they had completed all problem levels where they had made errors on the pretest. At that point, they were administered a mastery test. If mastered, they were no longer removed from class for the project (to do subtraction). If not mastered, this latest test was used to determine which levels to work on.

### **Results and Discussion**

The results can be described in a variety of forms. One important aspect of the results is the data that was collected during the evaluation which can be used to more fully describe each of the conditions. This data includes video tapes of each experimental condition, a record of the number of problems that students completed in each condition, and averages on the pretest. The second aspect of the results is that of effectiveness evaluation. There were a variety of measures for this aspect. The primary one is time until mastery. However, there was other data which was used to demonstrate effects. That other data includes weekly quizzes that were administered via paper and pencil and a delayed posttest that was on paper and pencil. I will begin with the descriptive data.

### *Descriptive Data*

Table 1 shows the numbers for the total number of problems completed by each group (an ANOVA ($p=0.002$, $F=7.85$) was run on these numbers and the results indicate that the ITS group performed significantly fewer problems than the other two groups using Fisher Post Hoc methods) and the mean and standard deviation on the pretest for each group. The average number of problems completed by each group may be slightly misleading, after all, once a student achieved mastery, they did not do any more problems. However, it also might be due to the fact that POSIT did not waste time on determining if the child needed to progress. In the other conditions, this may not have been the case.

The pretest was measured in the number of errors out of 18 problems. As can be seen, the average child did not know how to perform subtraction very well (on the average, each child got 5 out of 18 problems correct). There were no significant differences between the groups. If anything, the average child in the ITS condition performed more poorly than any other group.

Video tapes were created for each of the three conditions. The categories that have emerged from this data are Teacher Presence (teacher in the general vicinity of child, not present, or actually tutoring the child, see Table 2), Teacher Interactions (motivational comments,

| Group | Average # problems | Mean Pretest | SD Pretest |
|---|---|---|---|
| ITS | 159 | 13.42 | 3.1 |
| Class | 217 | 13.25 | 3.2 |
| Tutor | 265 | 12.92 | 4.0 |

Table 1. Descriptive data for evaluation

| | Present | Total | Tutoring |
|---|---|---|---|
| **Tutors** | | | |
| W | 18:46 | 17:12 | 00:20 |
| X | 19:48 | 25:05 | 01:47 |
| Y | 18:03 | 23:10 | 04:42 |
| Z | 16:00 | 18:53 | 10:36 |
| Tutor/Avg | 18:09 | 19:45 | 05:41 |
| Class | 05:34 | 13:45 | 02:45 |
| POSIT | 11:42 | 23:44 | 05:04 |

Table 2. Time spent on teaching.

immediate feedback, delayed feedback, support, discipline, see Table 3), and Student Interactions (performance comparison, help, interference, see Table 4).

As can be seen in Table 2, the tutor or teacher is near the child for a greater period of time under the tutoring condition (almost all the time - 18:09 out of 19:45) rather than in the class situation (about two fifths of the time) or the ITS condition (about half the time). In addition, as you might expect proportionately more time in the tutoring condition is spent on tutoring than the other conditions.

Table 3 summarizes the interactions that occurred between the instructors (teacher, tutors, or lab assistants in the ITS condition). The most frequent interaction that occurred was in the whole class condition where the teacher was correcting inappropriate behavior. This type of interaction did not occur at all in the ITS group and only minimally in the tutoring condition (and usually this occurred when the tutor was require to leave the table). Another interesting number is the fact that the lab assistants in the ITS condition tended to offer support more frequently than in the other conditions. The amount of feedback, both immediate and delayed, is not surprising in the tutoring condition.

Table 4 summarizes the interactions between students in each of the conditions. The ITS condition was the least social of the three (there was only a rare interaction and it was to relate how well they were progressing). Another interesting attribute of these numbers is that the other two conditions tended to have interactions that would interfere with a child's work (one child would interrupt another child). This may have been due to a novelty effect. POSIT was not designed to motivate the child and subtraction of whole numbers is not the most interesting of topics.

The intent of reporting this data was to more completely describe the three conditions in the evaluation. In the class condition, the interactions between teacher and child tended toward the correction of behavior. Also, the interactions between students tended toward disruption of work. The tutors tended to give more feedback and tended to have more interactions altogether than the other groups. The tutored children tended to interfere with each other, but there was some work related performance comparisons. The ITS group tended to relegate support to the adults in the room and there were no interruptions to performance. These are generalizations based on the data. The data was collected via video tape and may not reflect the actual processes that occurred during the rest of the evaluation, but all three conditions were video taped which might discount the differential effect of video taping. I now turn to the effectiveness data.

***Effectiveness Data***

There were three measures used to determine the effectiveness of POSIT. The first of those measures was the time until mastery measure. Table 2 shows the results for this portion of the evaluation. It should be noted that the evaluation was designed to run until all children in each condition achieved mastery. However, 2 students in the tutor condition failed to achieve mastery and 4 students in the class group failed to achieve mastery. The reason for this is that the study was run using parent volunteers. They volunteered for a specific time period (5 weeks). When that time was completed, they discontinued the evaluation, even though it was not completed. Therefore, it was decided to examine only the first 8 students in each group that achieved mastery (because only 8 had achieved mastery in the class condition). This has at least two effects on the data. One is that it reduces the sample from 36 to 24, a large reduction. Second, the lower ability students may have been most effected by the treatments and they were eliminated from the analysis (who knows how long the remaining four students in the class condition would have taken until they achieved mastery). Given these limits, the following results were obtained.

A 1 by 3 ANOVA was used in the analysis which produced close to significant main effects (p=0.0859, F=2.765). Although these results were not statistically significant at the .05 level, I believe that they were substantively significant to do some post hoc analyses. A post hoc Fisher test indicated that the class significantly differed from the tutor group at the .05 level. Effect sizes were also calculated between the class and the other two conditions (again, this is inappropriate given the probability, but the small sample and the incomplete data indicated the analyses might be used to get som

| | Motivate | Immedi | Delayed | Support | Behavior | Other |
|---|---|---|---|---|---|---|
| Tutor/Avg | 4.5 | 3.75 | 7 | 3.75 | 3 | 7 |
| Class | 1 | 1 | 4 | 5 | 15 | |
| POSIT | 2 | 2 | | 7 | | 1 |

Table 3. Interactions between the instructor and the student.

| | Perform. | Help | Interfere | Other |
|---|---|---|---|---|
| Tutor/Avg | 6.5 | 1 | 9 | 1.5 |
| Class | 4 | 2 | 15 | |
| POSIT | 1 | | | |

Table 4. Interactions between students.

indication of the current standing of POSIT). The effect size between the class group and the ITS group was 0.74. The effect size between the class and the tutor groups was 1.16. There are at least three points to be made about these results.

The first is that the class/tutor effect size should be close to 2.0 (Bloom, 1984). This effect size may have been obtained if the evaluation would have continued until the end. On the delayed posttest, the 2 students not achieving mastery in the tutor condition got 13 and 3 correct out of 18. The 4 students not achieving mastery in the class condition scored 12, 10, 9, and 3 correct (mastery, recall is 16 correct or better). Again, who knows how long it would have taken to get these children to achieve mastery. Another mitigating factor that might explain the lower than 2.0 effect size is the fact that the class size started with 12 (much smaller than a typical class) and continued to diminish to the point where the class condition at the end of the evaluation was only 4 (not too different from the tutoring condition of 1 to 3). Finally, the regular class group used a mastery learning approach to instruction. According to Bloom (1984), a mastery learning approach to instruction has an effect size of 1.0. Therefore, the effect sizes for tutoring and ITS would be 2.16 and 1.74, respectively. These figures are more in line with those suggested by Bloom. Of course there can be other explanations, but these are important ones specific to this case.

The second point to be made about these results is in regard to the 0.74 effect size between the class and the ITS groups. Recall that our estimate for effect size was about 1.0 (Orey, et al., 1991). The obvious explanation for this difference between predicted values and actual values is the fact that all 12 students in the ITS condition achieved mastery but only 8 achieved mastery in the class condition. Given this fact, I still maintain that the effect size estimate for ITS would still be in the general neighborhood of 1.0.

The other measures actually confound these results further. The results of the ANOVA comparing posttest results showed no significant differences ($p=0.8989$, $F=0.107$). The results of the weekly quizzes can be seen in Figure 1. The initial low level of the ITS group might be explained in terms of the fact they were taking the online version of the pretest, not actually receiving instruction. The continuing low level of performance on the written quizzes might also be explained in terms of transfer. After all, the ITS students were learning and being tested on the computer and they would have to transfer this learning to paper and pencil activities. This transfer or lack of it, might be demonstrated via two anecdotal accounts. First, on a posttest that was completed by a student from the ITS group there were square boxes drawn above and below the numbers. This graphical representation actually matches the interface that POSIT uses to examine scratch work that children use when completing subtraction problems. In this case, there was a positive transfer from ITS to written testing conditions. The second case was negative. One of the students in the ITS group received a 0 on the posttest. This student actually performed addition on every problem. If they had been addition problems, this student would have gotten all of them correct. Apparently, this student clearly understood that

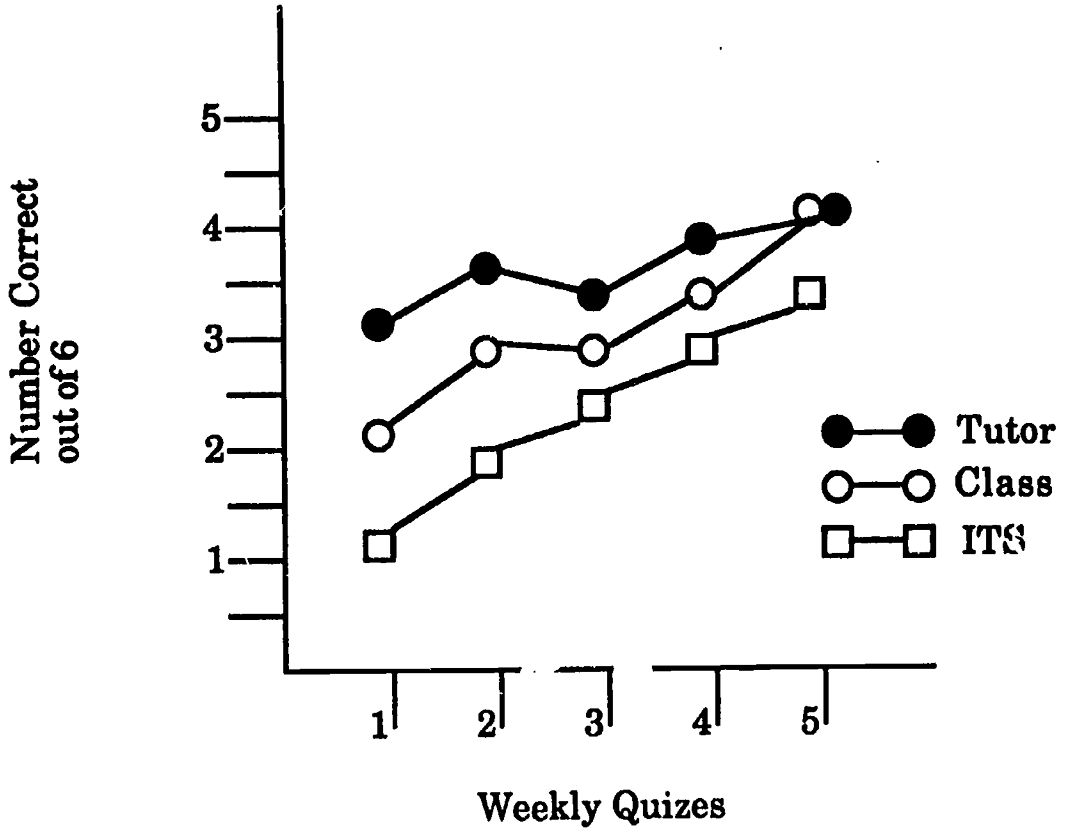


*Figure 1.* Differential results of the weekly quizzes

when using POSIT, the operation was subtraction. This also throws off the results of the posttest analysis since everyone else in the ITS group did quite well on the posttest.

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## KNOWLEDGE ACQUISITION AND KNOWLEDGE REPRESENTATION IN INTELLIGENT COMPUTER-AIDED INSTRUCTION

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**ABSTRACT**
This paper is a review of the literature on both knowledge acquisition and knowledge representation in intelligent computer-aided instruction. The review compares and contrasts systems that have used a variety of representation and acquisition techniques and makes specific recommendations based on the nature of the instructional content.

**INTRODUCTION**
According to the Quality Education Data (1989), 76,395 of the 79,693 public schools in the United States have two or more microcomputers. Further, there are 1,596,715 units - an average of 20.0 units per school or an average of 25.4 students per microcomputer. Computers are in the educational environment. The revolutionary potential of computers for instructional use has been apparent since the computer was first introduced to the classroom. However, large numbers of computers does not guarantee quality of education. We need to identify why, how, when, and for what computers are to be used in schools.

Roecks (1981) identified thirteen educational uses of computers, including instructional aid, instructional management, and computer-aided instruction. Jonassen (1988) divided computer use in the classroom into two categories, teaching about computers and teaching with computers. Teaching *about* computers includes teaching the concept of computer literacy, teaching of programming languages, and teaching of programming principles. In contrast, teaching *with* computers uses computers as an instructional tool or vehicle which may deliver and/or manage instruction. However, much of the present computer instruction is *about* computers rather than *with* them (Becker, 1986). Taylor (1980) classified computer uses as tutor, tool, or tutee. The computer as tutor is where the computer assumes the role of a device for delivering instruction such as tutorials and drills. The computer as a tool described in terms of utility functions such as spread sheets, database programs, and statistical packages. Instructional applications of traditionally tool-oriented applications are growing. In the tutee mode, the user teaches the computer rather than the computer teaches the user. There is considerable evidence that learner control over content is not always advisable. Jonassen (1988) claimed that users do not usually make the best choices, but they can be advised to do so.

Research findings showed that only 10 minutes out of a 50 minute class is used to work with selected individual students (Bunderson & Inouye, 1987), and not more than two minutes is given to each student per day for individual instruction (Deham & Lieberman, 1980). Computer-aided instruction (CAI) offers a way of providing individualized interaction with the learners. Individualizing instruction means the initial state of the learner is an important basis for prescription of content as well as determining instructional strategy. However, most of this traditional CAI courseware was criticized as behavioral oriented, low quality, ad hoc, or frame(page)-oriented CAI (Jonassen, 1988).

Intelligent tutoring systems (ITS) have raised considerable interest among instructional designers and educational psychologists as to their effectiveness for teaching and training. ITS are developed from the perspective of multiple areas such as computer science, artificial intelligence (AI), cognitive psychology, and instructional technology. Not many AI programs developed to date have been used regularly in the classroom. Most AI programs are developed as research tools to analyze some aspect of computer-based learning. They are developed on mainframes or AI workstations making them unavailable to schools that only have microcomputers. Few programs have been completed to make them suitable for development costs. Most AI programs are not based on a pedagogy which is currently used to teach a subject. Furthermore, there has been little formal evaluation research done by AI researchers to measure how their programs affect learning and compare to other instructional alternatives (see, Orey, Legree, Gillis, & Bloom, 1991).

As shown in Figure 1, each major advance in instructional methodology has resulted from the incorporation of a new learning concept using on a new generation of computer hardware. AI researchers are using AI programs to model learning processes and plausible models of learning are evolving that can be tested on the computer. Others are taking what we know about learning and trying to build teaching systems that interact with students in the right ways. Some cognitive scientists are studying people in natural learning situations. Questions that will be discussed here are: what kind of knowledge is involved?; how can the knowledge be acquired?; and how should the knowledge be represented?

| | | | |
|---|---|---|---|
| Theoretical Background | Behavioral Psychology (Skinner) | Constructive Cognitive Psychology (Piaget) | Cognitive Science (Newell & Simon) |
| Hardware Innovation | 3rd generation computer | 4th generation computer | 5th generation computer |
| Instructional Methodology | Programmed Instruction | Discovery Learning (Bruner) Microworlds | ICAI |

FIGURE 1. Evolutions of instructional methodology.

| Performance Level (Merrill's CDT) | Learning Outcomes (Gagne's Taxon.) | Types of Knowledge | Knowledge Representation | |
|---|---|---|---|---|
| Remember | Verbal Information | **Declarative** | Semantic Network | Shallow Level |
| Use | Intellectual Skills | **Procedural** | Rules | |
| Find | Cognitive Strategy | **Contextual** | Frames<br>Scripts | Deep Level |

FIGURE 2. Shallow versus deep processing of knowledge and instruction

Table 1. Manual Methods of Knowledge Elicitation

| Types of Knowledge | KA Techniques |
|---|---|
| Declarative | Almost any technique |
| Procedural | Interviewing, Observation, Protocol analysis, Task analysis, Scenarios or Decision analysis |
| Semantic | Concept sorting, Scenarios, Inferential flow analysis, Protocol analysis, Repertory grid |
| Episodic | Interviewing, Protocol analysis, Task analysis Scenarios, Event recall |

# INTEGRATING COGNITIVE THEORY INTO GAGNE'S INSTRUCTIONAL EVENTS

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**Abstract**
There has been a great deal of discussion about integrating cognitive theory into the development of instruction (Merrill, Li, & Jones, 1990; Orey & Nelson, 1990; Wildman & Burton, 1981; Winn, 1989). Some of the approaches have been quite radical (Merrill, Li, & Jones, 1990; Orey & Nelson, 1990; Winn, 1989). This paper will explore the possibility of integrating cognitive theory into an established development model -- Gagné's nine events of instruction. Rather than discarding the old theory and replacing it with the new -- a Popperian approach to the development of science (Popper, 1968) -- we suggest here that the field of instructional development might take the less radical form of scientific development as described by Lakatos (1978). This second form is more evolutionary than revolutionary. Hence, we will attempt to describe how current cognitive theory might evolve into our instructional development models. Specifically, we will describe how cognitive theory might have an impact on development decisions related to Gagné's events of instruction (Gagné, Briggs, & Wager, 1988). We will use the third edition of Gagné's book to describe the most up-to-date notions of how cognitive theory impacts on this development framework. Each section of the following text examines an event of instruction. Each section includes the name of the event, the learning process associated with that instructional event, and then the textual discussion of the current cognitive theories as they relate to that event. We will tend to use computer-based instruction examples where possible.

1. *Gaining Attention. Reception of patterns of neural impulses* (Gagné, Briggs, & Wager, p. 182). In terms of attention, there is a great deal of cognitive research that can have an impact on this first event of instruction. To gain and maintain attention, one needs to examine a model of attention. Norman (1976) provides the most cohesive model of attention within the information processing system. An important component of Norman's attentional model seems to be *pertinence*. After the initial perception or pattern recognition, there is a component of memory which Norman calls "Memory Recognition" which accesses Long Term Memory (LTM). This component of memory functions on the basis of pertinence for the individual. Pertinence can be something as clear as the learner's name or as ambiguous as a scent in the air which evokes a sense of nostalgia. It should be noted in passing that this memory recognition phase is at a "deeper" level of processing than that suggested by Gagné's definition -- *Reception of patterns of neural impulses*. Gagné's definition describes perception, not attention. The question is, how does this effect the development of instruction?

Earlier attentional models focussed on the physical characteristics of the attentional stimulus (Broadbent, 1958). Such attributes as -- the originating location of the stimulus, the volume of a sound, the brightness or different color of an image -- would cause an individual to attend to that stimulus. The later models attempted to account for such phenomena as the ability to recognize your own name being spoken in a noisy room. Norman (1976) as well as others (Shiffrin, 1976) suggested alternative models that would account for these types of phenomena. The result is that attention is not only influenced by loud or unique stimuli, but also the context of the stimulus. The implication for this event of instruction is that attention may be achieved by using relevant stimuli as well as strange creative sounds or images. Other implications of attentional theory relate to the maintenance of attention.

If attention is affected by pertinence, then instruction that is placed in the context of some over-arching framework might aid attention. Brown, Collins, & Duguid (1989) suggest that instruction should be situated in a context of a real task. Therefore, if you are attempting to teach about earthquakes, a valid approach would place the student in an observation center that simulates an earthquake. This approach is better at maintaining attention than a tutorial that displays screen after screen of information about earthquakes.

2. *Informing the Learner of the Objective. Activating a process of executive control.*

(Gagné, Briggs, & Wager, p. 182). Gagné implies that by providing the learner with the objectives, the learner can invoke a cognition about one's own learning. Metacognition means that one can have conscious control over one's learning or thinking (Brown, 1975). Metacognitive strategies include such things as, selecting memorial strategies for varying types of lists (choosing a mnemonic, for example), visualizing, taking notes, and selecting key words in a text to aid in comprehension. However, there is nothing inherent in a behavioral objective that would cause a learner to invoke any of these strategies. For example, a Gagné behavioral objective with its five components might be -- *[Situation:] Using a paper and pencil, [learned-capability:] state [object:] Gagné's nine events of instruction [action:] by writing them [tools and other constraints] without the use of notes, in order, and without error.* This statement establishes the goal for the student, but there is no indication about what if any executive control/metacognitive strategy should be used. If the intent of stating the objective is to *activate a process of executive control* then it might be more appropriate to inform the learner of the task and how they might accomplish that task. This might change the above objective to -- *[Situation:] Using a paper and pencil, [learned-capability:] state [object:] Gagné's nine events of instruction [action:] by writing them [tools and other constraints] without the use of notes, in order and without error. To do this you might use a [activate a process of executive control:] mnemonic device such as an acronym or a key word method.* Afterall, not all learners are equally adept at selecting memorial strategies, so stating how the learner might learn may be quite appropriate. If the purpose of *informing the learner of the objective* is to *activate a process of executive control*, than that process ought to be stated explicitly as part of the objective. Certainly, learning and memory strategies ought to be included as part of the fourth event of instruction -- *presenting the stimulus material.*

On the other hand, Gagné also includes *expectancies* as a part of his learning model. It might be inferred that stating the objective will cause the learners to establish what behavior is *expected* of them. This definition, however, is more related to behavioral learning theory than that of cognitive theory. In cognitive psychology (we looked in several texts on cognitive psychology and the root word expectancy was not listed in the subject index, Flavell, 1985; Glover, Ronning, & Bruning, 1990; [illegible]chmeister, & Nyberg, 1982), expectan[illegible]s might be interpreted from either a prior knowledge standpoint or schema theory standpoint. In this interpretation, the learner develops expectancies about certain characteristics of their environment. The learner has come to know that when the instructor states the behavioral objectives, the instructor is indicating a behavior that should be performed. This is different from a behavioral interpretation and several of the authors' of the current paper believe that the establishment of an expected behavior is not a bad thing for instruction. The act of goal setting is a powerful motivator in many contexts (Bandura, 1986).

3. *Stimulating Recall of Prerequisite Learnings. Retrieval of prior learning to working memory.* (Gagné, Briggs, & Wager, p. 182). This event is particularly compelling from the cognitive perspective. In order to develop cognitive structures (in other words, learning), one must tie what is being learned to what one already knows. Regardless, if the cognitive view is constructivist (e.g., schema theory) or information processing, the importance of prior knowledge is vital. In the schema view, the stimulation of prior knowledge will aid in the activation of appropriate schemata and perhaps their modification as the result of learning. This activation of a schema aids in both the interpretation of events as well as the storage of those related memories. In the information processing view, where memory is in an associative network, the stimulation of previous knowledge identifies associations that need occur. In other words, tie the new learning to the old. Using notions such as situated cognition (Brown, et. al., 1989), new information can be tied to the old if the new information is provided in the context of an activity that the learner has some knowledge about. That is, if the student that is using an earthquake observation center simulation needs to understand plate tectonics at some point in the simulation, that information is provided when and where it is needed.

This notion is not too dissimilar from the notions of Schank (1991). According to the case-based teaching approach proposed by Schank, instruction and memory is organized around stories. Memory is made up of stories and instruction should proceed by determining what story can be told when. As the learner operates a simulation, information is provided that is relevant to the needs of the learner. This information is provided as video clips or cases in most of the systems that Schank and his colleagues at the Institute for the Learning Sciences have developed.

4. *Presenting the Stimulus Material. Emphasizing features for selective attention.* (Gagné, Briggs, & Wager, p. 182). Perhaps the most powerful application of cognitive theory to the design of instruction would be brought to bear on this event. Here are a few that we thought were important.

Mayer's (1989) research on models would be effective here. According to this research, if you present a conceptual model to novice learners prior to or during the learning of the material, they will be better able to recall conceptual information and transfer this knowledge to novel problems. However, they will be less able to recall verbatim material.

Anderson's (1987) work on the development of declarative and procedural knowledge would also be a powerful construct for this event. Anderson has proposed one of the few cognitive learning theories (as opposed to cognitive theories). His theory states that as people learn skills they progress from declarative verbalizable information, to linking these component declarative pieces together to form procedures, and finally to a state where those procedures are automatized (do not require conscience control).

Resnick's (1982) distinction between syntactic and semantic knowledge would affect the nature of presentation. If the intention of the instruction is to get the learners to perform some behavior, then the instruction can focus on the syntax of the skills. If on the other hand, the behavior to be performed must also be understood, then the instruction should focus on the semantic aspects of the to-be-learned material.

Collins and Loftus' (1975) network model of memory would effect how the material to be learned was organized. If the intent is to get the learner to organize information as an expert does, then a map of concepts might be appropriate. Others suggest that if we organize information in networks, then hypermedia environments are natural (they are organized the same way that we think). This idea is rather controversial since most "experts" differ considerably in the way they organize information.

Metacognition (Brown, 1975) would also play an important role in the design of this event. Afterall, this is where the learning of the material takes place and metalearning is how leaners take control of their own learning. In a computer-based system, one could provide learning strategies for each piece of material to be learned. The designer of the instruction has more time and capability to examine how best to learn the content than the learner does. In addition, strategies for learning can be used as the content of instruction. The nature of the content, the organization of the content, and how the content interacts all may impact on how the information might get transferred from short term memory (STM) to LTM. Other cognitive notions that ought to impact on this event of instruction are such notions as encoding processes, knowledge as chunks of information (Miller, 1956), and parallel distributed processing (McClelland, 1988).

5. *Providing Learner Guidance. Semantic encoding; cues for retrieval.* (Gagné, Briggs, & Wager, p. 182). By semantic encoding, I assume that Gagné means elaboration, since he describes this process as one which allows the learner to move the material to LTM. It is generally accepted that LTM failures are due to the learner's inability to retrieve the necessary information rather than that information being removed from LTM. Therefore, the more cues that elicit recall, the more likely the learner will be able to recall the information or the better learned the material is. Spiro and Jehng (1990) suggest that hypermedia environments can help learners to make multiple connections to a piece of information ("criss-crossing conceptual landscapes"). There are a variety of cognitive constructs that can guide the developer when making design decisions at this phase of development. They all revolve around the notion that the more cues or links that one has for retrieving information, the more likely it is that one can do it. The first construct is that of massed versus distributed practice. A learner who is presented five opportunities to work on a specific task on five separate days (perhaps for a total of 50 minutes) will be able to perform better than a learner who is presented with those same five opportunities consecutively on the same day (also for 50 minutes). The psychological explanation for this phenomena is that the learner who receives the distributed practice may bring fresh ways of encoding the information that the massed practice learner will not do.

A second notion is that of context specific learning. If the material is presented in a variety of contexts, there will be more links to the information. Encoding specificity refers to the phenomena that occurs when the learner is provided with only a narrow context. The learner is unable to draw up that knowledge in other contexts. For example, if you learn material in one classroom, you will be able to recall the information better in that classroom than a different classroom. Ginsberg (1977) describes a child who was able to perform multi-digit subtraction at the end of the school year without error. However, at the beginning of the next school year the child performed all problems incorrectly. Upon closer examination, it was determined that the child learned to start the problem in the column closest to the piano, and the next year the piano was on the opposite side of the room.

Other factors that might be considered when developing instruction from a cognitive approach would be interference theory. Both proactive and retroactive interference can contribute to the failure of learning. In one case the new material interferes with the old and in the other the old interferes with the new. This effect is widely demonstrated with materials that are new to the learner or materials that require rote memorization. A second consideration which is directly related to interference is that of frequency. The more times you practice the better you will be given that you are provided with appropriate feedback (Event 7).

*6. Eliciting Performance. Activating response organization.* (Gagné, Briggs, & Wager, p. 182). It is not altogether clear what is meant by *response organization*. The nine internal processes that are described on page 11 ( Gagné, Briggs, & Wager, 1988) do not include this term. However, he does depict a process of *response generation* that makes use of information from both LTM and STM. The example given is that of getting the learner to actually write the plural form of the word *appendix*. This would require the learner to retrieve from LTM the rule for performing this task and then applying the rule to this particular instance. Once the rule is applied, a response would then be generated and either voice or hand output would be initiated. This appears to be a cognitive process.

More recent work in cognitive psychology tends to focus on process rather than product. The emphasis changes from what the observable behavior is to what that behavior indicates about the process the leaner went through to generate that particular behavior. This leads to the next event.

*7. Providing Feedback about Performance Correctness. Establishing reinforcement.* (Gagné, Briggs, & Wager, p. 182). Although reinforcement is a construct in learning theory, it is not a construct in cognitive learning theory. This does not mean that reinforcement suddenly does not work. It does. However, this paper is addressing cognitive theory applied to instruction and reinforcement is not a part of cognitive theory. Feedback, on the other hand, is an issue within the field and there is extensive research on the what, when and how of providing feedback. Most notably the work being done with intelligent tutoring systems (Wenger, 1987) and the research area of cognitive science (Anderson, 1987) has contributed to this area. Much of this research focuses on how the learner is responding (their solution process) and providing the specific feedback to modify the solution process so that a correct response can be generated. This does not relate to reinforcement -- a theory-ladened term from operant conditioning research.

*8. Assessing the Performance. Activating retrieval; making reinforcement possible.* (Gagné, Briggs, & Wager, p. 182). It is not at all clear what is meant by *activating retrieval* at this point of the instruction. In terms of learning, you are trying to determine if the learner has acquired the information, organized the information appropriately, is able to retrieve the information, and/or is able to use the information in a problem solving setting. If you take Anderson's (1987) view of the acquisition of procedural knowledge, assessment must take place as close to the learning (in time) as possible. In this way, incorrect subprocedures can be corrected before they become too well established (remembered). Some other considerations, besides those implicit in the above discussion, is the the notion of recall versus recognition. Among other things, research has shown that learners who expect to be tested in a recall format (e.g., essay, problem solving test) perform better than those learners who expect a recognition format (multiple choice, matching, fill in the blank) regardless of what format the actual test takes. A second consideration might be between reconstructive and reproductive processes. With reconstructive processes, the gist of the information might be important while with reproductive processes the verbatim recall might be important.

*9. Enhancing Retention and Transfer. Providing cues and strategies for retrieval.*

(Gagné, Briggs, & Wager, p. 182). Gagné, Briggs, and Wager (1988) suggest that retention can be enhanced by providing reviews of the content at spaced intervals (distributed practice). In order to enhance transfer, they suggest that practice be provided in widely varying contexts (again, multiple encoding links lead to more retrieval links). Transfer is widely accepted as a desirable outcome of learning. However, there are levels of transfer. For example, a math teacher might build the rationale that math problem solving transfers to other problem solving. Therefore, if a student is accomplished at doing problem solving in the Algebra context (Two trains are heading towards each other at 60 mph and 40 mph respectively....) then this skill will transfer to other problem solving contexts (resolving marital problems). The research on this far-reaching type of transfer is quite small. However, it is quite possible to help learners to transfer to similar types of problems. For example, you can do a variety of motion problems where the trains or boats or planes are heading towards or away from each other and focus the instruction on those aspects of the problem that are similar (*providing cues*).

Another aspect of transfer is the use of conceptual models (Mayer, 1989). Mayer has demonstrated several times that by using a conceptual model for the presentation of the content to naive learners, the learners are better able to remember (*retention*) and *transfer* to other areas. However, we have already suggested that this is an aspect for consideration in another event -- Presenting the stimulus material.

Not all of the events of instruction match up perfectly to cognitive theory (e.g., Brown, Collins, and Duguid's, 1989) cognitive apprenticeship or microworlds from constructivistic learning theory (Harel, & Papert, 1990), but then again not all swans are white. Instructional development is in a state of change, as it always has been, and as it probably (and hopefully) always will be. The trick is to learn from progress, and to make the change process evolutionary, and not revolutionary. We are advocating the further study of new learning theories and how and if they are complimentary to our existing theories of instructional development. By doing this we can learn how to make instruction more effective and efficient, and keep the field of instructional development in a state of growth.

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# LEARNER CONTROL AND MOTIVATION IN COMPUTER-BASED INSTRUCTION

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**Introduction**
The potential and effects of computer-based instruction (CBI) have been reviewed in many contexts, including elementary and secondary education (cf., Bangert-Drowns, Kulik, & Kulik, 1985; Colbert, 1991; Neimic & Walberg, 1985), special education (cf., Male, 1988; Robinson, 1991; Russell, 1987), higher education (cf., Deaton, 1991; Kulik & Kulik, 1986; Reeves, 1991), business training (Gery, 1987; Hawkridge, Newton, & Hall, 1988; Johnson & Foa, 1990) and military training (cf., Fletcher & Rockaway, 1985; Montague, 1988; Orlansky & String, 1981). Although only the most uninformed or inexperienced individuals would claim today that CBI is a panacea for instructional problems in these or any other education and training contexts, the interest in and support for interactive learning systems continues to grow at a steady pace.

Yet many questions about the effectiveness of CBI remain, some revolving around the interrelated issues of "learner control" and "motivation." Two often touted strengths of CBI are that "CBI allows students to be in control of their own learning" and "CBI motivates learners more than many other instructional methods." Further, it is usually argued that being in control of learning and being more motivated both result in greater achievement. The purposes of this paper are to review the evidence for these claims and to make recommendations for design of CBI to take advantage of what we know about learner control and motivation.

**Definitions and Perspective**
Learner control is defined as the design features of CBI that enable learners to choose freely the path, rate, content, and nature of feedback in instruction. Learner control is contrasted with "program control," i.e., design features that determine the path, rate, content, and feedback in instruction for the learner. Learner control and program control are not polar opposites, but represent a continuum of learner latitude that varies widely both within and between different instances of CBI.

Motivation is defined as the processes involved in arousing, directing, and sustaining learning (or some other behavior). These processes can be internal cognitive or emotional states (e.g., curiosity) or external contingencies (e.g., rewards). Interactive instructional methods such as CBI are often promoted because of their capacity for stimulating internal motivation and/or arranging the contingencies of external motivation.

One possible relationship between learner control, motivation, and learning can be stated simply as follows: "giving a learner control of instruction motivates him or her to learn more" (see Figure 1). Unfortunately, the research support for this relationship is inconsistent. Steinberg (1977, 1989) after completing two extensive reviews of the literature regarding learner control summed up the evidence as follows: The motivation effects of learner control were not accompanied by better performance. Learner control sometimes resulted in greater task engagement and better attitudes, but not necessarily in greater achievement. In some instances learner control led to worse performance than computer control. While many students were motivated by learner control, others were indifferent to it. Aptitude and trait-treatment research yielded no definitive conclusions about learner control (Steinberg, 1989, p. 117).

Another possible relationship between learner control, motivation, and learning can be stated as follows: "a motivated learner is able to take advantage of learner control options in instruction and thus learn more" (see Figure 2).

LEARNER CONTROL ➡ MOTIVATION ➡ LEARNING

Figure 1. Possible effect of learner control and motivation on learning.

MOTIVATION → LEARNER CONTROL → LEARNING

Figure 2. Possible effect of motivation and learner control on learning.

LEARNER CONTROL ↔ MOTIVATION → LEARNING

Figure 3. Possible interrelationship among learner control, motivation, and learning.

Research support for this relationship is not much clearer than that existing for the relationship illustrated in Figure 1. Klein and Keller (1990) concluded that "The relationship among learning outcomes, type of instructional control, performance, and motivation have not been adequately explored" (pp. 145-146). Kinzie (1990) provides perhaps the most ambitious theoretical analysis and literature review concerning this relationship. She concluded that "Research and theory suggest that the elements of learner control, self-regulation, and continuing motivation can be mutually supporting" (p. 18). She described and illustrated a complex interrelationship among the variables of learner control of instruction, self-regulation of learning, and continuing motivation and several related variables such as competence, personal control, relevance, and curiosity. Kinzie's analysis is more descriptive than prescriptive (Clark, 1989; Reigeluth, 1983). Hence, it provides insufficient concrete direction for the design of CBI to take advantage of the "mutually supporting" nature of the learner control and motivation illustrated in Figure 3.

**A Design and Use Dilemma**

The complexity of the possible interrelationships among learner control, motivation, and learning and the lack of strong, consistent evidence for the relationships present designers and users of CBI with a dilemma. Proponents continue to promote CBI as a solution to some of our most persistent problems in education and training primarily on the basis of its presumed power to motivate. For example, Dowdney (1987) claims that schools are beginning to meet the challenge of reducing the dropout rate by using CBI to meet individual needs and motivate students to stay in school. Yet, as described above, the theoretical and research foundations for designing and supporting the learner control and motivation aspects of CBI are not solid.

On the other hand, the assumptions upon which the claims about learner control and motivation are based are intuitively appealing ones. It seems eminently reasonable to believe that students who are allowed to influence and control their learning environments will demonstrate more positive learning processes and outcomes than students who depend on others (e.g., teachers, parents, and/or computers) to control their schooling. There is even research evidence that perceptions of personal control are associated with greater persistence, excitement about learning, and motivation toward the mastery of skills, at least for adult learners (Wlodkowski, 1985).

It also seems reasonable (if not obvious) that making instruction more motivating will have positive effects on learning, and there is even theoretical support for this intuitive assumption (Keller, 1987a, 1987b). And yet, research into the effects of learner control and motivation in CBI has yielded inconsistent support for these assumptions. The remaining sections of this paper represent an attempt to glean guidelines from the existing research to support CBI design and implementation efforts.

**Learner Control Research**

In contrast to program or system control, learner control in CBI exists when the design of the program allows learners to exercise significant choice over aspects of the program such as the feedback, content, sequence, and pace of instruction. However, giving learners *carte blanche* to do whatever they wish in CBI is not universally effective. The effectiveness of learner control appears to be a function of the abilities, inclinations, perceptions, or cognitive styles of students (Salomon & Garner, 1986), as well as the level of difficulty, number of questions, and type of feedback included in the program (Hannafin, 1984).

That learner control is not universally effective should not be surprising. Not all learners will possess the skills and drive to benefit from the options presented in learner controlled CBI. Component Display Theory provides a theoretical perspective for the differential effects of learner control (Merrill, 1983). Component Display Theory promotes learner control as a mechanism for adapting to individual differences, such as personality, characteristics, age, sex, socioeconomic variables, and learning styles.

A clear understanding of the interrelationships among various individual differences and the effectiveness of learner control does not yet exist. For example, consider the personality trait, locus of control, defined as a generalized expectancy of internal or external "attributions" for behavior and outcomes (Stipek & Weisz, 1981). There is evidence that students with an external locus of control will excel in high-structure situations, while internal students will do better in low-structure situations (Joe, 1971; Wesley, Krockover, & Hicks, 1985). However, in separate studies, López and Harper (1989), Klein and Keller (1990), and Santiago (1990) failed to find a strong relationship between locus of control as a personality trait and the effectiveness of learner control as a CBI design feature.

Other studies investigating the relationships between learner control and personality characteristics have yielded weak results. For example, Kern and Matta (1988) found a small, but statistically significant, relationship between personality traits measured by the Myers-Briggs Type Indicator and effectiveness of learner controlled CAI, and concluded that "Designers of CAI packages should consider development of intelligent systems that can alter the style of presentation in relation to the student's personality" (p. 107). Rubincam and Oliver (1985) reported observational evidence for a personality variable ranging from "cautious" to "confident" interacting with the effectiveness of learner control, and concluded that "Computer-based instruction incorporating learner-control options may be made more effective if the personality traits that affect student choices are better understood" (p. 224). Unfortunately, an adequate level of understanding of the relationships between personality traits and learner control needed to guide CBI design has not been reached.

Ross and Morrison (1989) promote learner control as a potentially effective and practical means of adapting validated instructional technologies to individuals. They suggest that "learner control is not a unitary construct, but rather a collection of strategies that function in different ways depending on what is being controlled by whom" (p. 29). Ross and Morrison propose to allow learners to select contextual properties of lessons such as text density and problem theme according to learning styles and preferences. They argue that although learners, especially low achievers, are not the best qualified to make decisions about the instructional aspects of CBI, they can make effective choices among presentational and/or contextual options.

Hannafin's (1984) review of the literature on learner control concluded that learner control was more effective when older, more mature, and/or more capable learners are involved, higher order skills are taught, and content is familiar. Hannafin also advocated the use of adaptive strategies such as coaching and advisement to support learner control, consistency in amount and type of learner control within a CBI program, and provisions for switching unsuccessful learners to program-control strategies.

Some of Hannafin's recommendations approach the specifications for intelligent tutoring systems (Polson & Richardson, 1988). The potential strength of intelligent tutoring systems (ITS) is that knowledge of a student's individual differences in performance, aptitude, personality, and other traits will form the basis for instructional strategies. However, the development of ITS has not progressed as rapidly as promised (Rosenberg, 1987). Hence, this paper deals solely with learner control and motivation factors as applied in traditional CBI programs.

Four categories of learner control strategies are discussed in more detail below, viz., content of instruction, sequence of instruction, instructional pacing, and feedback mechanisms. In addition, the research on learner control with advisement and adaptive control is briefly described. Each of these subsections is accompanied by a "guideline" to recommend how the research might be applied in the design and use of CBI.

**Content of Instruction:**
According to Carrier and Williams (1988), use of learner control strategies for the amount of content presented results in wide variation in the amount of material seen by students, and in general, those students who receive greater amounts of instructional content learn more. While it seems obvious that learners who experience more instructional content will learn more, there is some evidence that learners of differing abilities make poor choices concerning amounts of instructional content, e.g., high ability learners (who need less) may select more instruction and low ability learners (who need more) may select less. One goal of instruction is efficiency, i.e., students should spend only as much time on instructional content as is needed. Ironically, learner control strategies sometimes leads to inefficiency, such as when learners select more elaborative information than is needed (Tennyson, Christensen, & Park, 1984).

***Guideline # 1:***
*In general, it is not advisable to allow learners to control access to "essential content" unless reliable, valid performance measures indicate that they have mastered that content. Content defined as enriching or repetitive should be under learner control.*

**Sequence of Instruction:**
Automatic frame sequencing has been criticized as "brain corroding in its banality" (Brinkworth & Hobbs, 1982). Indeed, the most devastating criticism that can be hurled at a CBI program is that it is an "electronic page-turner." Instructional design theorists maintain that the effectiveness, efficiency, and appeal of instruction will increase when informed/motivated students are given the opportunity to select and sequence instructional strategies (Merrill, 1983).

Rubincam and Oliver (1985) found that students adopted a consistent learner-control strategy (test-first or instruction-first) when given the option. Although no significant difference in overall performance was found between the two strategies, students selecting the instruction-first strategy took longer to complete the course. Gray (1987) found that control of sequencing had a positive effect on comprehension, but not on retention, in sociology CBI. In contrast to most studies reporting attitudinal data (Steinberg, 1977, 1989), Gray found that students given learner control were more negative toward CBI than students under program control. Gay (1986) found a significant interaction between previous knowledge and learner control wherein students with low pretest scores made poor sequencing choices and students with high pretest scores learned equally well from learner control and program control. Gustafson, Reeves, and Laffey (1990) found that learners generally selected a linear strategy to progress through a hypermedia training course averaging more than nine hours of instruction, even though a wide variety of instructional options were available.

***Guideline # 2:***
*Well-designed CBI will include a variety of instructional options including overviews, statements of prerequisites and objectives, pre-tests, tutorials, simulation exercises, and post-tests. Although there is some evidence that learners are not always the best judges of what kinds of and how much instruction they need, a well-structured orientation to instructional options may provide them with a better basis for selection. Contextual and presentational options, if included, should be subject to learner preferences.*

**Instructional Pacing:**
It is generally recognized that students differ in the amount of time required to learn a task (Carroll, 1963), and that giving students control over the pace of instruction helps them to master learning objectives (Bloom, 1976). It also seems that control by the learner of display time is much more desirable than computer control of it (Weller, 1988). Although timed responses of screen changes may be intended to keep students alert and concentrated on their work, some students may be stressed by time limitations and/or will not be alert enough to keep up with the pressure of the time limit. In either case, their frustration is likely to increase and their motivation may deteriorate (Sasscer & Moore, 1987).

Information processing theorists believe that in order to be remembered, information must be encoded and moved from short-term memory to long-term memory. Short-term memory has limited processing capacity, so the student must selectively scan material in order to limit incoming information, and encode it into long-term memory after integrating the information (Wager & Wager, 1985).

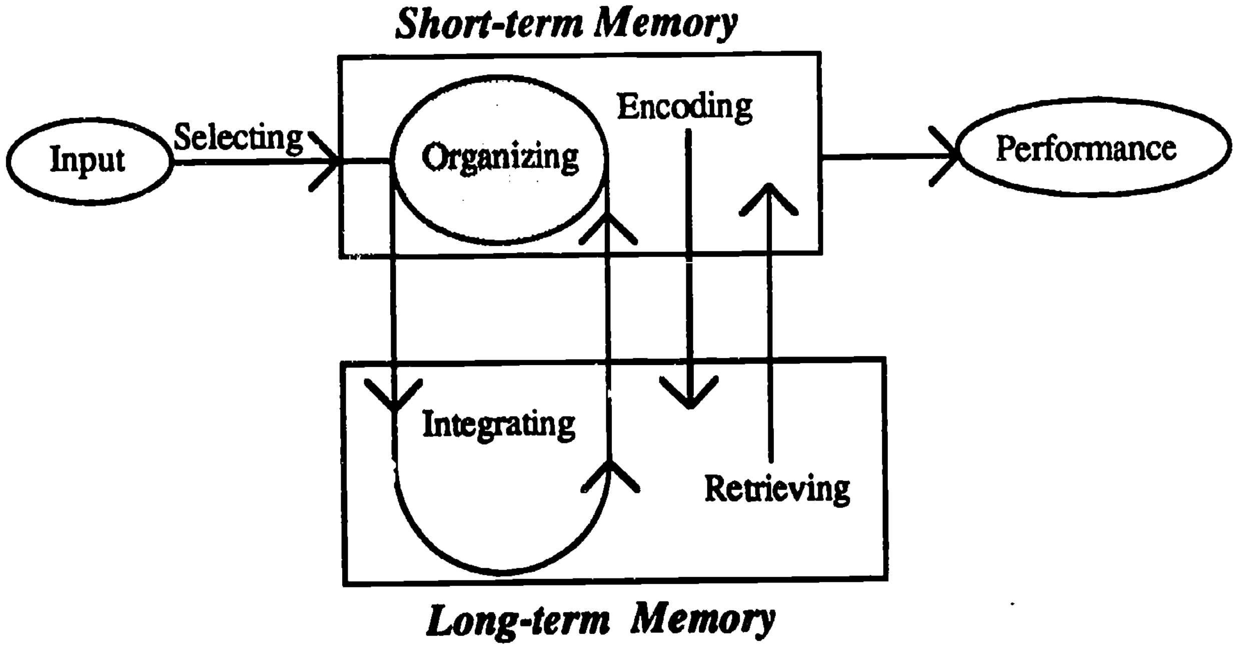


Figure 4. Typical information processing model (Mayer, 1989).

According to Mayer (1989), learning processes refer to the way in which students encode to-be-learned information. Figure 4 shows an information processing model for describing meaningful learning processes. It takes some time to select and organize new information, integrate it with existing knowledge, and encode into long term memory. Learners differ in the amount of time required for this encoding process (Mayer, 1989). Students should be allowed to take whatever time they need to process the information presented during CBI.

***Guideline # 3:***
*Student control of pacing within CBI is strongly advised. (Ironically, this strategy may prove difficult for local implementers as they attempt to manage students completing instructional units at widely varying times.)*

**Feedback Mechanisms:**
Appropriate instructional interventions or feedback must be available at the appropriate time to ensure optimum learning (Skinner, 1974). Response strategies generally employed in CBI include feedback regarding results, branching to alternative instructional sequences, repetition of previous instruction, and remediation of discrete conceptual or procedural errors (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). Appropriate feedback confirms the learner's expectancy, directs attention to relevant factors, and stimulates recall of relevant skills and knowledge (Gagné, 1977). Feedback for motivation is one of the few aspects of teaching recommended by all instructional theories (Heywood, 1986), however research concerning learner control of feedback has yielded mixed results.

Belland, Taylor, Canelos, Dwyer, and Baker (1985) found that the higher performing students were more likely to select elaborative feedback than the lower performing students who needed the elaborative feedback. Sales and Williams (1988) found that learner control of feedback selection resulted overall in students asking for knowledge of correct response or elaborate feedback more frequently than simple knowledge of results. Their findings conflict with other research (Carrier, 1984) that suggests that students will choose to see less material when given an opportunity to decide. Sales and Williams (1988) did not find differential effects for type of feedback on achievement or instructional time. On the other hand, Schloss, Wisniewski, and Cartwright (1988) reported that students who received feedback about their cumulative performance in conjunction with learner control outperformed students under learner control alone.

***Guideline # 4:***
*The type of feedback options (right or wrong, correct response, elaboration) should be based upon instructional requirements. If more elaborative feedback than knowledge of results is appropriate, allowing student control of access to the feedback is generally advised.*

**Learner Control with Advisement:**
The majority of the studies described above used variants of learner control unaided by advisement. There is evidence that learner control supported by some forms of assistance (e.g., guidance on recommended sequences of instruction or advisement as to the current state of achievement) is more effective than unaided learner control (Tennyson, Christensen, & Park, 1984). Steinberg (1989) concluded that "Students do not perform as well under [unaided] learner control as under adaptive computer control" (p. 118).

Adaptive (shared) control strategies allow some learner control during instruction and impose program control only if it is determined that the learner is not achieving the desired outcomes. Sales and Williams (1988) employed adaptive control in their study. After an initial period of learner control, subjects in the adaptive treatment were required to achieve or exceed a predetermined success rate on the practice items, and if performance dropped below the established criterion, the program assumed control of feedback selection.

Research on adaptive/advisement control has not been uniformly positive. Adaptive control strategies require greater instructional time to complete, with no associated gain in achievement in a study conducted by Goetzfried and Hannafin (1985). On the other hand, Tennyson and Buttrey (1980) found that higher performance occurred when students were provided with coaching or advisement as to what instructional resources to select. Ross and Rakow (1981), Carrier, Davidson, Williams, and Kalweit (1986), and Kinzie, Sullivan, and Berdel (1988) also reported positive effects for adaptive control over unaided learner control.

***Guideline # 5:***
*Learner control with advisement is highly recommended over unaided learner control. The nature of the advisement will be dependent upon the sophistication of the performance measures incorporated into the CBI as well as knowledge of learner error patterns.*

**Motivation Research**
Motivation is one of the most extensively researched constructs in psychology and education, and hence a complete review of motivation theory and research in this paper is impossible. Ten clusters of motivation theory and research are reviewed below accompanied by application guidelines for designers and users of CBI.

**Attribution Theory:**
Proponents of attribution theory assume that the search for understanding of the reasons for success or failure is a mainspring of human motivation (Weiner, 1972). Attributional responses involve attributing causes to success or failure outcomes. Locus of control is a major factor related to attribution theory. Students with an internal locus of control think of themselves as being responsible for their behavior whereas students with an external locus of control attribute their behavior to luck or other circumstances beyond their control. Students with an internal locus of control tend to have higher need for achievement and are more persistent in a learning context. Students with an external locus of control are often described as having "learned helplessness" with respect to areas of study.

***Guideline # 6:***
*The success of CBI can be maximized by providing students with instructions and feedback that would encourage them to make internal attributions about their ability and effort related to their success. This argues for some variant of learner control with advisement whereby students are given advice about their instructional progress and needs, but the actual selection of instructional strategies would be left up to them.*

**Self-Esteem Theory:**
The basic tenet of the self-esteem theory of motivation is that a student's behavior is largely a function of his or her self-concept (Shavelson, Hubner, & Stanton, 1976). For example, if a student thinks of him/herself as a "class clown," the student will act like a clown. Self-esteem is a very complex construct, and recent evidence indicates that it may not have as strong a link to performance in all subjects as was once thought. For example, in recent international comparisons of achievement in mathematics and science, Korean students scored the highest and yet rated themselves near the bottom in terms of self-esteem. U.S. students scored the lowest, but rated themselves the highest in terms of self-esteem!

***Guideline # 7:***
*CBI should be designed to enhance the self-esteem of students through positive affirmations. However, repetitive, innocuous affirmations such as "That's great" or "Correct" will be ignored by students after a short time. Contextual, individualized, creative affirmations are recommended.*

**Curiosity Theory:**
Curiosity theory maintains that curiosity, as a state of mind, encourages exploratory behavior and hence learning (Vidler, 1977). Moderately unfamiliar stimuli are said to promote curiosity whereas completely novel stimuli promote fear and completely familiar stimuli promote boredom. Curiosity seems to be closely related to an individual's creativity. Both are very difficult to measure.

***Guideline # 8:***
*The navigation procedures and basic structure of CBI should be consistent, but moderate variations in style of presentation and content will stimulate beneficial curiosity.*

**Western Electric Productivity Studies:**
A series of research studies were conducted at the Hawthorne works of the Western Electric Company near Chicago, Illinois in the late 1920's (Pennock, 1929). These studies found that virtually any change in the working environment (both positive and negative) led to increased productivity. The primary explanation for the results is that productivity increased simply because the workers were made to feel special while they were being studied. This became known as the "Hawthorne Effect."

***Guideline # 9:***
*Whenever a new technology such as CBI is introduced, a certain amount of "Hawthorne Effect" is inevitable. However, if the CBI is well-designed and effectively implemented, the perceived and real value of it will continue long after the novelty has worn off.*

**Theory X and Theory Y:**
Researchers from the Massachusetts Institute of Technology described two theories of management that have major implications for motivation, viz., Theory X and Theory Y (Carlisle & Murphy, 1986):

Theory X maintains that:
1) Most people, by nature, don't like to work.
2) Most people lack ambition and need a club over their heads to make them work.
3) Most people prefer to be told what to do.
4) Most people resist change.
5) Most people are gullible and not overly intelligent.

Theory Y maintains that:
1) People do not dislike work but may actively seek it.
2) People do not need the authoritarian type of leadership but prefer a participative kind of management.
3) People prefer setting their own goals rather than have someone else set them.
4) People do not shirk responsibility but rather seek it.

***Guideline # 10:***
*If the content and context allow, CBI should be designed to enable students to set their own goals and develop at their own rate.*

**Maslow's Hierarchy of Needs:**
Maslow (1954) developed a well-known hierarchy of needs that has five levels: 1) physiological needs, 2) safety and security needs, 3) social needs, 4) esteem and self-respect needs, and 5) self-realization needs. One basic premise of his theory is that as lower order needs are satisfied, other needs become more apparent.

***Guideline # 11:***
*The lower level needs of students must be satisfied if they are expected to be motivated by higher order needs. The environment in which CBI is implemented must be comfortable, non-threatening, and supportive.*

**Expectancy Theory:**
Proponents of expectancy theory believe that motivation is directly correlated with how much we want something and the probability that certain activities and actions will lead to obtaining it (Spence, 1960). A derivation of this theory called "mental imagery" or "visualization" has been used with success in athletics and other fields. Some research supports the notion that the expectancies of trainers can affect the behaviors of learners. If a trainer believes that his or her students are bright, active, and articulate, they may well behave that way. Unfortunately, the reverse may also be true.

***Guideline # 12:***
*Implementers of CBI should have positive expectations with respect to their students. CBI should be designed to encourage students to expect success.*

**Human Resources Development (HRD):**
The HRD perspective maintains that motivation is 100% internal (Laird, 1978). HRD specialists believe that behavior is influenced by motivation and external pressures. They maintain that the only way to get someone to do something (e.g., learn) is to make him or her want to do it. HRD specialists advocate using a positive approach to getting

someone to want to do something. A positive approach can involve anything that leads to an increase in satisfaction. HRD specialists recognize that people may be motivated by fear or danger, but they say such methods should be used only as a last resort.

***Guideline # 13:***
*CBI should be designed to take advantage of whatever is known about the students' internal motives so that their level of satisfaction is enhanced.*

**Malone's Theory of Intrinsically Motivating Computer-Based Instruction:**
Malone (1984) has conducted research aimed at building a theory of intrinsically motivating computer-based instruction. Much of his research has revolved around discovering what makes computer-based games so captivating. According to Malone, for CBI to be intrinsically motivating, it must have characteristics such as 1) challenge, 2) fantasy, and 3) curiosity. To be challenging, CBI should have a clear goal whose outcome is uncertain. There should be variable levels of difficulty and multiple levels of sub-goals. Using fantasy in CBI involves building in game-like structures that promote competition with the machine and/or other students. To stimulate curiosity, Malone advocates the use of graphics, video, animation, and/or music in CBI.

***Guideline # 14:***
*Trainers may want to incorporate some of the features of computer-based games into CBI, but only if the nature of the content and context indicates that it is appropriate.*

**Keller's ARCS Model of Motivation:**
Keller (1987a, 1987b) developed a practical model for incorporating motivational aspects into instruction. Keller defined four major categories of motivation in instruction, Attention, Relevance, Confidence, and Satisfaction. Hence, the model is known as the ARCS model. He also defined twelve design activities to guide the design of instruction in ways that enhance the intrinsic and extrinsic motivation of the learners.

***Guideline # 15:***
*CBI designers should include Keller's design activities into their overall instructional development model to maximize the motivational aspects of their programs.*

**Conclusion**
Despite the lack of a strong theoretical and research basis for the interrelationships between learner control and motivation, we have derived fifteen guidelines for design and implementation of CBI with reference to these two critical factors. A final caveat is warranted in that much of the learner control research cited in this paper is flawed in terms of sample sizes, treatment durations, subject selection, etc. (see Reeves, in press, for a detailed critique). Nonetheless, the theoretical and research basis for the guidelines we have included seems sufficient for their serious consideration by authors and users of CBI.

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# TECHNOLOGY USING TEACHERS: ARE THEY A DIFFERENT TYPE?

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**ABSTRACT**
Is personality type a factor in whether teachers volunteer for technology training? Does it influence their adoption of technology? The Myers Briggs Type Indicator (MBTI) was given to 240 technology training volunteers. After a year long training cycle, they were rated on level of adoption. The technology volunteers differed significantly from the general population at the .01 level on 4 of 5 comparisons of personality type by participants. Statistical significance was attained ($p < .05$) in 13 of 29 comparisons of personality type by subject area. The typical personality type of the technology training volunteers is Introvert iNtuitive Thinking Judging (INTJ). The different personality type does not appear to influence their rated level of technology adoption. The profile for this personality type describes an independent person who actively embraces an innovation because it represents a problem to be solved. They may not be as successful at getting others to adopt the change. Long term change strategies must offer incentives that appeal to other personality types as well.

Some teachers volunteer for technology training because they are interested. Some volunteers are already active users and just want to learn more. Some teachers are volunteered because they seem like the type. Others are volunteered because they are available. Whatever their reason for attending training, many of these teachers will become successful adopters of technology and others will not.

Is personality type one of the factors that influence whether teachers volunteer for technology training? Does it influence how well they adopt technology? Can school districts use personality type as a predictor of successful training participation and innovation adoption?

**Personality Type**
Jung's theory of psychological type describes personality factors as a key to an individual's motivation and academic or job performance (Lawrence, 1984). His theory considers the conscious use of alternate ways to receive and make decisions about information from the environment (McCaulley, 1990).

Myers and Briggs expanded the theory into the Myers Briggs Type Indicator (MBTI) (Myers, 1978) which has been used for over 40 years by counselors, educators and organizations to identify underlying personality strengths and weaknesses. The MBTI items are concerned with four bi-polar preferences on which the user chooses a relative preference.

Extraversion-Introversion attitudes represent ways of relating to the world and people. Extraverts (E) are continuously alert to people and events outside themselves, have a wide variety of interests, and take an active, trial and error approach to life. Introverts (I) direct their energy inward, pursue fewer interests but explore them more deeply, and take a reflective approach to life.

Sensing-iNtuiting perceptions represent ways of taking in information. Being practical and fact oriented, Sensors (S) attend to the literal meanings of concrete experiences and learn best by moving step by step through a new experience. INtuitors (N) perceive through associations and memory, attend to implicit meanings, and show more concern with insights and opportunities in the future than with the reality of the present. They learn in skips and jumps, looking for patterns and using imagination.

Thinking-Feeling judgments represent ways of making decisions. Thinking (T) types make decisions through a logical, impersonal, analytical and organized analysis of causes and effects. The decisions of feeling (F) types consider harmony, the feelings of others, and the relative importance or value of competing alternatives. In our culture, sex differences between thinking and feeling types are pronounced with females favoring feeling and males thinking.

Judging-Perceiving represents lifestyle orientation and is reflected in work habits. Judging (J) people like to move quickly toward decisions and enjoy organizing, planning and structuring. Perceptive (P) people enjoy being curious and open to changes, preferring to keep options open in case something better turns up.

MBTI results provide a profile of an individual's personality type. One dimension of each subscale is identified as dominant and an individual is described as one of 16 types, ie, INFP, ESTJ, ENTJ, etc.

The sixteen types are not evenly distributed in the MBTI data base population (Lawrence, 1984). Extraverts make up 70% while Introverts represent 30%. Sensors are 70% while iNtuitors are 30%. Thinking and Feeling have different distributions for male and female: for Thinking, 60% are male and 40% female; for Feeling, males are 40% and females 60%. Judging is 55% and Perceiving 45%. The predominant pattern in our American culture is ESTJ for men and ESFJ for women.

**Type and Teachers**
Individuals choose careers because their personality characteristics fit the characteristics of the career (Holland, 1973). All 16 types are represented among teachers. Extraverts (E) and Introverts (I) are about equally represented at all levels of teaching. The proportion of iNtuitive (N) types increases as grade level rises with Sensing predominant through high school. Feeling (F) types are in the majority through high school with Thinking (T) types outnumbering Feeling types at the college level. At all levels, Judging (J) types outnumber Perceptive (P) types (Lawrence, 1984, p. 21). The predominant K - 12 teacher type is ESFJ. Cornwell, Hegelson and Wachowiak (1987) reviewed MBTI validity research in educational settings and substantiated the preponderance of the SF types in teaching at elementary and middle school levels.

Kolb's work on the Learning Style Inventory (LSI) (Kolb, 1984) offers evidence on teachers' type by content areas. Kolb cites correspondences between the MBTI's Introversion and the LSI's reflective observation, and between extraversion and active experimentation. He says concrete experience is clearly associated with both the sensing approach to perception and the feeling approach to judging. Abstract conceptualization, on the other hand, is related to the intuition approach to perceiving and the thinking approach to judging (Kolb, 1984, pp. 79, 80).

Elementary and secondary educators cluster in the concrete experience quadrant. However, differences are found in content area subgroups. In a review of 36 academic specialities, the following classifications were made: vocational, special, secondary, and educational administration were in the concrete experience quadrant; math and science teachers were in the reflective observation quadrant; and social science and language teachers were in the active experimentation quadrant. This translates into MBTI terms by identifying more math and science teachers as Introvert and more Social Studies and Language teachers as Extravert. Vocational and special teachers are more Sensing.

**Technology and Type**
Students who are successful at using computers and other types of technology for learning show a different personality pattern from the typical population. Seven studies found significant relationships of personality type with use of various styles of technology based instruction. No studies of technology teachers' types were identified.

Five studies used computer assisted instruction (CAI). Carter (1985) studied 132 Airforce Institute of Technology participants who were more ISTJ with ST most frequent and NF least frequent. ENP types were disproportionately likely to drop out in Hoffman, Waters and Berry's (1981) study of 100 men and 55 women in a military training setting that used CAI. Conversely the ISJ types did not drop out as often. S types tended to complete CAI programs sooner than N types.

Gaston (1973) found that senior dental students at Ohio State who had favorable attitudes toward CAI tended to be S and J. Hopmeier (1981) reviewed other studies and concluded that I types are better suited to CAI than E types. Kern and Matta (1988) studied 90 undergraduate business students who used self paced instruction to learn Lotus 1-2-3. S types were more successful that N types.

Two studies investigated individualized learning with other types of technology. Atman (1989) identified type as an inadvertant contributor to success in distant learning courses. Students with higher goal oriented behavior profiles were ENTJ. Early (1933) found that of 2300 medical students at Ohio State, more N chose individualized over traditional instruction.

Combining these findings, students who had success and/or satisfaction using technology based instruction were more often Introvert Sensing Thinking and Judging (ISTJ). Myers (1978) profiles the ISTJ type as liking things kept factual, clearly stated and not too complex. They are organized, accurate, systematic, hard working and patient with detail and routine.

This study aimed to identify differences in personality type of teachers who volunteered for and participated in technology training and who subsequently were successful in adopting technology. Two hypotheses were tested in this study.

1. Technology training volunteers have the same personality type as the typical teacher.
2. Personality type does not affect adoption of technology.

**METHODOLOGY**

As this study took place, the New Kid Graduates Project was in the final phase of a five year effort to install technology in all schools in the Jefferson County Public School District. All 24 high schools were equipped with thirty-two unit networked Macintosh labs. Additional resources included integrated applications software, HyperCard, a desk top publishing station with digital image scanner, and a multimedia station with interactive videodisc and CD ROM.

A team of 12 teachers in each high school received 60 hours of training. A total of approximately 300 teachers participated during the two, year long phases. Some of the participants volunteered when the opportunity was announced, others were enlisted by their peers, and some were volunteered by their principal or department head. The training was conducted by the school district's team of technology support staff. Integrating technology as a tool in content areas was the primary focus.

The participants were expected to use the technology to teach their students. In this way, they would model for other teachers how to use technology for instruction. They were also expected to share their expertise with non-trained teachers by demonstrating, coaching, and providing inservice sessions.

The MBTI-Form G, Self Scorable version was administered during the early weeks of training. Of the 300 participants, 240 (80%) completed it in usable form.

During the year, the district's technology support staff provided on-site assistance and follow up. At the end of the year, they rated each participant on degree of adoption of technology. Adoption levels were defined as follows: high level - enthusiastically and consistently use all or most of the technology with students assigned to their courses, and are willing to share with other people; medium level - use some technology for personal purposes and some use with students; low level - have not brought students to the lab nor developed an independent personal level of use.

**RESULTS**

The participants were teachers of English, Science, Math, Social Studies and Other (home ec, business, vocational, special ed, art). Thirty percent of the participants teach English. This large number might be expected since the project focused on writing in content areas. Other subjects were less well represented. The Other category made up twenty-eight percent of the participants. The sex distribution of the participants in the study was 69% female and 31% male.

Table 1 shows the distribution of subject area by sex for the 240 subjects. A chi-square test revealed no significant relationship between the variables, $x^2$ (4, $\underline{N}$ = 240) = 8.60, $\underline{p} > .05$. Thus, there was no evidence that the proportion of females to males differed by subject area.

Table 2 shows the proportion of subjects in the various categories of the MBTI. A total of five significance tests were performed on these data. Each time, a chi-square goodness-of-fit test was performed using proportions taken from the general population as expected proportions and using the obtained proportions from the subjects. If proportions of study subjects closely matched that of the general population, then the null hypothesis was retained. Otherwise, the null hypothesis was rejected.

In the general population, .70 of persons are Extraverts and .30 Introverts. For the subjects of this study, .47 were Extraverts and .53 were Introverts, a significant deviation, $x^2$ (1, $\underline{N}$ = 240) = 60.02, $\underline{p} < .01$. Similarly, .48 of the subjects were Sensing and .52 were iNtuiting, a significant departure from the proportions of .70 and .30.

Technology Training Participants by Subject Area and Sex

| | Science | Math | English | Social | Other | Total |
|---|---|---|---|---|---|---|
| Female | 0.10 | 0.08 | 0.20 | 0.06 | 0.22 | 0.69 |
| Male | 0.06 | 0.07 | 0.09 | 0.01 | 0.06 | 0.31 |
| Total | 0.18 | 0.15 | 0.30 | 0.08 | 0.28 | 1.00 |

Table 1

Personality Type by Participants

| MBTI | General population | Number of participants | Proportion of participants | Chi square | p |
|---|---|---|---|---|---|
| Extravert | 0.70 | 113 | 0.47 | 60.02 | 0.00 |
| Introvert | 0.30 | 127 | 0.53 | | |
| Sensing | 0.70 | 114 | 0.48 | 57.86 | 0.00 |
| iNtuiting | 0.30 | 126 | 0.52 | | |
| Female | | | | | |
| Thinking | 0.40 | 97 | 0.59 | 24.27 | 0.00 |
| Feeling | 0.60 | 68 | 0.41 | | |
| Male | | | | | |
| Thinking | 0.60 | 51 | 0.68 | 2.00 | 0.16 |
| Feeling | 0.40 | 24 | 0.32 | | |
| Judging | 0.55 | 159 | 0.68 | 12.27 | 0.00 |
| Perceiving | 0.45 | 81 | 0.32 | | |

Table 2

$x^2$ (1, N = 240) = 57.86) $p < .01$.

In the general population, .40 of females are Thinking and .60 are Feeling. However, .59 of the females in this study were Thinking and .41 were Feeling, $x^2$ (1, N = 165) = 24.27, $p < .01$. In contrast, the males in this study did not significantly deviate from expectations. The proportions of .68 Thinking and .32 Feeling were close to the proportions .60 and .40, $x^2$ (1, N = 75) = 2.00, $p > .05$.

Finally, the data was analyzed on the MBTI categories of Judging and Perceiving. It was found that .68 of the subjects were Judging and .32 were Perceiving, a significant departure from the general population proportions of .55 and .45, $x^2$ (1, N = 240) = 12.27, $p < .01$.

In summary, the data revealed that, compared to the general population, participants in this study were more likely to be Introverted rather than Extraverted, iNtuiting rather than Sensing, and Judging rather than Perceiving. In contrast to the general population, females in the study were more likely to be Thinking than Feeling. However the ratio of Thinking to Feeling males in this study was not different than general data for males.

Personality Type by Subject Area

| | Science | | | Math | | | English | | |
|---|---|---|---|---|---|---|---|---|---|
| MBTI | Prop | x2 | p | Prop | x2 | p | Prop | x2 | p |
| Extravert | 0.50 | 8.38 | 0.00 | 0.50 | 6.86 | 0.01 | 0.49 | 15.68 | 0.00 |
| Introvert | 0.50 | | | 0.50 | | | 0.51 | | |
| Sensing | 0.55 | 5.00 | 0.02 | 0.42 | 13.76 | 0.00 | 0.44 | 22.39 | 0.00 |
| iNtuiting | 0.45 | | | 0.58 | | | 0.56 | | |
| Female Thinking | 0.68 | 8.17 | 0.00 | 0.52 | 1.34 | 0.25 | 0.68 | 16.33 | 0.00 |
| Female Feeling | 0.32 | | | 0.48 | | | 0.32 | | |
| Male Thinking | 0.68 | 0.56 | 0.45 | 0.67 | 0.28 | 0.59 | 0.64 | 0.12 | 0.73 |
| Male Feeling | 0.32 | | | 0.33 | | | 0.36 | | |
| Judging | 0.61 | 0.72 | 0.40 | 0.81 | 9.50 | 0.00 | 0.67 | 3.96 | 0.05 |
| Perceiving | 0.39 | | | | 0.19 | | | 0.33 | |

Table 3

Personality Type by Subject Area

| | Social | | | Other | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| MBTI | Prop | x2 | p | Prop | x2 | p | Prop | x2 | p |
| Extravert | 0.45 | 5.95 | 0.01 | 0.43 | 24.23 | 0.00 | 0.47 | 0.91 | 0.92 |
| Introvert | 0.55 | | | 0.57 | | | 0.53 | | |
| Sensing | 0.55 | 2.14 | 0.14 | 0.53 | 9.42 | 0.00 | 0.49 | 2.62 | 0.62 |
| iNtuiting | 0.45 | | | 0.47 | | | 0.51 | | |
| Female Thinking | 0.56 | 1.76 | 0.18 | 0.49 | 1.81 | 0.18 | 0.59 | 5.10 | 0.28 |
| Female Feeling | 0.44 | | | 0.51 | | | 0.41 | | |
| Male Thinking | 1.00 | | | 0.64 | 0.11 | 0.74 | 0.68 | 2.65 | 0.16 |
| Male Feeling | 0.00 | | | 0.36 | | | 0.32 | | |
| Judging | 0.92 | 0.00 | 1.00 | 0.61 | 2.59 | 0.11 | 0.66 | 4.97 | 0.29 |
| Perceiving | 0.08 | | | 0.39 | | | 0.34 | | |

Table 3 (continued)

The technology volunteers may be seen as sharply different from the general and teacher populations with only the Judging variable in common. They are more like technology using groups described in other studies on Introvert, Thinking and Judging variables.

| | |
|---|---|
| Study population | INTJ |
| General population - women | ESFJ |
| General population - men | ESTJ |
| Teacher population | ESFJ |

As a follow up to the analysis of data in Table 2, further analysis was performed, taking into account subject area. Table 3 shows the proportion of subjects in each MBTI type by subject area of the teacher. Separate chi-square goodness of fit tests were performed for each subject area (Science, Math, etc.) using the general population figures of .70 Extravert and .30 Introverts. For each subject area, the null hypothesis was rejected ($p < .01$). Within each subject area, the proportion of Introverts exceeded expectations.

The data for Sensing and iNtuiting were analyzed in a similar manner. With the exception of Social Studies, a significantly greater number of teachers ($p < .05$) were iNtuiting.

The proportion of Thinking and Feeling females was compared, again using separate chi-square goodness of fit tests for each subject area and the expected female proportions of .40 Thinking and .60 Feeling. The null hypothesis was rejected ($p < .01$) for teachers in the areas of Science and English. In both of those subject areas, there was a greater than expected proportion of Thinking teachers than Feeling. Using the same comparison and the expected male proportions of .60 Thinking and .40 Feeling, the null hypothesis was retained for male teachers in all subject areas. The ratio of Thinking to Feeling male teachers paralleled that expected in the general U.S. male population.

Finally, separate chi-square goodness of fit tests were performed for each subject area using the general population figures of .55 Judging and .45 Perceiving. The null hypothesis was rejected ($p < .05$) in Math and English because the proportion of Judging teachers was higher than expected.

The analyses of MBTI types within each subject area were generally consistent with analysis of the data combined across subject areas that was reported for Table 2. Introverts were more common than expected for all areas except Social Studies. A greater than expected number of female Science and English teachers were in the Thinking rather than Feeling category. As was found with the general male population, most of the male teachers in this study were in the Thinking category: this was true for all subject areas. Finally, a greater than expected proportion of Math teachers and English teachers were in the Judging rather than Perceiving category.

Table 4 shows data on the level of adoption of technology after training. Of the 240 participants, 152 (64%) were rated as "High" or "Medium" in their
level of adoption. This is clear evidence of the efficacy of training. Thirteen percent dropped out before completing the project

In addition, the effects of MBTI category on adoption level were studied. Subjects rated high, medium and low on adoption level were coded 3, 2, and 1 respectively. Then an independent t test was performed with adoption level rating as the dependent variable and MBTI category as the independent variable. Table 5 shows no significant differences. The average adoption level was not significantly different for Extravert compared to Introvert, Sensing to iNtuiting, Thinking to Feeling, or Judging to Perceiving. One interpretation of these

Adoption Level After Training

| Level | N | $p$ |
|---|---|---|
| High | 76 | 0.32 |
| Medium | 76 | 0.32 |
| Low | 57 | 0.24 |
| Drop Out | 31 | 0.13 |
| Total | 240 | |

Table 4

results is that training was uniformly successful across all MBTI types. Type did not appear to influence levels of technology adoption in this study.

Adoption Level by Type

| MBTI | Mean | t | df | p |
|---|---|---|---|---|
| Extravert | 2.14 | 1.00 | 200.00 | 0.32 |
| Introvert | 2.03 | | | |
| Sensing | 2.02 | -1.22 | 207.00 | 0.22 |
| iNtuiting | 2.15 | | | |
| Female Thinking | 2.20 | 0.60 | 142.00 | 0.55 |
| Female Feeling | 2.13 | | | |
| Male Thinking | 1.87 | -0.33 | 62.00 | 0.74 |
| Male Feeling | 1.94 | | | |
| Judging | 2.09 | -0.12 | 207.00 | 0.91 |
| Perceiving | 2.10 | | | |

Table 5

## DISCUSSION

The results of this study indicate that the teachers who volunteered for technology training are a different type. However, there were no significant differences among the variations of personality as to how well they adopt technology. The training provided by the school district coupled with their natural inclinations led approximately two thirds of them to use technology for themselves and/or their students. About one third also shared it with other teachers.

Myers' (1978) profile of the INTJ type paints them as independent innovators in thought and action who are stimulated by problems. They will spend any amount of time and effort to see their inspirations worked out in practice and accepted by the rest of the world. They may, however, fail to actively check the viewpoints and feelings of others, resulting in bitter rejection.

This type of person would actively embrace an innovation but might not be as active or successful in getting others to do so. If long term change is the goal, school districts need to be sure there are incentives that cause other personality types to become involved.

While the findings of this study are revealing, additional questions need to be addressed. Have the teachers continued and increased their use of technology? In what ways are they using it with students? Are they effective in helping other teachers in the school adopt technology? What overall impact has technology use had on the faculty and the climate of the school?

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# COMPUTER-BASED COGNITIVE APPRENTICESHIPS: AN EXAMPLE FROM WEATHER FORECASTING

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The purpose of this paper is (1) to outline strategies for turning computer-based instruction into "cognitive apprenticeships", and (2) to illustrate a cognitive-apprenticeship approach to teaching weather forecasting knowledge and skills through the design of an interactive multimedia computer-based learning (CBL) module. We report preliminary evaluation data on an interactive multimedia CBL module titled *Boundary Detection and Convection Initiation (CI)*. Convection Initiation, a module that includes laserdisc audio and video to simulate a forecaster workstation and provide problem-solving practice to forecasters. The cognitive apprenticeship model provides the conceptual foundation for a continuing series of IVD modules being developed by COMET, a cooperative of federal agencies and universities involved in meteorological training.

**Background**

The Cooperative Program for Operational Meteorology, Education and Training (COMET) is an organization under the University Corporation for Atmospheric Research (UCAR)[1] which has recently embarked on a comprehensive interactive multimedia CBL program for the operational meterological organizations of the United States[2] (Bonner and Spangler, 1991 ).

The focus of this paper is on one of the first two CBL modules contained in a comprehensive *Forecaster's Multimedia Library*. These two modules were recently field tested. In addition to these modules, the next two modules are under development. Heckman (1991) outlines the instructional design stratgies and additonal details on these first two modules.

**The Cognitive Apprenticeship Model**

Advances in cognitive psychology are continuing to influence the design and implementation of teaching technologies. In particular over the last several years, researchers have compared the often remarkable learning accomplishments in natural settings (home, work, and play) with the disappointing learning outcomes accruing from formal school settings (Rogoff & Lave, 1984; Rogoff, 1990). What is needed, according to Resnick (1989), is more "bridging" devices or technologies that bring realistic contexts and problems into the classroom. The Vanderbilt group (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990) have demonstrated the use of videodisc sequences-e.g., Sherlock Holmes or Indiana Jones- to establish meaningful "macrocontexts" from which problems in a variety of subject areas can be explored.

Collins, Brown, and associates (Collins, Brown, & Newman, 1989) have developed a "cognitive apprenticeship" model that seeks to borrow the best features from informal learning settings and incorporate them into more formalized instruction. The model includes four main categories of design considerations: *content*, *methods*, *sequence*, and *sociology*. The elements of the model are discussed below as they relate to the design of *Convection Initiation*, one of the completed modules.

**Content.**

Cognitive apprenticeships teach domain or textbook knowledge, but they also make explicit the strategic knowledge used by experts in solving real problems. A key goal for the COMET module was to provide authentic activities that required the forecaster to use situation-specific skills and knowledge to perform analyes of meteorological data (satellite, Doppler radar, surface observations, and others) and to make short-range (0-1 hour) forecasts. There are no distinct "concept" lessons or "rule" lessons. Instead, a series of "practice cases" are presented with accompanying followup questions that test the learner's prior or gained knowledge. The latter is accessable, through learner control, from topic specific conceptual models and procedural tutorials . Figure 1 shows these learning tools in the upper left corner of the

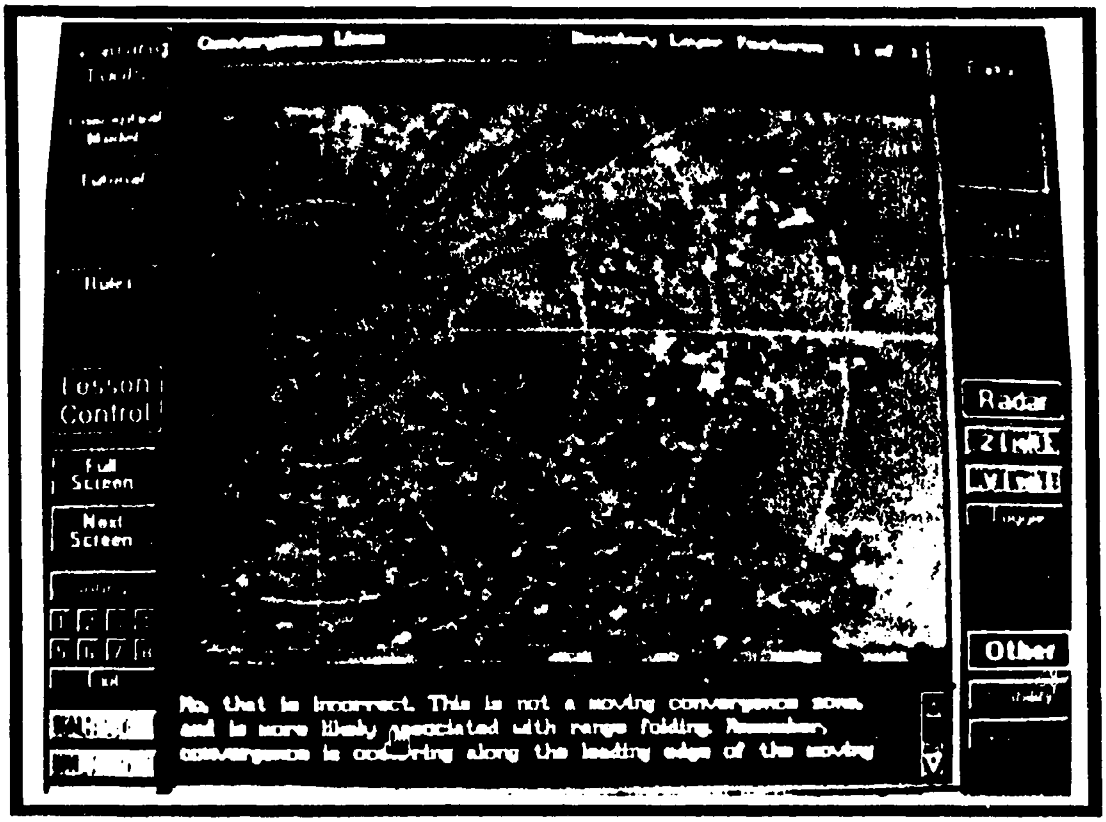


Figure 1: The Workstation Interface for the *Convection Initiation* CBL Module

user interface. In short, the domain and strategic content is made available to the learner in the immediate context of solving specific forecasting problems.

**Methods.**
Collins et al. (1989) have examined several exemplary instructional approaches and extracted a set of common teaching methods:

1. Modelling
2. Coaching
3. Scaffolding and fading
4. Articulation
5. Reflection
6. Exploration

CBL designs are relatively well-suited to the first four methods, and a growing number of toolkit-style programs and hypermedia programs allow for exploration. Reflection-comparing one's own problem-solving processes with others' is possible but somewhat difficult with CBL. A continuing challenge for CBL design is to develop methods of making instruction a natural dialogue rather than a forced-choice, linear path. In many respects, the COMET modules replicate a sophisticated forecasting workstation, where both learner and program may initiate actions toward problem solution, presentation, or feedback; the overall structure, however, is constrained by the lack of natural language processing of the computer.

A key issue faced by the design team was the problem of how to present material to learners when some of them already knew it in one way or another. A partial solution was in the learner control allowed by the hypertext options described above, but we still were concerned that a "rule-example-practice" template would become tedious to many of our learners. This feeling was reinforced when one of us attended a 3-day lecture-oriented course taught by an expert on the subject to members of our target population. Even though the expert was a gifted lecturer, students only came alive during the three scenario-based forecasting exercises. By comparison, the hundreds of satellite pictures, movie loops, and examples, while informative, did not engage or interest the group in the same fashion. We felt a need to present new conceptual and procedural information without appearing to be "lecturing" our audience. One of the most exciting prospects of introducing multimedia into the operational forecaster's training arena is that it will provide an alternate learning experience to all too often traditional techniques described above.

To address this problem, a case-based strategy was developed that embedded tutorial explanations within actual practice cases. New content in the lesson is not assumed to be new to the individual learner; instead, learners are encouraged to approach new problems and use whatever prior knowledge they may have available. *Tutorials, Conceptual models,* or *Expert Answers* are kept short (1-6 minutes) and are always presented in the context of a specific topic or practice case in which the learner is facing. We believe this strategy makes the module seem less "preachy" and condescending to experienced weather forecasters.

These ideas are illustrated in Figure 1. Shown in the "image window" is a Doppler radar reflectivity image, part of the data sets available for this practice case in the topic on detecting convergence boundaries. The learner has the option of answering the question or selecting the *Tutorial* which explains "how to" detect these boundaries using a variety of data. In this case, the learner has incorrectly identified the location of the boundary; the expert has provided a "hint," shown in the dialogue box beneath the image window. If the learner misses after one additional hint, they are forced to select the *Expert answer.* Here, the learner will hear the expert provide the correct answer through a series of images with associated overlays.

**Sequence.**

Collins and Brown note in their review of exemplary teaching models that some approaches allow students to explore the content in a free way, whereas others (particularly in well-defined disciplines such as math) require careful selection and sequencing of practice cases. Thus the sequencing rules may depend on the type of content being taught. Sequencing issues were obviously important at initial stages of the module's planning. Our first inclination was to incorporate a simple-to-complex sequence, moving from an examination of the surface boundary layer, toward understanding and identifying convergence boundaries, and concluding with nowcasting exercises requiring pinpointing storm initiation in time and location. An elaboration-type sequence, with successive lessons building complexity and reinforcing core concepts, seemed a natural sequencing strategy. We were led to re-examine our plans, however, and consider a looser hypertext sequence similiar to the first module, *Workshop on Doppler Radar Interpretation.* [3] Typically in hypertext, learners can browse and proceed through material in an unstructured way. This requires that materials be designed a way that makes them accessible at any point in time within instruction, making it harder to build logically from simple to complex. Hypertext also allows materials to take the form of a database, usable for instructional tutorials and practice, but also allowing easy access for reference or example. Thus we could see competing "desirables" at stake in the sequencing question: more logical and meaningful unfolding of complex content using an elaborative model versus greater flexibility and reference accessibility using a hypertext model.

Based primarily on the nature of the content and the learner population, we have chosen to follow a simple-to-complex elaboration sequence through careful selection of cases; however, within each practice case, a variety of hypertext-like options are available to the learner, allowing access to *Rules, Tutorials, Conceptual models,* and *Expert answers* (discussed below). Learners are encouraged to work through lessons and cases within lessons in their given order, but to access the various *Learning Tools* available in varying order as needed. Such a hybrid modela mix of well-structured problems and hypertext-like exploration is probably appropriate for a large number of instructional situations.

**Sociology**

Often neglected by instructional-design theories, the social setting of instruction and the work environment serve as strong constraints and mediators of instructional effectiveness. Ideally, learners should be initiated into a community and culture of "expert practice." Cooperative and competitive factors need to be harnassed and utilized for good ends. The intrinsic motivation inherent in learning the content should be preserved and not preempted by external structures and constraints. And learning should occur in authentic social contexts where knowledge is drawn on to solve meaningful problems. In the section below, we describe how social elements were built into the *Convection Initiation* module.

**Enhancing Social Design**

The social aspects of the cognitive apprenticeship model seem to pose the greatest challenge for CBL design. CBL is often administered on an individual basis, with a single learner engaged at a computer workstation. Although group work is a desirable option, sometimes it is not possible. The COMET modules are a case in point. Modules are to be completed on the job, but because forecast offices are sometimes staffed with only 2 - 3 forecasters on duty at a time, learners must complete instruction individually while working a shiftduring. The design challenge is: how can we build in needed social reinforcement, convey a sense of community in what is essentially an individualized learning experience and build in dialogue between the learner and experts in the our science community? To address the cognitive apprenticeship's social design, the *Convection Initiation* module incorporated several strategies, including:

1. The module begins with the learner listening in on an informal "roundtable discussion" among the three subject matter experts used in the module. They are discussing how each observation system, satellite data, Doppler radar and others, will singlularly and collectively improve the forecaster's ability to make short-range forecasts (nowcasts). This sequence does three things: 1)it establishes initial dialogue with experts who in the past might have simply been names on a journal article; 2) it provides an overview to the entire module; and 3) it establishes a link with the expert's face and voice and the numerous "audio only" *Expert answer*" sequences provided throughout the module[4].

2. Following each forecasting practice, one of the three experts provides feedback on the case in the form of an *"expert answer."* This is a 30 - 90 second explanation of the case. Meteorological data on-screen are highlighted with cues such as arrows, lines, etc. The personalized feedback from the actual experts should allow some social modeling to occur. The meteorological field is fairly small; moreover, most field forecasters cannot attend the many annual scientific conferences where the "experts" typically present papers. In addition, it is impossible for the experts to provide learning at the sponsor's forecast offices (approximately 600 sites). Getting to know the experts through the CBL modules should help strengthen the sense of community within the field.

3. The module concludes with an intrinsic simulation where the forecaster, teamed with another forecaster, "Ron," solves a series of realistic, time-based forecasting problems. The purpose of the simulation at the beginning and end is to: (1) establish expectancies and activate prior relevant knowledge, (2) provide integration of knowledge and tie-in back to learners' work environments, and (3) to model successful forecasters and motivate learners to emulate the actors' responses to the problem. This third function of the simulations compensates in some measure for the isolation of individualized instruction completed at a computer desktop.

Through these efforts to make the module more personalized, the social elements needed to support good instruction are artificially created. We believe these compensating strategies will help improve the reception of the modules in the field, and improve the attitudes of learner completing the modules on an individual basis.

**Results of Field Testing**

Recently, both CBL modules were field tested at one NWS forecast offices and two AWS offices. Additional testing will occur at another NWS office and a NOC forecast office. Based on preliminary analysis of evaluation data, the following findings have emerged.

1. Students prefer the CBL modules over traditional course-based instructional modes. The dominant reason for this was that computer-based learning provided them "control" over the experience, they could move around the learning material with a high degree of freedom, and it was well suited for shift workers who usually have to learn on an individual basis.

2. Students are divided in their preference between audio-only expert answers and the experts' use of chromaboard. While some students reported benefiting from actually seeing the expert stand up and explain the data, others reported that the audio explanations tended to be more to the point and less distracting. All forecasters, however strongly agreed or agreed that employing well known experts to provide background or experts answers was helpful.

3. Elements of the cognitive apprenticeship were generally well-received by learners. These elements include the case-based orientation of instruction, the options for accessing a Tutorial or Conceptual Model.

Observations obtained by the evaluators suggested that forecasters, after approximately an hour into CI began identifying with the experts, as if the experts were "in the computer" and they had established some level of dialogue with them. The use of "hints" provided in textual form by the experts were favorably received by the learners; the hints frequently steered the forecaster to the correct answer. There was little or no negative feeling by learners who incorrectly answered questions; they actively sougth (this was true even when they correctly answered the question) the correct solution using the *Expert answer* and felt that they had "learned something", despite the incorrect answer.

**Conclusion**

The *Convection Initiation* module is designed according to a cognitive apprenticeship model. The module's goals go beyond content delivery: learners should gain confidence in their problem-solving skill, and should feel part of a community of other expert forecasters. Even though our preliminary results lack a sufficient data population, the results are very encouraging. Additional results will be obtained from the second phase of beta testing; in addition, a summative evaluation phase is planned for each module. Results from these additions should shed more light on the effectiveness of employing a "cognitive appreticeship" model.

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[1] UCAR is a consortium of North American universities that provide higher education and research in atmospheric and ocean sciences.

[2] The primary sponsors of the CBL program is the National Weather Service (NWS), the Air Weather Service (AWS), and the Naval Oceanography Command (NOC). In addition, COMET expects to provide modules to a large number of universities, foreign weather services, industry, and others.

[3] The design team wanted to create a balance between a more structured design and a purly hypertext strategy. The content and learning outcomes of *The Doppler Workshop* dictated a more hypermedia approach. The balance was more closely reached in the CI module.

[4] The *Doppler Workshop* module employs a"chromokey" technique where the learner is provided audio and visual dialogue with the two experts. The design team intentionally employed these two different techniques of expert dialogue so that a comparison could be made. Results will be evaluated later.

Selected Formal Papers From the

# Special Interest Group for Telecommunications (TELESIG)

# A MODEL FOR THE USE OF TELECOMMUNICATIONS TECHNOLOGY AND MULTI-MEDIA SYSTEMS TO CREATE REAL-TIME MULTIPLE-USER COMPUTER-BASED LEARNI NG ENVIRONMENTS

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**ABSTRACT**
Telecommunications technology has long been associated with the delivery of instruction. In recent years, it has become an integral part of many computer-based learning systems. The purpose of this paper is to discuss how telecommunications technology can be used with multimedia systems to enhance single-user computer-based learning and describe a model for real-time multi-user computer-based learning.

**INTRODUCTION**
Historically, telecommunications technology has long had an association with the delivery of instruction to people of all ages. These people were in either a group setting (such as a classroom), or in a remote setting (such as an individual home) and the delivery mode was audio (radio or tape) or audio/video (television); those media continue to be used today.

Initially, the use of radio and television was in a passive mode. The user/student were not actively involved in the learning experience and the instruction, in many cases, was not particularly successful because there was no live student/teacher interaction.

The use of television in the learning environment provided an early form of a multimedia system for learning. It had the capability of providing audio, still-frame and full-motion video with color to either an individual or group of learners. At the same time (and prior to television), motion picture, film strip and slides with audio tape provided similar kinds of multimedia systems for users.

These early forms of multimedia systems had mixed success as instruments of learning. Television was especially threatening to many educators who believed that they would soon be replaced by a television set in the classroom.

These early multimedia systems also suffered from the fact that the user was still passive in the learning experience. While the use of multimedia was effective in some cases, the user was still not actively involved. In the late 1970's, the development of the personal computer (PC) gave promise of helping solve the problem of user involvement. After all, if a computer program could be written to deliver instruction in a manner that could be controlled by the user, then the problem of active involvement could be solved. Initially, the PC had only the capability of presenting text with limited graphics on the screen. Most of the programs designed for computer-based learning were developed by educators who did not understand the power and capability of the PC. The end result was that many programs were somewhat sterile in their impact on the user and were really little more effective than the textbook itself. At this point in its development, it was possible to have animation, but no full-motion video associated with those computer-based learning programs. Also, at this point of development, computer-based learning was primarily designed for use by a single user on a one-to-one basis.

Along the same time, there was renewed interest in a multimedia technology that had its serious beginnings about a decade before (the last 60's and early 70's). The videodisk had the capability of audio, still-frame and full-motion video that could be controlled by the user. The videodisk soon found a number of applications in education and training but was expensive to create and operate, however, many people felt that the technology had great potential.

It was not long (the early 80's) until there was an integration of the PC and videodisk technology so that the PC could control access to the videodisk. Since the user could control the PC and the videodisk gave the PC still frame and full-motion video capabilities, the computer-based videodisk system was seen, by some educators, as the next best mode of instructional delivery to the classroom teacher and, in some cases, surpass some teachers.

The computer-based videodisk technology was (and still is) most appropriate for a single user environment. It can be used in a group setting, but there can only be one computer/videodisk unit. It is not possible to use a computer/videodisk system in a group setting (such as a networked environment) where multiple users can share the same videodisk resource at the same time. The reason is that the videodisk contains an analog signal that does not allow it to be stored in a workstation's digital memory. Hence, only one user can access the videodisk at any time, thereby eliminating any advantage of a networked environment.

Technological advances, both in recent years and in the near future, in both multimedia systems and networking will allow the development of a networked (both local and wide area) environment for multiple users and computer-based learning. In the next several sections, we will examine these advances and then describe a model for a future computer-based learning system.

**ADVANCES IN MULTI-MEDIA SYSTEMS**

Current computer/videodisk technology clearly demonstrates that the PC can utilize and control analog-based multimedia very effectively. Computer-generated graphics and videodisk images can be mixed on the same screen simultaneously through the use of PC-resident graphics overlay hardware and software. This technology has limited quality audio (FM radio) and video (NTSC television). It also has the limitation that videodisks are expensive to produce and cannot be changed in content once the videodisk is mastered. Thus, the computer/videodisk system has limited flexibility. For some applications, the limited quality and flexibility are not problems. We are now in the age of digitized audio and video. This state of affairs has significant implications for multimedia systems that are controlled by PCs.

The successful commercial implementation of digital audio, in the form of the compact audio disk during the early 1980's paved the way for industry interest in both digitized audio and video. While digital audio was first developed and played on laser optical systems, digitized audio stored on a hard disk soon followed. Digital audio products produced much higher quality sound reproduction than ever before at a cost slightly higher than comparable stereo products.

The appearance of video digitizers and scanners made it possible to import still video images into the PC's memory where they could be combined with digital audio, edited and manipulated by the user. The problem was that the digitized informal data, especially the video images, required a great deal of memory for storage and thus significantly limited the number of video images that could be stored. Compression algorithms were developed and these algorithms did help. For example, an image that would normally require 10 kilobytes of storage could be compressed into 1 kilobyte without significant change to the image. The compact disk, read-only memory (CD-ROM) technology demonstrated that efficient retrieval techniques existed. It was now feasible to have a multimedia system that could feature audio, text, and a limited number of still frame video images. All of this media could be stored on a high density disk or a hard disk and could be implemented in a local area network (LAN) environment were it could be shared by multiple users. But, the multimedia system did not have the capability of handling full-motion video.

The statement of the problem and its causes relative to full-motion video is relatively simple, but its solution is at best difficult. The problem involves the following. A video image requires a great deal of memory for storage. Full-motion video requires a playback speed of 30 images per second. Without compression, it is not possible to transfer the images from storage to the screen fast enough to achieve motion because of the large amount of data; the transfer rate is simply not fast enough.

The compact Disk Interactive (CD-I) technology, yet to see the "light of day", has developed a set of compression algorithms to solve the problem, but full-motion video is achievable on only a fraction (about 1/8) of the screen.

The breakthrough to this problem may come from the development work of digital video interactive (DVI) technology by Intel-Princeton. Prototypes demonstrate short segments of full-screen, full-motion video but the technology is not yet commercially available. IBM, in conjunction with Intel-Princeton, is testing the technology and hopes to implement it on PS-2s in two or three years. Other companies are also studying the full-motion video problem but are using other techniques such as fractional geometry.

The DVI technology makes use of dedicated chips that compress the video images for storage. The compressed images are then transferred to a work-station where they are decompressed and played back. The transfer can be from an external disk to the workstation or from a server on a LAN to a workstation.

**ADVANCES IN TELECOMMUNICATIONS**

There have been a number of advances in telecommunications technology, particularly in the increased capability and reliability of transmission media. Voice and data have been successfully transmitted for some time. Video could also be transmitted successfully through the air and over some specialized cables. But, it was not feasible to transmit voice, data and video over the same media simultaneously. The development of coaxial cable and more recently, fiber optic technology, have greatly improved telecommunications capability.

The development of high quality, high-speed local area networks for communication between computers has opened the door to some interesting possibilities when combined with multimedia systems.

The first versions of this combination were seen in video conferencing. Video conferencing allows simultaneous two-way analog video and audio between two or more remote sites just as though the individuals at each site were in the same meeting room or classroom where live interaction could take place. Video conferencing could occur when sites were several miles apart over dedicated communications channels. Video conferencing has proven to be commercially feasible although it is very expensive. Hence, its use has been more prevalent in the private industrial sector than in learning environments. Computers have not typically been a part of a video conferencing system.

The impact of PCs has now been felt in the extension of video conferencing technology. This new technology, known as multimedia teleconferencing, will have a significant impact during the 1990's. This technology makes use of multimedia technologies to provide users with the ability to effectively integrate a wide variety of information contained in multiple formats, and from a wide variety of sources, into a unified system. The drive for the development of teleconferencing is the desire to re-create all forms of all available information that is possible in a face-to-face meeting. For example, a conventional business presentation is likely to encompass more than the participants seeing, hearing and asking questions of the presenter. In real-life, handouts are made available, proposals are changed and passed around, videotapes are viewed, images such as photos and graphics are displayed, and computer-generated data is presented for review and comment. If this type of multimedia interaction is available in a typical in-person meeting, users contemplate why similar capabilities are not also available in existing teleconferencing systems.

In fact they are. A new generation of teleconferencing systems and subsystems are taking advantage of the processing power offered by the PC and the technological advances in imaging systems to offer multimedia capabilities in electronic meetings.

Such systems are having an impact at all levels of teleconferencing, from the traditional conference-room setups to the mobile roll-about units used for quick meetings. In fact, according to some observers, the trend toward multimedia capabilities will help bring about the long-awaited explosion in desktop, PC-based teleconferences, with participants not only seeing and hearing each other, but also passing and interacting with image-, paper- and electronics-based information . (Gold, 1990

**REAL-TIME MODEL FOR COMPUTER-BASED LEARNING**

The scenario described in the previous section can be applied to computer-based learning. The traditional definition of computer-based learning has been that material is presented to a user via a computer, usually a PC, and the user reacts to whatever is presented in some predetermined manner. There is nothing "live" or real-time about the typical computer-based learning environment.

Multi-media teleconferencing could be used to enhance computer-based learning in a real-time environment. First of all, it would allow the presentation to be made in real-time to a group of users not necessarily in the same physical location. Each user would have a PC networked by a LAN (or a wide area network) to the instructor. A class could be conducted with the instructor having two-way audio and video communication with each user and each user could have the same capability to communicate with every other user PC in the group. Discussions and problem solving activities would be live (real-time). Ideas and proposals could be shared with all group members via the PC. Instructor notes could be passed to the users via the PCs and multimedia presentations could be made via the PC. In-class examinations could be taken by each student and submitted to the instructor via a digitizing tablet or scanner.

**CONCLUSION**

The current model of computer-based learning is designed for a single user in a non-real-time environment. This environment will be enhanced with advances in multimedia systems such as DVI. These advances in multimedia technology and advances in telecommunications technology will allow real-time computer-based learning to take place in a group environment.

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# PREPNET: CONNECTING PENNSYLVANIA AND BEYOND

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**Abstract**
PREPnet, the Pennsylvania Research and Economic Network, is one of over 2,300 regional TCP/IP-based (Transmission Control Protocol/Internet Protocol) networks which constitute the Internet. PREPnet's stated purposes include: providing electronic communications, including significant amounts of data and graphic images, between academic institutions and research colleagues throughout the Commonwealth of Pennsylvania; providing interconnections to other networks for worldwide communications; and, contributing to the economic development of the Commonwealth. This overview of PREPnet provides a description as to how the network is accomplishing these objectives.

**The History of PREPnet**
PREPnet, the Pennsylvania Research and Economic Network, was formed in 1987 by a consortium of seven public and private educational institutions including Carnegie Mellon University, Drexel University, Lehigh University, Pennsylvania State University, Temple University, University of Pennsylvania, and University of Pittsburgh. In addition to that provided by the educational institutions, significant funding for PREPnet was (and still is) provided by Bell of Pennsylvania and also by the Commonwealth of Pennsylvania.

Since its founding, PREPnet membership has grown from the original seven educational institutions to over twenty-five educational institutions and a similar number of industrial firms. Current negotiations point toward an even more rapid increase in membership in the future.

**The PREPnet Structure**
**Support Personnel**
The entity known as PREPnet is primarily user supported. Day to day operations, as well as the marketing of PREPnet, are handled via a small staff at the PREPnet NIC or Network Information Center. PREPnet policies are set by the PREPnet Steering Committee, which consists of policy representatives from the charter members, and, to a lesser extent, by policy representatives from the other members of PREPnet. As PREPnet expands, discussions are underway within the Steering Committee as to whether, and how, the Steering Committee should be expanded.

In addition to the policy representative, as well as a designated alternate policy representative, each PREPnet member also has additional support representatives including an operational representative, an engineering representative, an information representative, and a user services representative. In some member institutions a single individual may fill more than one of these roles. For instance, the operational and engineering representative positions are often filled by a single individual as are the information and user services representative positions. It is the role of the operational representative to maintain the institution's connection to PREPnet and to keep PREPnet operational by aiding in fault isolation and diagnosis. The engineering representative provides advice to policy representatives on issues relating to network architecture and design. It is the role of the information representative to provide information on PREPnet and PREPnet resources to end-users at each institution. Finally, it is the role of the user services representative to assist end-users in accessing PREPnet and the resources available on it.

**Network Layout**
PREPnet is a high-speed (T1 - 1.5 million bits per second) TCP/IP-based (Transmission Control Protocol/Internet Protocol) network with major hubs in Allentown, Philadelphia, Pittsburgh, Harrisburg, and State College. A Scranton hub is connected to the Philadelphia hub via a 56K line. Future expansion calls for addition of a Meadville (northwest Pennsylvania) hub in order to remove some of the load from the almost full router at the Pittsburgh hub; thus, allowing future connections to the Pittsburgh hub.

PREPnet is connected to the Pittsburgh Supercomputing Center at the Pittsburgh hub. The Pittsburgh Supercomputing Center is also connected to NSFNET (National Science Foundation Network). Therefore, it is through this gateway that PREPnet connects to NSFNET and the rest of the Internet.

**PREPnet Pricing**

Gary Augustson, Penn State's policy representative to PREPnet, is quoted as saying "the goal of PREPnet is to make connectivity affordable for all of our partners in Pennsylvania" (Bermar, 1990, p. 98). To this end, a rather far-reaching pricing structure has been put in place. While a large university or non-profit organization pays a membership fee of a few thousand dollars a year, a small university or non-profit organization only pays about one-fifth of that amount. Since the Commonwealth of Pennsylvania has made major contributions to PREPnet, state-affiliated universities are charged an annual membership fee of only slightly more than a small university. While large commercial firms pay a membership fee of about three times that of a large university, to facilitate economic development small firms only pay an annual membership fee similar to that of a small university. [Note: A list of the current PREPnet pricing structure is available via anonymous FTP from the PREPnet Network Information Center archives at FTP.PITT.EDU .]

In addition to the annual membership fee structure, PREPnet members also may choose different classes of service in order to keep costs down and more closely match the service received to their communication needs. Options range from high-speed T1, 56K, or 9.6K router-based connections via dedicated lines, to slower terminal server-based dial-up connections.

Financial constraints are often found at the forefront of PREPnet discussions. PREPnet is still working to acquire the critical membership mass required to make the network self-sufficient. At the same time, PREPnet growth must be controlled to maintain level loads on the network and at the network hubs. The addition of a new hub is a major expense which needs to be cost justified by the number of memberships which will be using that hub. To maintain controlled growth, and to supply the finances needed for this growth, the PREPnet pricing structure is under constant review.

**PREPnet Growth Potential**

**Acceptable Use Policy**

One of the problems in marketing the network involves defining what are acceptable uses of the network. Having a very restrictive acceptable use policy would have the adverse reaction of limiting the number of organizations wishing to become members. While a very liberal acceptable use policy might be sufficient internal to PREPnet, PREPnet does connect to NSFNET and the rest of the Internet. Having an acceptable use policy which differs from the other networks to which PREPnet connects would result in information flowing through PREPnet which would not be allowed into these other networks. It would be difficult, if not impossible, to prevent this information from leaving PREPnet to these other networks. To eliminate acceptable use problems with external networks, the "PREPnet Acceptable Use Policy and Agreement" requires that all traffic exiting PREPnet adhere to the "NSFNET Acceptable Use Policy." Unfortunately, even the NSFNET policy is an interim policy.

**Academic Expansion**

Discussions are underway to expand PREPnet to all academic levels. Recent contracts with the Pennsylvania Department of Education call for the investigation of the feasibility of providing state resources through PREPnet to state school districts and Intermediate Units. These contracts also include implementing access to PREPnet for the Department of Education and making the catalog of the State Library available to PREPnet users. Discussions within the PREPnet Steering Committee have focused on making K-12 connectivity a part of PREPnet's mission. However, concerns have also been expressed that PREPnet currently cannot handle a flood of school districts wishing to be connected.

At the higher education level, final discussions are currently taking place to connect to PREPnet the rest of the fourteen institutions which make up the State System of Higher Education (SSHE). Discussions about adding an SSHE representative to the Steering Committee have focused on the possibility that SSHE schools may have closer ties to school districts and could work more closely with selected districts to connect the districts to PREPnet.

Negotiations are also underway with a number of different library organizations in order to make the resources of these organizations available on PREPnet. Although these organizations already have their own networks in place, these networks are somewhat less sophisticated than PREPnet.

**Commercial Expansion**

All traffic exiting PREPnet is governed by the

"NSFNET Acceptable Use Policy." The stated purpose of NSFNET is to provide support for research and education in and among academic institutions. Any activity in direct support of this purpose is considered to be consistent with the purposes of NSFNET; hence, acceptable use of NSFNET. The main restriction to NSFNET use is that commercial use of the network is prohibited. Further, as a member of FARNet, the Federation of American Research Networks, PREPnet also endorses the FARNet guidelines. The FARNet guidelines state that traffic between mid-level networks should be restricted to research or academic purposes, or to direct administrative support of these endeavors.

Adhering to these policies presents PREPnet with a rather stringent set of guidelines regarding commercial use of the network. Commercial firms which conduct research in conjunction with academic institutions, qualify under these guidelines and may become affiliated with PREPnet. On the other hand, commercial firms which simply wish to electronically communicate with these research conducting firms, without working in conjunction with an academic institution, do not meet these guidelines and hence, traffic from these firms may not exit PREPnet.

Problems arise when commercial firms not only conduct research with academic institutions, but also market products or services to these institutions. While providing support of their products to the institutions through PREPnet and NSFNET is acceptable, marketing new products is not generally acceptable on PREPnet, and not at all acceptable on NSFNET. Although PREPnet encourages commercial affiliation, acceptable use guidelines must be observed. In order to foster economic development within the State of Pennsylvania, the "PREPnet Acceptable Use Policy and Agreement" includes as acceptable the use of PREPnet "for purposes of technology transfer or the economic development of Pennsylvania" as long as this traffic remains within the confines of PREPnet. Firms which are accepted as PREPnet affiliates must sign the "PREPnet Acceptable Use Policy and Agreement" which also stipulates agreement to the "NSFNET Acceptable Use Policy."

**PREPnet Resources**

As PREPnet is part of the Internet, all Internet resources are available through PREPnet. In addition to Internet resources external to PREPnet, numerous resources are available directly on PREPnet. The first of these PREPnet resources is the PREPnet NIC or Network Information Center. Via anonymous FTP (File Transfer Protocol) to the PREPnet node FTP.PITT.EDU, users gain access to a vast amount of information related not only to PREPnet, but also to the entire Internet. Available information includes acceptable use policies, lists of PREPnet and Internet resources, and even "FYI" documents from the National Science Foundation on topics ranging from getting started with the Internet to technical specifications on using TCP/IP.

Resources available specifically on PREPnet fall into three general areas: on-line databases, downloadable files, and library catalogs. On-line databases include: PENpages (PSUPEN.PSU.EDU), a database of agricultural information made available through the Cooperative Extension of Penn State; EBB (PSUVM.PSU.EDU), a database of information relating to Penn State; EDIN (available through EBB), a database of economic statistical data; LUNA (NS.CC.LEHIGH.EDU), an information system pertaining to Lehigh; and MEDINFO (MED.UPENN.EDU), a medical bulletin board available from the University of Pennsylvania. Downloadable files (available via anonymous FTP) include: The NIH (National Institute of Health) Guide (FTP.PITT.EDU), containing information on scientific initiatives and administration regarding extramural programs; and NIAC, the NASA Industrial Applications Center (FTP.PITT.EDU), containing information pertaining to research centers and laboratories under the direction of the U.S. government. Library catalogs include: LIAS (LIAS.PSU.EDU), Penn State; LIS (CMULIBRARY.ANDREW.CMU.EDU), Carnegie Mellon; ASA (ASA.LIB.LEHIGH.EDU), Lehigh; PennLIN (PENNLIB.UPENN.EDU), University of Pennsylvania; and, PITTCAT (GATE.NIC.PITT.EDU), University of Pittsburgh.

Internet resources are also available to PREPnet users. One of the more popular of these resources, Usenet news (which is available on the Internet as well as through other sources), is "a giant distributed bulletin board system" (Coursey, 1991, p. 48). Through gateways to CREN (Corporation for Research and Educational Networking), LISTSERV's are also available. LISTSERV's are basically discussion groups on specific topics. Both of these resources are primarily means through which collaboration between colleagues may take place. While communications between single users is an effective research tool, the number of people reached through Usenet or a LISTSERV is on a much greater scale. Therefore, sending out a question on either of these systems can result in a much more rapid solution to a problem.

**Moving toward the NREN**

The "High Performance Computing Act of 1991," which is currently before Congress (S. 272), calls for the establishment of a multi-gigabit National Research and Education Network (or NREN) by 1996. Through PREPnet, Pennsylvania will be in a position to take advantage of the NREN once it becomes reality.

**Current Nationwide Networks**

A number of government agencies, including the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF), are already running independent, but interconnected, nationwide networks. Some of these networks relate to national security and have restricted access. However, the largest and best known of these networks, NSFNET, run by the National Science Foundation, is relatively free of these restrictions.

NSFNET is basically a nationwide backbone network which connects other networks. Through NSFNET, anyone connected to PREPnet can communicate with anyone else connected to any other regional network which is connected to NSFNET. NSFNET even has over 700 connections to international regional networks. The over 2,300 worldwide interconnected regional networks are collectively referred to as the Internet.

**The National Research and Education Network**

The National Research and Education Network can probably best be thought of as NSFNET on a much larger scale. While NSFNET has just been upgraded to a T3 network with a data transmission rate of 45 megabits (45 million bits per second), the NREN is envisioned as having a transmission rate of at least 1 gigabit (1 billion bits per second). There is even some disagreement as to what is meant by the statement that the NREN will be a gigabit network. NSFNET is currently running at 45 megabits meaning that a total of 45 million bits of information can flow from one network node to the next in any given second, regardless of the number of individual users of the network sending information. When discussing the NREN, some people envision the transmission rate as 1 gigabit per user, and not just 1 gigabit for the entire network. The term terabit (1 trillion bits of information per second) is even beginning to be used to describe transmission rates.

The NREN is envisioned as a prototype network. It is expected that private enterprise will create similar networks to provide similar capabilities to the commercial sector, and even the private sector. Just as most homes currently have phone and cable television connections, by the turn of the century network connections to the home may be a reality. Gateways will be established to allow information to flow between the NREN and these private networks. A number of large corporations have already invested major amounts to make this vision a reality. With the unique blend of educational, governmental, and commercial entities currently connected to PREPnet, networking in Pennsylvania is in a unique position to evolve as a part of this nationwide information infrastructure.

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