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ABSTRACT

The 49 short (one- or two-page) conference papers presented here document concern for the use of hypermedia and multimedia technology in education. Discussion includes the use of multimedia technology in various subject areas, programming languages, electronic books, intelligent tutoring systems, distance education, knowledge representation, instructional strategies and learner modelling, cooperative learning environments, software development, information retrieval styles, computer games, professional development, computer simulations, technology uses for the disabled, advantages and disadvantages of hypertext, online dictionaries, guidelines for multimedia design, cost effectiveness, and virtual environments. (AEF)

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SHORT PAPERS

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TO THE EDUCATIONAL RESOURCES
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Use of Multimedia Development Software for Engineering Courseware

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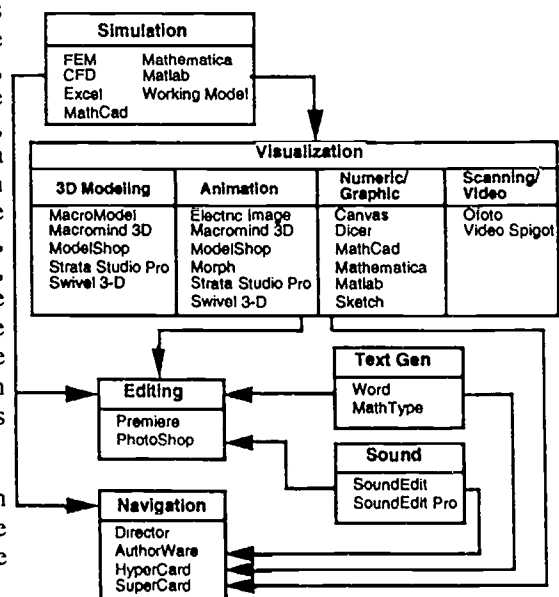
Over the last several years, integration of multiple media sources into a single information system has been rapidly developing. With the recent introduction of many high level authoring, animation, modeling, and rendering programs for personal computers, significant multimedia courseware programs can now be developed by professors and students. Even with these new tools, a considerable amount of time is required to produce an interactive multimedia program for engineering education. This paper examines various multimedia development tools and how they can be used for engineering education courseware.

With support provided by the NSF SUCCEED Coalition, we have initiated a research and development effort to produce engineering courseware using various multimedia technologies. The primary goal of the courseware is to illustrate a number of basic but highly abstract concepts in introductory engineering mechanics courses using integrated video, speech, and three-dimensional graphics in self-contained software modules. These modules supplement lectures and textbooks, and illustrate topics not readily accommodated in the printed format of a book. For example, data visualization can be an important factor in multimedia courseware to enhance concepts describable only in words or symbols in a textbook or lecture. The paper discusses our experience with currently available authoring, modeling, rendering, animation and data visualization software.

The engineering concepts best suited as a topic for an engineering courseware module are those which are highly abstract and difficult to visualize, such as a 3D stress tensor, or are dynamic, such as complex structural dynamic response. Concepts which are static (a two dimensional bending moment diagram) can still be presented but often are not as stimulating. On the other hand while a simple 2-D bending moment diagram can very easily be shown in a textbook, multimedia methods can link it to a video of a practical situation or illustrate how changes in loading affect the diagram. The presentation of highly abstract concepts which may have no physical form can be facilitated and enhanced using multimedia. Consider, for example, using multimedia to illustrate the behavior of a 2nd order tensor as it is used to represent stress or strain. In this case the multimedia techniques used may be closely linked to scientific visualization methods.

The development process for a courseware module is highly nonlinear (see figure), and although numerous multimedia software programs are needed, they can be separated into categories based on functions performed, e.g., simulation, modeling, rendering and authoring. Once an engineering topic has been chosen for implementation, the developer will in many cases, need to first simulate a problem or situation that is the engineering focus, then transform output from the simulation into an appropriate visual form, define animation to describe the system, render the animation, generate audio and text components, define the navigation topology and finally integrate everything using an authoring package. Depending on the nature of the topic, not all of the processes listed above are required for every module. Frequently a single program has the capability to perform many of the tasks simultaneously.

Our presentation describes experience with development of more than 12 modules. Several of these modules are demonstrated to illustrate some of the development issues.



Development of a Multimedia Interface Compatible with Changing South African Student Demographics

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Inequalities inherent in the South African secondary education systems, directly attributed to apartheid (segregated schooling for white, black and indian South Africans), have rendered meaningless traditional University admission requirements. As a result, many tertiary education institutions have adopted progressive affirmative action policies to increase the accessibility of higher education to previously disenfranchised communities. The success of such policies requires the development of innovative and dynamic teaching methods that would cater for the academic diversity of both present and future student populations. Such mechanisms must allow for self pacing, while not marginalising into remedial programmes those students with the potential to succeed. Such was the promise of traditional computer based training (CBT). To date, the impact of CBT modules in South African tertiary education has been minimal. This may be due to the lack of vividness or fidelity of the presentations and may be overcome by a multimedia approach. Hence, the aims of this research were to: 1. Involve the target group (first-year science students) in the development of multimedia programmes; 2. Investigate possible cultural biases within multimedia presentations; 3. Attempt to identify the visual literacy and computer skills of these students; and 4. Discern the most useful and easy-to-understand icons required for clear communication with the target group. Questionnaires were used to determine the ability of biology students, from both historically 'black' and 'white' Universities, to identify and design icons (paper-based, 349 respondents). In addition, colour and voice preferences of these students were identified (computer-based, 65 respondents).

Indian students exhibited a greater ability to interpret 16 icons than did white or black students. Similarly, they outperformed the other two groups at pictorial representation of command or options. This capacity of indian students appeared to be correlated to a number of factors including greater access to and training in computers, more frequent viewing of television and movies and only sporadic reading of books, when compared to the other two groups. Furthermore, all students had a greater capacity to identify icons than to devise them. Some black student outperformed, or were equally competent to, white students in this exercise, although the percentage of non-response by black students was high. There appeared to be little intuitive understanding of iconic information among the groups tested, in that students preferred icons containing words and, therefore, reinforcing and enhancing meaning. Computer literacy was not developed highly. We identified icons that appeared to be understood by most students, which included: Next Page, Previous Page, Video and/or Movie, Start, Stop and Fast Forward. In addition, we obtained a number of icons better suited to the representation of Picture and Listen. Icons for Help, Dictionary and Index will have to be taught, while it will be necessary to develop new representations for Go to, Go Home, Exit, Menu and Memo. A sub-sample of students was used to identify voice and colour preferences. Most student selected a clear female voice without a discernible accent. Blue was the most popular colour, followed by red.

We believe that any user interface developed for use by our students will require not only pictorial representation of commands or options, but should contain text that clearly identifies the choices available. Also, it will be necessary to teach students how to use such software, especially as the syntax of operating the mouse-button is closely allied to the use of an iconic interface.

Harmony: A Tool for Navigating Through Deep Hyperspace

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Harmony is a new tool conceived for navigation through *deep hyperspace*, i.e. large-scale (many tens of thousands of nodes), dynamic hyperstructures. One of the main problems of such hyperstructures is disorientation – the “lost in hyperspace” syndrome. Harmony draws on the real-world experience of “finding your way in an unfamiliar part of the world” to suggest promising approaches to the task of navigating through deep hyperspace.

The underlying infrastructure of a *Hyper-G* (Kappe, 1993) server provides the basis for Harmony’s navigational metaphors. Based on the real-world observation that a hierarchical stack of progressively more detailed maps (e.g. The World – Canada – British Columbia – Vancouver) is better than a single global map, Hyper-G provides for the hierarchical structuring of hypermedia documents into collections and subcollections in addition to (and orthogonal to) the traditional plane of link-based browsing. Harmony’s navigational facilities include:

- **Hierarchical Navigation:** Harmony’s *collection browser* displays the tree structure of the collection hierarchy, opening up new levels of detail as the user navigates down the hierarchy. Subcollections can be opened and closed and documents viewed by double-clicking. The collection hierarchy’s representation is automatically expanded to show the location of documents reached by other navigational techniques (search, local browsing, etc.). Such *location feedback* is an important feature of Harmony not found in other comparable systems, allowing users to build up knowledge of the location of documents within hyperspace.
- **Search:** Harmony supports both attribute (title, keyword, etc.) and full text search, performed by default in the current collection. A ranked list of matching documents is displayed, from which individual documents may be selected. This is similar to looking up a historic building in the index on the back of a city map.
- **Local Browsing:** Local browsing refers to the process of following hyperlinks from within a document. Harmony presently supports linking from text, image, and 3D scene documents. Local browsing can be compared to visiting a historic building and then wandering down a few nearby streets.
- **Local Map:** A “local map” can be generated to show documents related to a particular document by hyperlinks. By default, two levels of incoming and outgoing links are presented. The local map is active: users can double-click on documents to view them. In our analogy, a local map corresponds to a kind of short-range radar, showing the vicinity around the current document.
- **Information Landscape:** Harmony’s information landscape is a 3D representation of the collection hierarchy. Users can “fly” over the landscape looking for salient features, like taking a helicopter flight over a city and picking out its important buildings.

We believe this combination of new and traditional features helps alleviate the sense of disorientation commonly experienced when navigating deep hyperspace.

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A New Language for Defining Sample Answers in Authoring Systems

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Authoring systems for courseware development usually contain answer judging modules as constituent parts. Entering a text string as an answer to a posed question is a standard option. This so called free form text question/answer facility is usually based on purely syntactic principles. Thus, the author specifies a class of legal sample answers by using an appropriate specification language. The system classifies student answers by syntactic comparisons with the sample answers.

In current authoring systems (like Authorware Professional[2], Autool[3]) an author typically may require that certain (key-)words must appear in a legal answer, he may define synonyms and make use of several options, like ignoring word order, punctuation, capitalization, blanks etc. Difficulties, however, occur when the author wants to characterize words or phrases as forbidden for a correct answer. A further desirable property of the answer judging module is to tolerate typing errors in student answers up to a reasonable extent.

We describe a new specification language, called TAL (TRAIN authoring language) which provably exceeds the expressive power of similar languages. It in particular allows to forbid the occurrence of words in parts of legal answers. TAL is defined inductively like a logical language. Thus, using TAL an author may require that " 'red' and 'yellow' or 'blue' but not 'green' should occur in the answer". First, the author can require that specific strings of phrases (defined by means of patterns) must occur somewhere in or at the beginning of an answer. For this purpose the elementary expressions of TAL are used. If φ and ψ are TAL expressions, then $[\varphi \& \psi]$ and $!\varphi$ are also TAL expressions. An answer matches with $[\varphi \& \psi]$, if it matches with φ and with ψ ; an answer matches with $!\varphi$ if it does not match with φ . Furthermore, TAL contains with expressions φ and ψ also the order expression $0(\varphi, \psi)$; an answer X matches with $0(\varphi, \psi)$, if the beginning of X matches with φ and the rest of X starting at the position where φ ends matches with ψ . A more precise definition requires to define for every answer X and TAL expression φ precisely an end-position "end of φ in X ". This definition has also to take into account that typing errors up to a limit specified by an author should be tolerated in student answers. The following events in a text string are considered as typing errors: missing of a character, a superfluous character, a wrong character, or the interchange of two adjacent characters.

We illustrate the use of TAL by a number of examples. Then we show that TAL can simulate the specification languages of the above mentioned authoring systems. Finally, we report about the implementation of TAL as part of a new prototype authoring system TRAIN[1]. The evaluation of expressions $\varphi \in \text{TAL}$ requires the implementation of a recursive evaluation function which takes φ and a student answer X as input and produces the output 'true' if X matches φ . For the evaluation of the elementary TAL expressions Ukkonen's improved dynamic programming algorithm for approximate string matching[4] and a version of the shift-or-algorithm for pattern-defined phrases[5] has been implemented.

The new specification language allows to specify very complex sets of answers even when using the logical operators alone.

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Dynamic Media for Electronic Books

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Electronic books have become an important mechanism for the storage and delivery of multimedia information within a variety of different contexts. In situations where their use is appropriate, there are obviously many advantages to using electronic books instead of conventional ones. Some of the more important reasons for the growing use of 'electronic publication' is the substantial volume reductions that can be achieved (compared to publication on paper), the ease with which electronic information can be accessed and shared, the flexible ways in which it can be delivered and the ease with which it can be transferred from one geographical location to another. Of course, electronic information has two other important assets - it can embed interactivity and it can be highly dynamic (that is, it is able to change its form and content to fit particular needs and requirements).

The organisation of information within electronic books can be based upon the use of both linear and hypermedia structures. The particular approach that is used will usually depend upon the purposes for which a given electronic book is to be used. Although many electronic books have been published in a linear format, increasingly, there is now a move towards the more extensive use of hypermedia structures - primarily, because of the added flexibility that this approach can be used to achieve.

The types of information contained within a given electronic book will be dictated by the needs and requirements of the individual application for which it is to be used. Sometimes, the use of pure text will be sufficient. However, augmenting text with diagrams and static pictures is also a fairly easy thing to accomplish. Of course, the advent of multimedia personal computers and consumer equipment for handling sound (such as the Sony Data Discman and Philips' CD-I) means that sound is now becoming a valuable resource in many electronic books. Many publications are now also able to embed moving pictures - for example, the McGraw-Hill Encyclopedia of Mammalian Biology.

There are two basic approaches to the provision of moving picture sequences within electronic books: animation and digital motion video. Each approach has its associated attractions and limitations. Each also has a context in which its use is most appropriate. Indeed, there is a complex ensemble of interacting factors that must be considered when attempting to decide whether to use an animation sequence or a video sequence for a particular purpose within any given electronic book publication. We have been studying the use of these resources in different situations in order to explore how the important factors interact and influence each other. The intent of the work has been to formulate a prescriptive model which can be used to recommend which type of resource to use in any given situation. Some of the types of application that have been studied include: interactive training manuals; electronic brochures; on-line technical manuals; interactive video tutorials and simple surrogations based on virtual reality.

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Distanciation versus Illusion: a key issue in educational multimedia

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Educational multimedia systems should not only provide access to off-the-shelf information, but should develop the critical awareness of students and their ability to transform what is given into something new. The concept of the Virtual Museum is an attempt to electronically recreate both the institution of the museum and its contents. It aims to reproduce the aura of the object, the prestige of the public gallery and the authority of the expert. In the Virtual Curator (Beardon & Worden, 1993) the user is a curator with a store of unexplored objects. Objects can be copied, assembled into groups (e.g. a poster, or a display cabinet) and arranged within a virtual exhibition space. Any such assembly can also be put back into the store for future re-use and new objects can be added. The user's task is to mount an exhibition on a theme. Using the Virtual Curator a student appropriates cultural images in order to construct her own point of view from her own perspective.

Many multimedia systems imply an illusory (virtual) reality inside the machine engendered by the use of photorealistic images, but photorealism in turn implies a single viewpoint from which the whole scene is authoritatively viewed. The significance of all objects in the scene, involving their position, their orientation, their relative size and the extent to which they are hidden, is determined by the location of this viewpoint. Objects are not displayed according to an understanding of their construction or significance but with respect to the single all-knowing eye, something that has been central to European culture since the Enlightenment.

Brenda Laurel compares the computer's illusory world to the theatre, with agents who act and directors who control the action (Laurel, 1991). She does not adopt a critical approach to multimedia but encourages the audience to willingly suspend belief in order to be passively healed and strengthened. Bertholt Brecht was opposed to the concept of a theatre of illusion - one which encourages users, "to read the proffered text naively, as a mirror-image of a preexisting world" (Wright, 1989, p.56). Brecht developed the concept of "distanciation" to refer to the creation of a critical distance between audience and play in order to break the illusion and make the audience aware of what is real. "Distanciation is not a style or aesthetic gambit but an erosion of the dominant structures of cultural consumption ..." (Pollock, 1988, p.163).

Brecht developed several techniques to achieve distanciation: events are represented so that the audience feels instant recognition; the play is fragmented into a number of discrete episodes that are interrupted and do not form a continuous unbroken narrative; the stage design is not naturalistic; collage and montage are used. These are good guidelines for the development of sophisticated educational multimedia software. They have been embodied in the multimedia system "Queen's Park" where the objective is both to explain the history of a local park and to explain the process of creating history. A guide is used who tells the story of constructing the history and various distanciation techniques are employed. For example, photographs are presented in a way that encourages a double reading as both part of the process and part of the product. Also, there are times when text and image interact to raise questions about the nature of historical enquiry.

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Integrated Telephony in Executive Education - the Auckland MBA Experience

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Competition in the executive education market in New Zealand provided the motivation for the University of Auckland to improve the quality and efficiency of the Executive Master of Business Administration (EMBA) learning process in 1993, via a project involving the integration of telephone technology and Apple PowerBook computers.

The objective of the EMBA programme is to impart knowledge, skills and values to relatively computer illiterate students through a learning process which comprises large group, small group and individual activities. For the EMBA students the combination of one day per week on-campus instruction in a lecture room environment, off-campus preparation for group and individual assignments and work and family responsibilities results in inevitable scheduling difficulties.

A proposed solution was to enable programme participants to work anywhere, anytime, both individually and with their colleagues, and to be effectively "wired up" to the university. Scheduling difficulties associated with the group learning process would be mitigated by enabling students to use the telephone system to transfer files, send/receive mail, access databases, engage in real-time conferencing and use telephony-aware groupware.

Various hardware and software suppliers were asked to submit proposals. The Apple Macintosh PowerBook was selected because its intuitive user interface was ideal for users with little computer experience, and AppleTalk Remote Access (ARA) software allowed users to access a network and transfer text, graphic, audio and video files over standard telephone lines - all at the click of a button. Students were required to purchase a PowerBook, 14,400bps data/fax modem, printer, ARA, QuickMail, Microsoft Word and Excel and Aldus Persuasion. EMBA faculty were similarly equipped.

Initially AppleLink provided a bulletin board service which enabled participants to exchange files, communicate news items and send electronic mail using a very simple interface. However, since the objective was to provide more than just a bulletin board ARA was next used to enable direct communication between remote Macintoshes and campus network services. Dial-in access to the university network was achieved using a nine-line hunt group on the University's Ericsson telephone exchange which connected to three Cayman Systems GatorLink ARA servers. These servers were directly connected to the ethernet backbone and a Macintosh Quadra functioned as a mail server and data repository for general access to information and secure areas for storage of individual and syndicate group files. Farallon's Timbuktu enabled remote server administration and Claris FileMaker Pro was used for help desk information and call logging. NCSA Telnet provided access to the university's IBM ES9000 mainframe-based "Notis" library catalogue. CE Software's QuickMail allowed electronic mail exchange among programme participants and other university staff members and the QuickConference feature enabled groups to engage in real-time exchange of information.

The next phase of the project will involve the introduction of groupware, such as Group Technologies' Aspects and ON Technology's Instant Update, which will make it easier for students to collaborate on documents in a coordinated manner. It is in this area of electronic collaboration that we will be able to truly exploit the potential of distance education. Although e-mail facilitates the preparation of group projects edition control can become a nightmare, and even the "cut" and "paste" of modern software can become cumbersome when multiple authors are working between multiple versions of the same document.

A key question is whether the integration of telephone technology with personal computers has improved communication and learning. The short answer is yes. The computer has become an indispensable tool and many students applied the technology to their business environment. Staff and student presentations have become more interactive and professional. Collaboration has been made easier and more exciting. In terms of the success of the EMBA programme applications for places in the 1994 programme have increased and in contrast with past trends the majority of applications are for the EMBA programme.

Intelligent advisor systems and visual cues

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Among the mandatory courses of the undergraduate curriculum in Computer Science at Université Laval, there is *Systems analysis and design*. Information modeling, and more specifically Entity-Relationship approach (Chen, 1976), is an important topic covered in that course. Data modeling is not easy. The learner's task in data modeling is to figure out what types of data underlie the business function under study. The learner must also capture a replica of that structure. Each business function is different. Leshin, Pollock, and Reigeluth (1992) stated that: "Transfer tasks cannot easily be broken down into steps, because the activity varies each time the task is performed" (p.82). Elaborating an ERD corresponds to a transfer task. The *Systems analysis and design* course has two parts. Concepts, principles, and rules are taught during a theoretical part. Learners transfer this knowledge during a practical part; they have to resolve cases. The COncceptual DATABASE Modeling Advisor (CODAMA) was developed to further the transfer of knowledge during the practical part.

Summary of visual elements

Students enrolled in *Systems design and analysis* course have weak knowledge of the domain and no practical experience. They draw their ERD with a CASE tool. CODAMA is interfaced to that CASE tool. The CODAMA's visual elements are the following (Boulet, 1992):

ERD or part of an ERD is used. Each ERD refers to several kinds of documents used within the organization (such as forms, memos, lists).

Underlined words allow the recall of prerequisites in the short term memory. Learners use the mouse to select the prerequisites to be explained.

A network of prerequisites is presented in different ways. A learner can ask to visualize the explanations related to a particular prerequisite. In that case, the related part of the network is displayed. Another learner may want to know where she or he is within the network. CODAMA will take into account several data collected in regard of explanations requested and mistakes, to make an hypothesis about the level of knowledge. The corresponding part of the network will be displayed.

A hierarchy of prerequisites can be displayed. A learner can ask to which objective a particular question or mistake is related. CODAMA will show where she or he is within the hierarchy. Another learner can ask which objective(s) is (are) not mastered. CODAMA will display the hierarchy. CODAMA can also provide an answer to a learner asking for the list of prerequisites to a concept or a principle. It can also show where the learner is within the hierarchy; it will make an hypothesis based on several recorded data.

Conclusion

Students, when asked what is an entity or a relationship, use less textbook like explanations and more examples. So, the advisor favors the transfer of knowledge. At the end of their curriculum, students have a training period within an organization. More than sixty percent asked to use CODAMA during this training period. A part of this success is due to the various uses of images and visual cues. They have to be carefully thought and planned during the development life cycle.

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A Computer-Based Learning Environment For Investigating Skills, Learning, and Teaching In Technical Listening

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This paper presents the development of a computer-based training (CBT) environment (Timbral Ear Trainer II) for timbral ear training, a specialized form of ear training aimed at sound engineers. The purpose of developing the environment is threefold: improve learning and teaching in timbral ear training, improve our understanding of the perceptual and cognitive skills associated with the domain, and improve our understanding of principles and fundamental mechanisms involved in learning and teaching. We present a set of initial assumptions about the skills involved, the learning mechanisms, and the training strategies that are appropriate for this domain. We then present a number of ways to implement versions of these assumptions and to test the relative effectiveness of these alternatives.

We are developing Timbral EarTrainer II in part to gain a better understanding of principles of learning and teaching, both within the specific area of timbral ear training and more generally. We describe our environment by systematically articulating choices that we make among theoretical, instructional, and technological alternatives. We also propose to test some of these design alternatives to investigate aspects of the phenomena that the environment is supporting, i.e., learning a specialized skill.

One of the main responsibilities of a sound engineer is to control the quality of the sound during the recording process. An important qualitative aspect of a recording, besides the musicality of the performance, is its timbral content. Proper level and spectral balance between the mixed elements of the recording and the absence of extraneous noises and distortion are key elements. The sound engineer needs also to associate timbre differences and desired sound qualities to objective parameters of sound commonly under his or her control. Therefore, timbre perception acuity and memory as well as listening strategies are essential skills for sound engineers. Analyses of these skills form the basis for assumptions that can be articulated and implemented in Timbral EarTrainer II.

The environment being developed is hybrid, using a variety of teaching methods depending on the nature of the skill being trained. For example, the memorization of an initial set of nine timbre categories requires extensive practice. For this part of the training, drill and practice exercises are used. In contrast, the development of effective listening strategies requires guided practice. Therefore, this part of the training is based on an apprenticeship model using coaching.

A research module is being developed as part of the learning environment to test our various assumptions. For example, different instructional sequences will be tested against each other. Different interaction modes, giving the students more or less freedom in navigating through the program, will be tested. The initial set of assumption stresses practice as the main learning mechanism. We will test how the presentation of theoretical material (e.g., on auditory perception, timbre perception) might contribute to the learning. We will also test the effectiveness of letting students control the difficulty level of the exercises. Different interface designs will also be tested.

The effectiveness of the different designs in improving the students' acuity and memory for timbre and their listening strategies will be verified using a pre-test / post-test procedure. The performance level of the students is evaluated both in terms of accuracy and speed of execution (e.g., long-term memory for timbre categories, the strategies used in complex listening tasks). The data collection methodology is non-intrusive: a "spy" module records all actions performed by students during their work.

An Interactive Case Study in Strategic Marketing: An Examination of Some Conceptual, Design, Development and Testing Issues

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Cases are integral to most marketing courses (Kotler and Armstrong 1991; Cravens and Lamb 1993; and Jain 1993). They help bridge the gap between the formal class-room environment and the highly pressured, practical world of marketing. Cases require students to sift through a mass of material; to identify strengths, weaknesses, opportunities, threats and key issues facing the organisation; to specify and evaluate alternative courses of action; to make recommendations; including the expected costs and benefits of implementation. In the process, students must demonstrate a sound grasp of theoretical and/or conceptual issues under-pinning "real-life" situations. Weaknesses of the traditional "paper-based" case approach are the static nature and presentation of information and that students progress through the case in the same sequence, rather than according to their cognitive and/or perceptual preferences for assimilating information.

The Royal New Zealand Ballet Company was selected as the Department's first multi-media case, both because of its challenging nature and because of the extremely "visual" material. It provides all the elements of the traditional approach to case study work plus the advantages of an "interactive learning system" in that it is multi-centred; it includes multi-media; and it is in a multi-modal format (Barker 1991). The case structure is relatively non-directional. Sections in the Menu box are neither numbered nor suggestive of priorities (Figure 1). Students progress through the Menu items according to their own priorities, predispositions and/or on-going feed-back results. At any stage they can access additional information, pictures, video and/or audio clips which supplement the material in the primary box, by clicking on any word or item that is in Bold type, to bring up a secondary box (Figure 2). Students need to judge for themselves how much this material is "worth" in terms of the amount of time and effort they devote to it. Finally, students can delve to various levels of analysis, depending on the "costs" they associate with analyzing the material to a level and standard sufficient for the task at hand.

Figure 1.

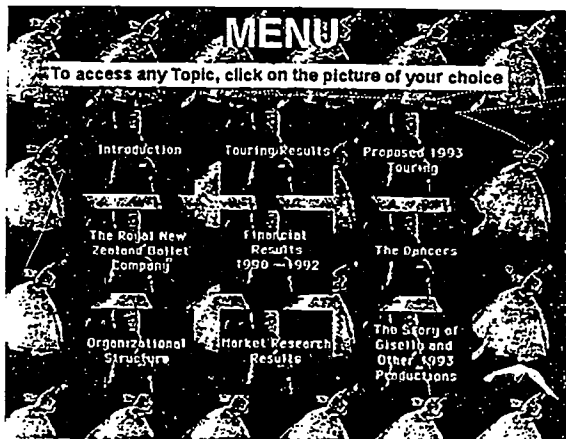
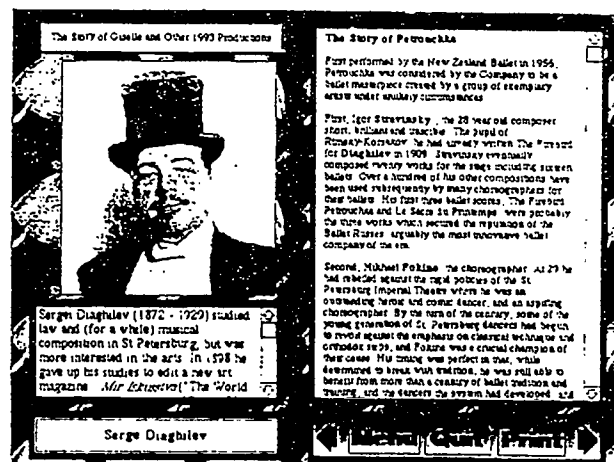


Figure 2.



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Adaptive Hypermedia in an Intelligent Learning Environment

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For a number of years we have been investigating the problem of creating intelligent learning environments (ILE) which integrates an intelligent tutor, a learning environment, and a hypermedia system. Such an integrated system can support learning both procedural and declarative knowledge and provide both guided and student-driven styles of learning. Our position is that an integrated system should be not just a sum but a real integration of its components. In particular, we propose that the results of students' work with any of the components during the session are to be reflected in the central student model and then taken into account by other components to adapt their performance to a particular student.

This paper presents our experience in creating an adaptive hypermedia component for ILE. There are two ways for a hypermedia component to adapt its work to the student's knowledge and learning goals. First, it can adapt the content of a hypermedia page, providing more explanation for newly learned concepts, shortening it for well learned concepts and sometimes hiding references to concepts which are not ready to be learned. Second, it can adapt the layout and the content of the list of hyperlinks to related nodes, providing an implicit guidance by reordering or marking the hyperlinks. The latter way is also known as *adaptive navigation*. There are several known works in the world devoted to both the ways of adaptation. We propose a special approach for creating an adaptive hypermedia in ILE which supports both the ways of adaptation. The main features of our approach are the following.

- The central part of the hypermedia network is designed as the visualized and externalized domain structure network (concept map).
- All teaching operations are directly represented in the hypermedia network and interlinked with all related concepts.
- An external hypermedia representation of a concept or a teaching operation is not stored, but generated or assembled from its internal frame-based representation.
- The content of the hypermedia page is adapted to the student knowledge reflected in the student model.
- The hyper-links from general index and from any node to related nodes are visually marked reflecting the current "educational state" of the related nodes for the given student.
- Student interaction with the hypermedia component is reflected in the student model and can be used by other components of ILE.

We have designed several ILE for different subjects which employ adaptive hypermedia. These systems use original adaptation techniques. More information about our work on adaptive hypermedia can be found in (Brusilovsky et al, 1993).

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A Windows-Based Speech Aid and Language Learning Tool For the Speech Impaired

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Computer-based speech aids for the vocally impaired use indirect activation (e.g. iconically labelled keys) to reproduce synthetically or naturally generated vocal sounds. Our current research exploits existing flexible design models for development as language learning tools that may assist the speech therapist. Most vocally handicapped people suffer other forms of handicap; either cognitive, physical or both. System design for such a broad spectrum is therefore complex and it is a folly to assume any vocal handicap in isolation. Speech aids should offer some alternative means of input based on remote switches [1]. Where the user is quadriplegic or possibly suffering from varying degrees of spasticity, there is a need to transfer the functions of all the keys on a standard keyboard into one or two switches. Algorithms using predictor techniques have been investigated in order to improve user models [2].

User interface models

A touch screen system was built to test software linking a speech output to a softkey input. Various multi-level screen structures were explored. It was decided to create a program suite with two main components. One allows easy configuration of the user touch panel so that the human interface can be adapted to the specific needs of the patient. The other acts in accordance with the instructions to link a large digitally-stored vocabulary to unique key images on the flat panel of the speech aid, thence controlling a speech synthesiser. Within the parameters of this basic format, various alternatives were explored. Some included alphanumeric key symbols whilst others allowed full-size icons to be drawn freehand on the panel. The BUILDER program is capable of changing any individual pages presented to the user. The USER program may have a softkey or remote switch input.

A number of Windows-based models have been produced. Prototype versions offer the speech therapist the choice of setting up a virtually unlimited number of speech keys dependent on specific patient needs. The strength of the original design flexibility has opened the way for more complex interactive models which still make use of the BUILDER/USER concept. However, instead of merely following a conceptual path to a speech output, partial reinforcement can be offered in the shape of visual and audio feedback. This permits the therapist to design repetitive training programs for specific utterances making use of stored high quality speech. Work is currently being done on more complex techniques which will be particularly useful for patients requiring language skills. In this mode the system will initially be controlled by a speech therapist. For example, an iconic symbol could be displayed as a trigger for an utterance from the patient [3]. If necessary, partial utterance delivery may be given by the system as the patient seeks to produce the required speech.

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Coping with a Multitude of Users in Multimedia

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Reduction in class contact time devoted to recreation and leisure studies led to the development of an interactive multimedia database designed to partially compensate. *Recreation Perth* was planned initially as a resource to assist therapy students select recreational activities to suit clients' needs. As this project has developed, secondary benefits have become apparent which may outweigh the initial objectives. The exercise has provided unique learning experiences for students, many of whom have had limited previous experience with computers. Additionally, the database's design allows information to be presented in different ways using a range of media options, thereby allowing it to be employed by therapists and accessed independently by clients with special needs.

One of the initial concerns was that occupational therapy students, in the past, had displayed limited computer knowledge and there may be hesitancy or resistance to use of the database. During 1992, the author interviewed new undergraduates to establish the extent of their previous computer experience. The results found that although only two students out of a population of 53 had no personal computer experience only one, from this mainly female population, had completed a computing unit in final year of high school (Hattie and Fitzgerald, 1987). Almost all considered their level of "expertise" and knowledge very limited. This restricted degree of computer awareness and competency raised some concern, not only to the success of *Recreation Perth*, but to the ability of qualifying therapists to serve the needs of their clients adequately. The undergraduate program currently has little formal call for student involvement with computers, but this technology can offer so much to therapist's clients, particularly those with developmental and physical disabilities (Niemec and Walberg, 1992).

To address these concerns, emphasis was placed on designing the database to make it appealing to the users with appropriate navigation aids based on proven educational principles. Students have been involved significantly in the design and development of this project. For instance, students working individually or in groups, have undertaken research seeking appropriate design requirements for adaptations of the database to suit the needs of both therapists and client groups. Over 100 students have provided the population in trials to test the effectiveness of screen designs, navigation aids and help features (Lee and Cameron, 1994). To date, over 260 students have been involved in researching information on recreational pursuits and reporting their findings in a range of media formats for database entry. This exercise is also providing a useful means to assess student performance. Working in small groups, students are required to produce a comprehensive proposal on the recreational activity they intend researching. On approval, they commence a structured procedure which includes each student participating in the activity, collecting/producing information and presenting their findings to their peers and submitting a formal report which includes a critical analysis of the activity.

Last year, *Recreation Perth* won a federal government Teaching and Learning award to enhance its design and explore methods of assisting new users to interactive multimedia. This funding has allowed: ease of data loading features to be designed; improved graphics; optional Help and Guide features researched; preparation for CD-ROM mastering. A strategy has evolved in the design and development of this multimedia database which is currently being applied and tested in a new multimedia project. This is a self-paced learning package covering standardised tests for assessing clients suitability for particular vocational occupations. This strategy involves: consideration for user's memory limitation; overviews for new users; quality graphical interface; "human" contact with help features; and last but not least user involvement in design and development.

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An Intelligent System for the Education of Non-Linear Dynamical Systems

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We describe a computer program that can be considered an intelligent system for a domain of mathematics. The domain is known as "Dynamical Systems Theory". This domain is quite complex since it has been shown that even a very simple "dynamical system" can exhibit a behavior known as "chaos" (Devaney.R.,1989). The computer program uses Artificial Intelligence (AI) techniques to model a human expert in the process of teaching "Dynamical Systems Theory". The computer program contains the knowledge of the human experts expressed as rules and facts (knowledge base), and uses as a tool of reasoning the inference engine of the PROLOG programming language (Covington.M.A.,1988). As a result of efficiently using AI methodology for the education of Dynamical Systems Theory, we obtain an intelligent system that can be used as a tool to teach this complicated and relatively new area of mathematics. To our knowledge this is the first intelligent system developed for the domain of Dynamical Systems.

Given a Dynamical System (DS) the computer program "knows" what numerical calculations have to be done to obtain all the possible behaviors of the system for different parameter intervals. For this the program has two modules. The first module has all of the knowledge about the theory of DS including the methods needed to identify the possible behaviors. The second module has all of the numerical methods needed to calculate the solution of the DS. The intelligent system also has a data base of examples of known DS that a student of this area of mathematics has to learn to get a deeper understanding of the theory.

The intelligent system has been tested with encouraging results with a group of students of the "Program for Mathematics and Physics" (PROMYF) of CETYS University in Tijuana, Mexico. The PROMYF program is aimed at young students from Universities, to motivate the learning of mathematics and physics through the use of computers in the education, and also through teaching exciting new areas of mathematics (like Dynamical Systems, Chaos and Fractals), and their applications to physics and engineering. The PROMYF program is organized by the School of Engineering of CETYS University each summer since 1992 and it is aimed at University students of the Tijuana area in Mexico. The goal is that this intelligent system can become a useful tool in teaching this new area of mathematics.

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Evaluation of a Multimedia Learning System with Social Context

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INTRODUCTION

Multimedia applications, with its rapid growth of related technology and dropping of hardware prices, is receiving considerable worldwide attention by educators within the field of instructional technology. By accessing and integrating versatile information, such as video, sound, image, and text, multimedia applications in education afford a great potential in improving teaching quality.

As the computer hardware costs dropping down with functions improving impressively, the computer assisted learning (CAL) has brought a dramatic potential. Nevertheless, the CAL environment causes other problems. One of the major disadvantages in conventional CAL environment is the lack of social interaction. It was argued that learning environments with various degrees of social context would affect learners' motives, which, in turn, will have differential effects on learners' performance (Berlyne, 1978). In the present study, the effects of three learning environments with various degrees of social exposure on learning performance were examined.

DESIGN METHODS

A total of four pairs of comparison on learning effects were examined in this study:

self-directed learning vs. cooperative learning,
self-directed learning vs. competitive learning, and,
cooperative learning vs. competitive learning.

In cooperative and competitive groups, subjects know and can see each others during the experiment, whereas in self-directed learning group, subjects took an independent study via computer. It is assumed that subjects all acquire with appropriate entry ability levels to learn. Due to the environmental constraints, the experiment was held in two continuous days, only six subjects took the experiment on the same day.

DISCUSSIONS AND CONCLUSION

Both the pre-test and post-test scores in three groups did not show a significant differences. That means all subjects were with the same entry ability level, and there were no significant treatment effects. It was also found that more subjects preferred to learn in the competitive environment than in the other two environments. In addition, it was found from survey that most subjects would like to learn with companions who are better than himself/herself. This is an interesting finding which may be unique to Chinese culture. It is then suggested for future study to do homogeneous-ability grouping within treatments for maintaining subjects' optimal motivation.

The other important finding is that in the cooperative learning environment, subjects seldom exchange opinions with their partners by typing in text to the communication window. Another finding is that not many subjects in the competitive group sensed the pressure of time limit. In other words, subjects in the competitive and cooperative learning environments were actually in the self-directed learning environment. It is no wonder there existed no significant difference in post-test scores.

Researches of the different learning models' effects on learning performance and on motivation have been a lot, the results are not consistent - some are even contradictory. How to choose representative learning models with significant factors operating inside is still a big challenge. The study serves as a pilot one for future deliberation. By building up such a distributed social learning environment with multimedia support, it is the researcher's hope to provide a prototype for futuristic learning environment and bring impacts on education revolution in the coming centuries.

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Does Maths CAL Help Third-World Students ?

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The project aimed to assess the effectiveness of computer assisted learning (CAL) in supporting the mathematics education of students from the disadvantaged communities (mainly Black) at a supplementary education Centre, called Ethembeni ('Place of Hope'). For various reasons the quality of education in most Black schools in South Africa has been and still is very poor. The Centre is building the learning culture essential for academic progress and its students are highly motivated, self-disciplined, and possessed of a desire to learn. The Centre is mainly funded by business. In order to help larger numbers of students the Centre considered CAL and approached us to advise them on starting a CAL facility, assist in the selection of a suitable systems, monitor and support the implementation of a CAL facility, and provide ongoing support thereafter.

A team of researchers from the Depts of Computer Science and Mathematics at UPE evaluated two candidate maths CAL systems experimentally. One of the systems is a locally-developed specialist maths CAL system and the other an internationally known content-generic system. Both systems provided course management facilities. The 140 11th grade students enrolled for a maths course at Ethembeni, were used for the project. From this population, 3 groups of 40 students each was chosen by stratified sampling; one each for the two CAL systems mentioned and one as a control group. The stratification was based on a standard pretest score, gender, age and school.

All groups attended maths classes at Ethembeni for the duration of the course (7 weeks). The control group received no CAL. One experimental group attended the CAL lessons on Friday afternoons and the other on Saturday mornings for a session of three hours. The same topics were covered in both groups. The CAL systems presented the students with problems, marked their answers, recorded their responses and provided help when necessary, BUT the students worked out the problems themselves on paper. Thus they remained independent problem-solvers, capable of functioning without computer support. We also played music while the students worked. They enjoyed this very much and it did not seem to affect their ability to concentrate. They solved math problems while keeping time to the music.

Finally the student attitudes towards the hardware, CAL systems and courseware used and the project administration were evaluated by means of a questionnaire. Learning outcomes were evaluated by means of an end-of-course test written by all the students. This test was set and marked by the maths teachers at Ethembeni and moderated by the research team.

Both experimental groups learned to use the interfaces of the CAL systems surprisingly quickly, becoming competent after one three-hour session despite the fact that the students were initially all computer-naïve. The students proceeded at their own individualised learning tempos. The bright students rushed ahead, while slower learners were not demoralised by being left behind by the others. The students experienced the CAL systems as non-threatening and relaxing to work with, and had very positive attitudes towards the project and the use of CAL in teaching mathematics. We were astonished to observe that the students were able to concentrate and work for three hours at a time.

Student responses were positive to all the closed response questions. They did not mind doing the course in English, although it was their second or third language. The major sources of complaints were the sandwiches they received and the impatient bus drivers!

The statistical results showed that the null hypothesis, viz that the use of CAL does not improve the mathematics competence of the students at Ethembeni, can be rejected with a confidence limit of 95% in the case of one group. Although the other group also showed improvement it was not significant. A detailed report of the project and the findings is available (internal report no. 94/02). The team has learned a lot about the practical aspects of running a CAL facility, how to study the interactions of students with CAL software and the nature and needs of disadvantaged learners. After the experiment ended, it was decided in consultation with Ethembeni to continue and expand the program with the objective of educational upliftment of both students and teachers.

Co-Learning at a distance : FIRST trial of an integrated learning environment

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In our educational Institute, we are trying to enhance Open Learning [JOHN 93]. We take into account the idea that learning is a social process [RESN 91]. It is based upon a certain type of "mediation", as Vygotsky said.

So, we propose two types of mediation, through two classes of resource :

- human resources : teacher, tutor, expert and learners together whose relations are based on the "socio-cognitive conflict" that W. Doise defines as a constructive interaction between peers [DOIS 84];
- technical resources : we have built a multimedia environment for education within the European Delta Co-Learn project [DERY 93][VIEV 93].

One of the four prototypes, named RTMConf, provides a group of students with an integrated learning environment. The learning activity is supported by a platform for the collaborative work (CSCW). The system is designed for a small group of participants using the metaphor of a virtual meeting classroom.

The experiment

The students have to solve together a mathematical problem using the different tools of the RTMConf : the public window, the telepointer, the opinion collector, the time manager, the audio tool and the welcomer tool. They communicate together through PC stations under Windows 3.1. These stations are connected to a server by ISDN (Integrated Services Data Network) and include an audio channel. They were four students sites (with four students in each sites) and a teacher site.

Results

The experimentation validated the physical architecture in terms of performance and usability of the different used networks and tools. The metaphor also seems to be correct and the proposed tools effectively help the communication between learners. The teacher must help the learners to use the right one, adapted to their current task.

The audio channel is necessary to establish a good and rapid of the task and the coordination.

But for the usability of the system, we have seen that to put more than two students by site was an error. The teachers need to manage simultaneously a great number of information (technical and pedagogical). They should also change their usual mode of teaching to benefit from the system. So, we have to plan a good formation of teachers who will conduct some Co-Learn session.

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Mathematica as a Conjecture Making and a Multimedia Tool

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Introduction

Today many university instructors across the world are integrating computer algebra systems (CAS) into their mathematics curriculums. One of their goals is to make the subject matter more appealing to the student. The wide availability of the CAS has indeed revitalized the teaching of mathematics as well as the research. If used the right way, it has a big potential of exploring every corner of a curious student's mind, giving him ample opportunities to form, test, and prove mathematical conjectures (de Alwis, 1993).

The popular CAS include, Mathematica, Maple, Derive, MacSyma, Theorist, Reduce and muMath. However, in this paper we will concentrate only on Mathematica. It is a CAS that can be used as a numerical or symbolic calculator, a tool for graphing, or as a visualization system to analyze data. One of the biggest strengths of Mathematica is its powerful built-in programming language. This provides an ideal tool for forming and testing conjectures of mathematical or physical phenomena. By combining the Mathematica programming language with its animation and sound capabilities, one can make mathematics spring into life! For example, in the subsequent sections, we will observe projectiles moving through the sky emitting various sounds and dynamic models for world population growth. These are excellent examples on how to use Mathematica as a multimedia studio. Not only that, we will also discover some useful theorems in the process. Our students will definitely be inspired by mathematics taught and presented this way. Consequently, they will be able to understand and appreciate the subject more.

What we have used is Mathematica standard version 2.0 on a Macintosh IIfx platform running at a clock speed of 40 MHz. Some good references on Mathematica are (Wagon, 1991) and (Wolfram, 1991).

The Motion of a Projectile with and without Air Resistance

Consider the motion of a projectile fired from the origin $(0,0)$ with a velocity v ft/sec at an angle θ radians with the horizontal. Let (x,y) be its position at time t seconds and g be the acceleration due to gravity in ft/sec^2 . Then in the absence of air resistance, its equations of motion are given by $x = v\cos(\theta)t$ and $y = v\sin(\theta)t - gt^2/2$ (Symon, 1971). By eliminating t between the above two equations, one can obtain the equation of the trajectory of the motion $y(x) = x\tan(\theta) - gx^2/(2v^2\cos^2(\theta))$, which is a parabola. In a typical calculus class one usually does not consider the motion with air resistance because of the complexity of the equations of motion. However, with a powerful CAS like Mathematica, students can analyze this motion as well. Let m be the mass of the projectile. As given in (Symon, 1971), one popular model is to assume that at any time t , the frictional force due to air is directly proportional to the velocity at that time. By denoting this constant of proportionality by b , one can show that the equations of motion are given by

$$x = \frac{mv\cos(\theta)}{b} (1 - e^{-\frac{bt}{m}}) \quad \text{and} \quad y = \left(\frac{m^2g}{b^2} + \frac{mv\sin(\theta)}{b} \right) (1 - e^{-\frac{bt}{m}}) - \frac{mgt}{b}.$$

Eliminating t between these last two equations and denoting y by $y_{\text{air}}(x)$, one obtains the trajectory of the motion with air resistance

$$y_{air}(x) = \left(\frac{mg}{bv\cos(\theta)} + \tan(\theta) \right) x - \frac{m^2g}{b^2} \ln \left(\frac{mv\cos(\theta)}{mv\cos(\theta) - bx} \right)$$

Using these equations, one can write a Mathematica program to simulate the motion of a projectile with and without air resistance in the same set of axes. In the actual presentation, one can observe the motion of two projectiles, one in solid red (without air resistance) and the other in dashed blue (with air resistance). On the top of each graph, one can see the current time and the position of each projectile. Not only that, accompanied with every movement of the projectile, one can also hear an interesting sound. At the very bottom, the maximum heights and the ranges of the projectiles are displayed. One can export a few frames of this animation to a graphic program such as Canvas. Within Canvas, one can start editing these frames. One can also import images from popular Clip Art packages and then do the final editing within Canvas. Then import the final edited frames back into Mathematica.

World Population Growth - Exponential and Logistic Models

Let us consider two models for world population growth. According to the exponential model, one assumes that the rate of growth of a population is directly proportional to the number of individuals in the population at that time (Ross, 1989). Let t denote the time in years, and $P(t)$ denote the population at time t . This means that $dP(t)/dt = k_1 P(t)$ for some constant k_1 . It can be easily verified that the solution of this differential equation is $P(t) = P(0)e^{k_1 t}$ where $P(0)$ denotes the initial population. The exponential model seems to work very well over a short period of time for human populations and also for certain mammalian species under certain conditions. However, it is unrealistic for longer periods of time. The logistic model is proven to be more satisfactory for restricted environments with a limited amount of food supply. In such an environment, let M denote the maximal population. The logistic model assumes that the growth rate $dP(t)/dt$ is directly proportional to $P(t)(M - P(t))$ (Ross, 1989). Hence one can write that $dP(t)/dt = k_2 P(t)(M - P(t))$ for some constant k_2 . One can also show that the solution of this differential equation is given by $P(t) = P(0)M/[P(0) + (M - P(0))e^{-k_2 M t}]$. This equation implies that $\lim_{t \rightarrow \infty} P(t) = M$. Therefore, unlike the exponential model, the logistic model is more realistic.

Based on the above equations, one can write a Mathematica program to simulate the world population growth. In the actual presentation, one can observe two graphs climbing up as the time t increases, one in dashed red representing the exponential model and the other in solid green representing the logistic model. The current year and the total populations predicted by the models are also displayed. One can also use the graphic program Canvas and a Clip Art package to create images of a big metropolis and import them back into our animation. This is a prime example on how to use Mathematica as a multimedia studio.

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An adaptive questionnaire based upon an automatic knowledge assessment tool

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One of the most praised qualities of computer assisted training (CAT) is its ability to deliver individualized training. In CAT, the pace of individual learning is not determined by the learning group's average, or maximum, or minimum learning pace. It adapts to the individual's capabilities. Even the content can be tailored to the individual's background knowledge and personal training needs.

Current state-of-the art CAT systems support individualization of the training process by allowing free or flexible navigation within the training content, as opposed to a rigid linear content presentation controlled by the computer. However, this flexibility imposes an additional burden on both the instructional designer and the learner. For example, the instructor must decide the appropriate sequencing of exercises according to the successes and failures of the learner. Or the learner must explore the whole training content and decide what is appropriate.

We present a method for reducing the effort and complexity of designing and delivering individualized training based upon the automatic assessment of the learner's expertise. The method induces, from empirical data, the learning order of knowledge units (KU—they can represent mastery of concepts or skills). This ordering is thereafter used to infer an individual's knowledge state (see Falmagne *et al.*, 1990, for the cognitive foundations of this method). Through a sampling of a person's knowledge state, the system assesses the probability that this person knows any given KU. The application of such method to adaptive CAT systems are numerous.

We built a system for an adaptive questionnaire based upon this method. A question represents a KU. Every time a user answers a question, the probability of correctly answering each other question is updated automatically, according to a success or a failure, based upon the empirically derived ordering of questions (which constitutes a *partial order*). The ability to use this information for adaptive purposes is shown in a mode where the system chooses the most informative question (based upon a question's expected value of entropy reduction given an answer). If the user correctly answers the questions chosen by the system, the degree of question difficulty tends to increase gradually. On the contrary, if the user fails systematically, the degree of difficulty will tend to decrease. For example, we constructed an adaptive questionnaire on UNIX. The automatic assessment module was initialized with data from 20 subjects. The following sequences represent the mean failure rate of questions presented to the user for successive successes and failures respectively:

Questions' mean failure rate for consecutive successes: 33%, 48%, 67%, 57%, 81%, 76%, ...

Questions' mean failure rate for consecutive failures: 33%, 48%, 24%, 38%, 24%, 24%, ...

Moreover, the user's *global score* will rapidly rise with the above successes and drop with failures:

User's global score with consecutive successes: 61%, 69%, 72%, 77%, 81%, 84%, ...

User's global score with consecutive failures: 61%, 54%, 51%, 49%, 47%, 45%, ...

Without the inference power from the automatic assessment, the resulting scores at the end of the above sequences of questions would correspond to 64% instead of 84% for successes, and 58% instead of 45% for failures.

Systematic validations of the method for correctly assessing an individual's knowledge state were performed in a number of different experiments on the knowledge of WordPerfect™ text-editing commands (Desmarais *et al.*, 1993; Desmarais and Liu, 1993). These results showed that, for example, a close to perfect knowledge assessment was inferred after sampling 70% of a subject's knowledge state, and that sampling 50% of the knowledge state would reduce the standard error score of estimates to about half of the error score without inferences. The method thus successfully reduced the number of questions that needed to be asked to assess a subject's score.

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Helping students get unstuck

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When students attempt to learn by doing, they will get stuck. If a human guide is available, the student can receive the support he or she needs to get moving again. We call this kind of support a *procedural nudge*. A student who is learning by doing in a computer-based environment has an even greater need for a procedural nudge. For maximum learning to take place, the student should receive just enough of a push or guidance to get past the sticking point without being explicitly told the answer. In addition to providing the right kind of help, designers should consider the personality traits students may attribute to the tutor. A clear, consistent personality enables the learner to appropriately interpret and use the procedural nudge. We have observed the following five human personality types providing procedural nudges within computer-based learning environments.

The **Eager Expert** understands the domain, knows the student's problem, is smart, and, because it doesn't have the patience to guide the student to the answer, it simply gives the student the answer. While it is probably the most typical kind of assistance currently available within educational software, it rarely results in learning.

A **Gaming Genius** also understands the domain, knows the problem, is smart, but seldom gives direct answers. This personality provides the student with vague hints and ambiguous answers. The Gaming Genius is usually implemented to give just enough information to get the student moving again. The student, however, perceives that the Gaming Genius is toying with the student and enjoys seeing the student struggle.

The **Fallible Colleague** may or may not understand the domain or the problem, requiring the student to carefully evaluate any advice he or she receives. This personality has good intentions, offering many solutions or answers, yet some answers are wrong. One pedagogic advantage is that the tutor can give the answer without fear of giving it away, since the student will not be completely confident that the answer is correct.

The **Clever Confidant** does not understand the domain nor does it know the problem, but it is smart. The Clever Confidant knows how to reason about problems in general and ask questions the student should ask him or herself. The advantage here is that the Clever Confidant begins to model the behavior the student should be exhibiting in the problem-solving process.

A **Blind Brain** understands the domain, is smart, but does not know the student's problem. With this personality the student is forced to conceptualize his or her problem before the tutor can help. Any answer the Blind Brain provides is only as good as the conceptualization the student provides. Unlike the Fallible Colleague, the appropriateness of the advice is not random, but dependent on the student's ability to understand and communicate the problem.

All of these personalities, with the exception of the Eager Expert, can provide a procedural nudge. Assuming the personalities are implemented in a clear and consistent manner, each will encourage the learner to develop different problem solving skills: Gaming Genius - making inferences; Fallible Colleague - judging the validity of data; Clever Confidant - asking oneself the right kind of questions; Blind Brain - conceptualizing the problem. Both Clever Confidant and Blind Brain have the additional advantage of accomplishing these pedagogical goals without annoying the learner.

An AI based programming environment for the learning of programming

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The variety of programming paradigms widely used in practical situations stresses the importance of building computing environments aimed at helping students acquire the capability to computationally model problems independently of a specific language. Moreover, if such environments are endowed with the capability of automatically producing code in different languages (i.e. imperative, logic, functional, etc.), students are operatively motivated to study modelling problems, and are provided with a tool for rapid prototyping on different programming schemes. On this basis we have designed a system, called MEMO-II, intended to be used in the teaching/learning of programming with University students. A prototype version of the system runs on IBM/486 under SCO-Unix operating system.

MEMO-II is a programming environment which allows the user to build programs from formal specifications via interaction with the system. The process of generating a program from a specification is carried out by the system.

To help students understand the different processes intervening in the building of programs, that is how a model is built and modified, how interesting conjectures are made and verified, how a representation can be derived, MEMO-II places a series of facilities at the disposal of the user. Via the facilities, the user autonomously decides about the specification to be explored, formulates properties which must be verified and the knowledge to be used in the proof, establishes which links with mathematical structures should be analysed, decides which tests must be carried out. The system helps the user in this activity by guiding him in the description of the specification, by verifying its adequacy with respect to feasibility, by giving proof of the properties indicated by the student and by deriving programs from specifications.

The process is carried out interactively; the facilities of the system are accessed through commands. An algebraic specification oriented language, a validator of specification, an automatic translator and a theorem prover are the core of the system. A broad analysis of the technical organisation of the system and its components can be found in [Antoy et al. 1993].

From a pedagogical point of view, the work is based on three main observations: it is commonly acknowledged that we need efficient ways to teach abstraction; teaching modelling contextually with a language makes it difficult to understand the difference between the conceptual and technical processes leading to solve a problem computationally; the amount of time and effort needed to build computer systems devoted to teaching problem solving suggest making them applicable in a variety of educational contexts. To overcome these difficulties, we propose using systems endowed with the following features: 1) to support a variety of programming languages in order to be applied to several educational contexts; 2) to place at students' disposal a series of tools for the development and testing of formal specifications, independently of a particular programming paradigm; 3) to grant the user facilities for producing effective programs focusing his attention on the cognitive aspects of programming rather than on the technical ones.

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HCDE: A Hypermedia _ Based Courseware Developing Environment

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The Hypertext and multimedia information is merging into the hypermedia at the present. A hypermedia _ based courseware developing environment, HCDE, has been developed and implemented at Xi'an Jiaotong University. The main functions and features of HCDE are as follows:

1. HCDE provides the multimedia information interfaces in the low _ cost hardware environment, so it can be popularized easily. These interfaces can link the hypertext nodes with the text, graphics / image, animation and the Chinese speech. They are constructed by software technology without speech card, video _ card and other special hardware.

2. A novel "bus _ oriented" message driving control model in HAE is designed for increasing the independence of modules, extensibility and maintainability. HCDE consists of the Hypermedia Authoring Environment (HAE) and a ToolBox which includes five special tools. HAE includes 12 object classes (or called modulus) to organize all forms of information into the card of hypertext and automatically generates a hypermedia courseware by defined 15 messages driving. The sending message and control transfer take place on the message queues, exchanging information between the modules occur indirectly.

3. HCDE is a non _ programming opening environment for teachers and allows them to write the courseware script in English or Chinese by simple authoring rules (only 16 control symbols as prefixes of the objects) rather than in programming way. The tools have friendly HCI and detailed help information. The efficiency of developing courseware can be raised tens times.

4. HCDE supports courseware engineering, creates knowledge base of ITS and student model. It also supports interactive teaching applications, instructional path control by logical lock. A good navigation algorithm is designed to avoid the 'lose-way' problem, in the meantime, deadlock problem has been solved.

5. The object _ oriented method and self _ adaptive are adopted in HAE to realize the compatibility, tailorability and adaptivity of system. A new and original speech signal compression algorithm ZBCOMP on Chinese Speech Synthesis System and the new ideas about generating animation are achieved. HCDE was developed in BORLAND C++ 3.0, running on IBM _ PC with 80x86 CPU, VGA, HD (> 20M) and LOUDSPEAKER. The system owns Chinese character library, supports mouse and keyboard. It has been used to develop courseware, electrical document and knowledge base of ITS at more than ten universities.

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Mathematical Objects in a Visual Interactive Environment : MOVIE

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Cognitive and social sciences have pointed out some fundamental characteristics on the nature of learning (Pea, 1992) :

- the development of intelligence is actively constructed by the individual,
- learning is situated in a community of practice,
- learning is a process of communication between human beings,
- learning aims to everyone's autonomy and cooperation.

According this results, a mediatized learning environment must provide two essential functionalities :

- it must provide the learners with an interactif and shared workspace. It is the field of the action and of the observation.
- it must enable and ease the conversation about the action in real time and afterward. It is the field of the communication and of the negociation of meaning.

We are developing such an environment, called MOVIE, for learning mathematics. MOVIE is a visual interactive environment for the calculus. The objects of MOVIE are all kinds of usual objects (price tags, gauges, clocks...) or mathematical objects (formulae, graphs, figures...) it is possible to calculate with.

Composed objects are built by copy and by paste of basic objects. For the calculus we use a visual formalism wich extends the algebraic coding to a third dimension, according to a spatial syntax.

MOVIE is thought from scratch for the collaborative work : the learners put on the shared workspace the objects they are appropriate to the studied problem. These one are given to everybody's action.

MOVIE is multimetaphors : the one of the direct manipulation and the one of the language coexist for the managing of the calculus.

MOVIE is multimedia : the change of standpoint on the calculus can enable cinemational animations.

MOVIE is multiagents : we can put agents in the environment. They relieve human operators in some tedious tasks.

We have developed a first prototype in Smalltalk 80 (Gers, 1993).

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Glucomedia: How to integrate multimedia environments & ITSs through advisory strategies and learner modelling

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The combination of multimedia environments with ITS takes advantage of the various ways the information can be processed. The information is related to the facets of the content to be learnt but it is also related to the characteristics of the learner. Interaction is possible when the progression through the available network of information depends on what the system knows about the learner.

The concept of significant interaction

An intelligent system has the ability to reason about the direction which the learning interaction should take at any given moment. The accuracy of the model that is used to adapt the interaction depends on the quality of the inferences that can be made by the system regarding the learner's cognitive abilities, needs, beliefs and strategies. Significant interaction occurs when the information is interpretable by the learner in terms of meaningful units of information that can modify the learner's representations or motivate him/her to go further. The learner is thus participating in a multi-modal transaction defined as exchange cycles of information, more or less meaningful, to generate significance or understanding of a phenomenon or a particular state (Merrill, Li Zhongmin & Jones Mark, 1991). The main pedagogical issue is to give the learner more control over its interaction with the system and, at the same time, to allow the system to adapt its interventions during the learning session.

In the design of environments based on significant interaction, three dimensions are intertwined:

- **The intervention level:** The system interacts significantly with the learner at different levels: *perceptive, transactional, cognitive, pedagogical and evaluative*.
- **The structural components:** *Objectives* describe expected *representations* to be set up through the use of various *strategies*.
- **The quality criteria:** Every component, at every level, should be *clear, coherent and relevant*; it includes some *analogy* (denotative and connotative), some *redundancy* (density of information) and some degree of learner's *control*.

An example: GLUCOMEDIA

The main objective of *Glucomedia* is to motivate, inform and teach patients who suffer from diabetes to improve their control over the disease. The system presents day life situations which call for a decision from the patient. At any time, according to the evolution of patient's knowledge, *Glucomedia* can complexify the situation presented, incorporating new elements that may force the patient to revise his/her previous decision or to make new ones. The intelligent learning environment is based on two qualitative models: free exploration and apprenticeship. The multimedia components of *Glucomedia* have been integrated in the knowledge base. The multimedia functions can be activated by the advisor in conjunction with the evolution of the learner's knowledge.

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The lessons of user trials on the development of a Hypermedia Learning Environment.

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We have been developing a Hypermedia learning environment based on the Constructivist model of teaching for several years now (Gill 93). From our own observations and also those in other institutions we recognise that many students hold deep misconceptions, and incorrect models of many physical laws, such as Newton's Laws of Motion (Osborne & Freyberg, 85). We have implemented the constructivist model within a HyperCard™ based system which allows the user to branch and follow non-linear routes of learning with extensive multimedia support for this particular topic. We have been experimenting with these principles for a number of years now, and have developed four discrete systems to date. We are committed to an on-going testing of the system, in order to gain important feedback, which is tremendously important in educational software development. Our systems have been successfully tested at the Department of Design, Brunel University; Fachhochschule Hannover, Germany; the Rivers School, Massachusetts, USA; and the Department of Education, University of South Dakota, USA. The age of the students range from 14 years to 24 years, with varying backgrounds, which has provided us with interesting data.

Results

Contrary to some of our earlier assumptions, the models held by the students are not self standing ideas that they apply universally to many different phenomena, but are a kind of sub-conscious fuzziness, which consists of some formal scientific explanation. A student will pick certain terms and definitions from the correct concept, and then mix it with their own wild inaccuracies to form their explanation. Students have a tendency to cling to key words like 'resistance' and cheat the system looking for correct answers, which inevitably hold recognisable key words. Many of the younger students treated the system as a game, always wanting to know if they were right or wrong. However the older students are quite happy with the informal approach, taking much more time, and was best summarised by one student as "doesn't say you are right or wrong, you have to think and understand it". The use of audio for signifying key interactions was greeted with a positive response. However the use of spoken human directions for certain activities was found to be ineffective and often annoying. Students were asked if they would like to have the texts read back to them and the answer was a resounding 'yes'. Such a feature has been easy to implement with the new Apple PlainTalk extension. It must be noted that the younger students had an aversion to reading much of the card texts. Each card held a reasonable amount of text, with up to 15 lines and 180 words (on a 640 x 480 pixel card, with 14pt Palatino). This is not a large amount of text compared to many systems, but it was often too much. Extreme cases saw users flick to a card, be presented with a lot of text, and then move quickly on to the next card without stopping to read the text. These students were often on 'the hunt' for the Quicktime movies and animations. Macromind Director™ animations and Quicktime™ video sequences were originally played automatically on the opening of each card. However the students were not happy with this as they wanted to have more control when the animation appeared, when it played, and when it stopped. By allowing the user to open the movie at their request we have been able to improve card to card times, and to display multiples of the same movie on screen, allowing the user to examine sequences more thoroughly. All the students tested were more than happy to open these movie objects, and would often spend several minutes watching and rewatching a short movie. Comparing the success of the movies with the lack of interest for text, it is quite clear which holds more captivation for the students. Newer versions of the system now contain much less text per card, with more text, diagrams and explanations in the Quicktime movies. This is perhaps not a major surprise to anyone who has observed teenagers play computer games and the amount of TV they watch. These factors are undoubtedly important to the success of learning systems and these trials have provided us with many important points.

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A Cross-Domain Experiment in Case-Based Design Support: ArchieTutor

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Over the last few years, our research group has developed a series of case-based design support systems. Each system in this series represents an experiment in combining case-based and multimedia technologies for supporting conceptual design in complex domains. In the Archie project (Pearce et al., 1992), we explored the use of past designs for aiding architects in designing new office buildings. In the AskJef project (Barber et al., 1992), we investigated the use of multiple types of knowledge, including past designs, for advising software engineers on the design of human-machine interfaces. The more recent ArchieTutor system represents a cross-domain experiment in using AskJef's framework for supporting design teaching in Archie's domain.

ArchieTutor operates in the domain of architecture, as does Archie. However, instead of supporting professional architects in solving complex design problems, our goal for ArchieTutor is to support design teaching in beginning architectural classes. More specifically, the system is intended to support design teaching in two ways. First, building on the results of AskJef, it is intended to support design teaching by helping beginning architectural students in understanding the nature of the design domain of office buildings, and the structure of design problems and solutions in the domain. Second, following the results of AskJef and using Archie as a base, it is intended to support design teaching by exposing students to some of the knowledge sources and skills useful in design generation and design critiquing.

This form of "subversive tutoring" does not force the student to learn about the domain but invites the student to explore the domain in the context of solving a design problem, and presents knowledge in such a way that it is likely to be remembered. The most important features are:

- ArchieTutor makes the relationship between the different types of knowledge explicit; the student has access to a cross-indexed knowledge network (design cases, design principles and guidelines, and domain models) in the system's memory.
- ArchieTutor provides a vocabulary for cross-indexing design cases, principles, and domain models.
- Organization of ArchieTutor's interface strongly reflects the organization of knowledge in its memory.
- Graphical representation of the case allows the student to focus on a specific chunk of the design by zooming in, or look at the design as a whole by zooming out.

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Supporting the Learning of Recursion at a Distance

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Research in the area of artificial intelligence in education (AI-Ed) has made progress on three fronts. First, AI-Ed researchers have constructed discovery learning environments in which a learner can use creative play with the aim of achieving self-actuated goals. Second, AI-Ed researchers have explored reducing the complexity of learning by providing scaffolding that can slowly fade. Third, AI-Ed researchers have begun to understand how to individualize tutorial interaction so that the cognitive needs of the learner can be dynamically fulfilled. The key to this individualization is the ability to perform "student modelling" where learning states are diagnosed from learner behaviour and incorporated into a longer term model of the student.

We have developed two systems for supporting the learning recursion in LISP. PETAL (Bhuiyan, 1992) provides a scaffolding environment in which learners are supported in their *mental model*-level problem solving as they solve programming tasks. SCENT (McCalla et al., 1988) is able to diagnose strategic and logical errors in learners' completed programs and is able to provide English advice about their solutions. In this research we have shown how PETAL can be used "stand-alone" by learners at a distance to receive the local support they need as they develop solutions to their programming tasks, but, when they feel the need for individualized advice on their completed solutions, the learners can receive it remotely from a centrally running version of SCENT.

PETAL consists of three Programming Environment Tools (PETs) to support learners in the use of three mental models of recursion. As learners use a PET, they express mental model-level decisions by actions carried out in the PET. PETAL can generate runnable LISP code from the mental model-level descriptions the learners create. This helps learners to offload onto PETAL the necessity for dealing with the intricacies of LISP syntax and semantics, thus allowing them to concentrate on problem solving rather than coding. We have found that the PETs themselves serve as a powerful learning tool that scaffolds problem solving for novice programmers.

The SCENT advisor is a traditional intelligent tutoring system in that it builds an internalized model of the student programmer's strategy in order to comment upon it. It is non-traditional in its use of *case-based* and *granularity-based* reasoning methodologies to help it to build this model. At the heart of the SCENT advisor is a recognition engine that determines what strategies the learner has used in his or her LISP program. The recognition engine uses a model-based approach to recognition, comparing the learner's solution to models in a fixed strategy library. In our approach, we overcome fundamental problems of model-based recognition, especially problems in robustness, flexibility, and adaptability.

In order to connect PETAL and SCENT and to run multiple PETALs at the same time, it was necessary to convert SCENT into an advice server, managing advice requests from multiple PETAL clients. The protocol involves PETAL sending an advice request to SCENT and when the solution has been analysed, SCENT returns the advice. The learner then browses the advice in PETAL while SCENT proceeds to handle other requests.

We conducted an experiment with nine first-year university students using the PETAL/SCENT integrated system. The protocols confirmed that students would work for some time before requesting advice. During the exit interviews students were positive about PETAL but were split on the perceived value of SCENT. Some were frustrated because SCENT would not give specific instructions about how to fix their code but they appreciated the fact that it would show where their code was wrong and give hints about how to correct it.

This work integrates systems from two different streams of AI-Ed research to synergistically provide a truly useful learning environment in a cost-effective way. We believe that the PETAL/SCENT integrated system is a role model for linking scaffolding environments to a central AI-based tutoring system.

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Training services in a cooperative environment

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The environment considered is an integrated and multi-site environment which must provide technical support for information management (designing and implementation facilities, maintenance), for information transmission (computer networks, mailing service) and for information processing (tracing and evaluation services). Such a tele-teaching centre requires two categories of pedagogical resource sites : • the main training centre which organizes, manages and diffuses the training services (pedagogical bricks) and • the training centres (remote sites), which provide the learners with all necessary human and technical services (ACTS : Adapted Class Training Service and AGTS : Adapted Group Training Service) required for the instruction process.

Training services in each training centre are structured in three layers : support, global and cooperative layers. Each training service of any training site is designed using an object-oriented approach, it is based on functional and independent 'building blocks' (Natarajan, 1992).

Support layer represents the information, network, software and hardware platforms.

Global layer represents four types of SITB (Service Independent Training Building Block) : pedagogical service to manage apprenticeship of learner group, information service for supporting learning activities, evaluation service to evaluate a learner group, and cooperation service allowing the interaction between users (to exchange messages and pedagogical resources). Pedagogical service is represented by basic resources (multiple-choice-questions), isolated or grouped (questionnaire), which constitute pedagogical 'bricks' that can be teleloaded from each training centre. Information service is represented by knowledge source such as : lexical concepts of domain. Evaluation service is represented by multiple choice question and questionnaires

Cooperative layer is represented by two cooperative services : ACTS and AGTS. ACTS is managed by a class manager controlling (by control interactions with the corresponding group manager) an electronic class according to a class teaching strategy, each learner group is classified by a knowledge level ('novice', 'confirmation', 'deepen' and 'master'). Each AGTS is managed by a group manager controlling a particular knowledge level according to a group teaching strategy. The components of each AGTS are : • actors (teachers, learners and reusable SITBs), • roles (actor's behaviour), a set of roles has been identified in the ECOLE (European Collaborative Open Learning Environment) project (Eijkelenburg, 93) : speak, react, ask, answer, observe and work, in addition to that we consider inform, evaluate, and tutor, • activities, a learning activity allows to establish a learning situation according to roles played by actors, and • the manager of pedagogical situation execution, it must to manage the training sessions, through a series of pedagogical activities adapting each pedagogical situation to learner's needs (individual or in group) in a flexible training.

A multi-site environment such as SEMIEC (in french : 'Système Evolutif Multimédia Intégré d'Enseignement de la Comptabilité') based on the training architecture (Hernández, 1993) is being developed in the distance education context of apprenticeship of accountancy at IPST (the 'Institut de Promotion Supérieure du Travail' is a french institute for professional training).

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Fuzzy Techniques for Understanding Students' Solutions in an Intelligent Tutoring System

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Synchronizing parallel processes is a difficult and complex domain. To offer students practical experiences in this field we developed SYPROS, an intelligent tutoring system. SYPROS uses tree-like structured goals and plans for the representation of its problem solving knowledge (cf. [HeGo93]). An important aim in developing SYPROS was to make it able to observe a student's problem solving process and to understand a student's solution. For this reason the goal-plan-tree generated by SYPROS is enriched with buggy goals and plans.

Diagnosing a Student's Solution

The process of diagnosing a student's program consists of three steps: To each program statement a *matching algorithm* finds all plans which match this statement. The *interpretation algorithm* reduces this one-to-many relation to an one-to-one relation, i.e. for each program statement it determines exactly one plan which is fulfilled by the statement. Finally, the *diagnosis algorithm* assigns one or more diagnosis categories like correct, incorrect, necessary, inconsistent etc. to each goal (cf. [HeGo93]).

The Interpretation Algorithm

The interpretation algorithm of SYPROS uses information about the student's knowledge and behavior which can be obtained from the student module. But most of this information is uncertain knowledge.

In order to investigate which model fits best this kind of knowledge we followed Pearl's classification of theories of uncertainty (cf. [Pear88]) and looked into the *neo-probabilistic* approach, e.g. Bayesian networks, into the *logicist* approach, e.g. default logic or truth maintenance systems, and into the *neo-calculist* approach, e.g. Dempster-Shafer-theory or fuzzy sets (cf. [Zade65]).

Comparing these models we found out that fuzzy techniques are well suited for the interpretation algorithm. Therefore, in SYPROS the uncertain information is modelled by fuzzy sets, and the interpretation component is implemented as an expert system based on fuzzy techniques (cf. [Zier93]).

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Educational Multimedia Software Development Model: A Revised Empirical Approach

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Until now, traditional software engineering development models (DeGrace and Hulet Stahl, 1992) have failed to meet the particular requirements for multimedia software production in general (Brooks, 1987) and educational multimedia software in particular. There is an important need for a simple software development model for producing educational material, particularly, in countries with different cultural realities and where teachers are not technology aware. This paper is the first step to produce a set of guidelines that help them to go with the technology.

Our educational multimedia software development model highlights the following principles: (a) Early study and definition of the user, assessment of the pedagogical value and usability of the proposed software (Dockterman, 1991). (b) Easy to build and low cost combination of sketches and prototypes that help during the design and implementation. (c) Early and reiterative evaluation of the project in all of its dimensions (content, functionality, structure and usability). (d) Parallel work of the members of the team, allowing the evolution, evaluation and implementation (Boehm, 1989; Nielsen, 1992) of each component of the software separately but also integrating them into a tangible product at early stages.

We divide the software development model in five stages: (i) **Project Definition:** These are mainly brainstorming sessions of the working group (teacher, psychologist, engineer and art designer). Some of the points addressed here are: theme and contents, availability of information (text books, videos, etc.), the user and his/her environment and resources for development and use. (ii) **Project Design:** It has three main goals: to collect the maximal amount of information, to define the application's general structure and to formalize the design with a graphical representation of the components (like a softecture in Gilb 1988), the browsing structure and the helps available. This stage is divided in three minor steps that compound an iterative process with incremental contents and expressiveness. Each one represents an evaluation point, where the project is critically analyzed. (iii) **Application Evolution.** It is an iterative process in which users probe (test) alternates with rearranged computer prototypes. (iv) **Software Product Production:** This step includes all the additional and complementary material that the software should include in order to become a real market product. (v) **Maintenance:** It is not included as a real stage of the software development model, but must be considered in the development model because of the resources that it will demand to do it.

These five steps summarize the proposed software development model. Some additional considerations such as the role of each member of the team (designer, educator and engineer), the representation tools and the evaluation procedures, as well as the general features required for the end-product are currently being worked on.

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An Environmental CAI-System In The Field Of Psychology

The Construction of CTP System And The Effectiveness of Classroom Demonstration Using CTP System

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Our "Computerized Textbook of Psychology" ("CTP" for short) project has been promoting the development of a courseware for psychology on personal computers. Some parts of this study have been published elsewhere[1]. The aim of the CTP project is to develop an environmental CAI system so that it will provide a new technical environment for learning and teaching psychology, for not only students but also those scholars, who intend to reorganize the vast field of psychology. In contrast with conventional ICAI/ITS approach, which can not be applicable to such a field with large and/or non-linear knowledge structure as psychology, the CTP system brings the "browser frame" into hypertext structure, which help browsing and searching the target easily out of large knowledge space. The CTP system stands open to the selective modules in knowledge space in the forms of explanations, figures, animations and simulations.

Classroom Demonstrations Using CTP System

As a unique feature of CTP in contrast to other CAI systems, all the demonstration programs in the CTP system can be used for classroom demonstration as well as self-educational system. We have conducted two experiments(120 subjects each) to examine the effectiveness of the classroom demonstration function of CTP. The purpose of the experiments was to assess the visibility and understandability of the classroom demonstration under regular classroom circumstances equipped with inexpensive audio-visual system. Although no explanation about the demonstrations was given to the subjects in the experiments, high visibility and understandability in such a way as the experimental results showed the demonstrations attracted the students' interest and made them experience psychological facts.

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A Hypermedia-driven Computer Assisted Mathematics Remediation Package

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There has been a long-time concern about the adequacy of mathematical skills of many students entering primary and early childhood education courses. Because of resource implications, it has not been feasible to offer a remediation program. Therefore, it was undertaken to develop a computer assisted math remediation package.

Description of Requirements for the Package

Because there is a wide range of students' abilities and backgrounds, an underlying pre-requisite for the package is that it be self-paced. Furthermore, it was intended that the software developed be capable of catering for its users' different learning styles.

Analyses indicated that for this particular target group, the content needed to introduce students to unfamiliar mathematical content, particularly algebraic expressions and in doing this, equip them with skills to transfer knowledge to unfamiliar situations. Therefore, the package is intended to use problems which require a range of background mathematics knowledge and also require many steps in each problem's solution.

A group of 25 students and mathematicians was asked to solve a selection of problems and to describe the problem solving processes used. These processes were categorised as: visualising a 3-dimensional model of the problem; drawing a 2-dimensional representation; using equations, and using English expressions. For each problem, the package will offer a series of appropriate strategies across these four sub-headings.

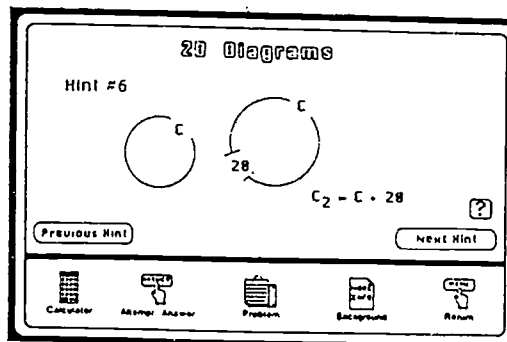
Implementation of the Package in a Hypermedia Environment

The package is being developed using HyperCard to create a hypermedia environment. This will allow the incorporation of text and graphics into a user-friendly interface. The non-sequential nature of multiple problem solution paths is readily implementable using hypermedia. Marsh and Kumar (1992, p25) state that the multi-dimensional nature of hypermedia presentation is consistent with learning models of recent cognitive theories.

The figure at right gives a good indication of the user interface design. It can be seen that the student has access to a calculator; can leave the tutorial temporarily to attempt an answer; can have the original problem displayed at any time; has access to background knowledge, and can leave the present tutorial and return to the problem solving menu.

The advantages of developing a hypermedia system are consistent with Johnson and Grover's hypertutor model (1993, p7). These include learner control using an intuitive, consistent interface, immediate feedback, and easily accessible learning resources.

note: a full version of this paper is available from the authors.



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CASPER: A Hypermedia Departmental Information System

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It is important for college students to have as much information available on their department as possible. This information should be up to date, and easily accessible and digestible. When students have a question, they should have the means to find their own answers quickly and easily.

To satisfy this need in our department we designed and implemented a hypermedia information system called CASPER - "Computer Assisted Studies Planning and Educational Resources." The CASPER software includes an Oracle database, a full colour Hypercard interface, and Quicktime movies. The CASPER hardware includes a Macintosh IIfx with a 13" colour monitor, a mouse, and a laserprinter. The student interacts with CASPER using only the mouse.

CASPER contains information about our department, its instructors, its courses, and equivalent courses at other universities.

CASPER helps the student find information about our department. A student can see a list of presentations and other upcoming events, or read a list of answers to commonly asked questions. The student can see a full colour map of the department and click on rooms to see who its occupants are.

CASPER helps the student find information on a particular instructor. A student can click on an instructor based on that faculty member's name, or their face from a set of full colour pictures. Clicking on a faculty member brings up information on that instructor including their name, title, phone number, office number, lab number, office hours, research interests, and teaching assignments for the current and future terms. The student can also play short full colour movies of the faculty members introducing themselves, allowing the student to see and hear them.

CASPER helps the student find information on a particular course. A student can click on a course from a list of all the courses taught in this department, or a list of all the courses taught this term. The student can see when and where the course is being taught, a sample syllabus for the course, and who the instructors will be for the next several semesters.

CASPER helps the student find information on equivalent courses at other universities. A student can click on a university and see which courses transfer to our department, or click on a course in our department and see a list of equivalent courses at other universities. This includes information on the equivalent course from the other university's Course Bulletin.

With all of this information available, CASPER helps the student choose which courses they will take in the coming terms. A student enters information about the courses they have previously taken, and the grades they have received. CASPER shows which courses remain to be scheduled, when those courses will be offered, and who will be teaching them. The student can then move term by term into the future scheduling courses. Once the student has created their plan of work they can print it out or save it onto a floppy disc. With the floppy disc, the student can return to CASPER at a future date and make changes to their plan.

CASPER has a friendly interface that makes the system fun to use, as well as informative - encouraging students to explore. CASPER allows the student to quickly and easily see related information. Clicking on an instructor's name or picture anywhere in the system brings up information on that instructor. Clicking on a term brings up a complete list of courses offered that term. Clicking on a course brings up information on that course. Clicking on a room number brings up the departmental map showing where that room is located.

In February 1993, CASPER was placed in our department's main office where it is always left running. Student reaction has been overwhelmingly positive. They find the system very easy to use the first time they sit down in front of it. Their only complaints have been that the system should contain even more information.

CD-I: a Multi-media Tool for Distance Learners

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A relatively recent development in multimedia appears to be an excellent candidate as a wide-ranging resource for distance learners. CD-I (compact disc interactive) is both a media and a system specification and defines what can be present on a disc, how it is coded and organized and how disc/system compatibility can be maintained. Other advantages of CD-I include compatibility with the CD-Digital Audio specifications (the Red Book), compatibility with existing consumer electronic products (stereo systems and televisions), compatibility with other broadcast conventions (PAL, SECAM) and expansion possibilities which turn the CD-I system into a complete microcomputer system.

Given that interactivity has been defined in various ways in distance education and that interactivity is at the heart of CD-I, Lundin (1989) has identified six levels of interaction in the distance delivery of instruction. For this discussion, levels 3 through 5 are relevant:

Level 3: 'limited interaction' in which the participant has choices regarding the exploration of the CD-I-based course content;

Level 4: 'responses' which are requested from the learner;

Level 5: 'simulated' interaction in which the material acts as a catalyst for real-time interaction among participants.

In each of these levels, the learner is in firm control of the pace of interaction and is actively engaged in the acquisition and mastery of the course-related skills and concepts. When using CD-I in level 3, the learner can choose to view the course materials from various perspectives if the disc designer has provided for unrestricted access to the disc's contents in addition to the navigational tools (screen design and interface). Level 4 interaction would be commonplace as CD-I is designed for exactly this. Level 5 would occur during the real-time videoconferencing and would allow for the use of a common source of information for all participants.

Propositions about the use of CD-I in distance education, related to the above three levels, appear to emerge:

Proposition 1. CD-I technology can provide the distance learner with more opportunities to employ personalized learning strategies than traditional distance delivery systems;

Proposition 2. CD-I technology has the potential to enhance and to facilitate the exploration and organization of new information;

Proposition 3. CD-I technology has the capacity to reduce the obstacles inherent in technological interaction.

This new technology (new, at least, in the way in which it is employed in instruction) can offer increasingly more convenient and more effective channels of educational opportunities for CD-I is a system that is at once flexible, individualistic, comprehensive, and easy-to-use.

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Information Gathering Styles in an Interactive Environment: the Influence of Computer Literacy and Technology Use

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Multimedia software permits users to access information in many new ways compared to traditional media such as books. In this study, subjects were instructed to find information on aviation heroes of the 1920s in a multimedia encyclopedia (Compton's Interactive Encyclopedia on the CD-I platform). Our goal was to discover the relationship between information gathering styles and levels of computer literacy and technology use. We also created profiles of the most and least efficient searchers.

Subjects with high levels of computer literacy on three dimensions ("anxiety," "confidence," and "liking," as operationalized by Loyd and Gressard, 1986) were more efficient searchers than those with low computer literacy scores. Heavy technology users on two dimensions ("everyday technology" and "information seeking") were more efficient searchers than light technology users. However, the computer literacy and technology variables did not effectively predict satisfaction with the encyclopedia, which was high even among inefficient searchers (Kamerer and Wilcox, 1993).

The most efficient searchers typically used the "Title Finder," which is analogous to an alphabetical look-up. Title Finder searches were approximately twice as efficient as other, more associative approaches such as "Time Machine" (search by date) or "Fact Index" (search by category). The most efficient searchers were also more than twice as likely as inefficient searchers to use "hot key jumps," while the least efficient searchers were more likely to use a wide range of features. Inefficient searchers also spent a fair amount of time getting lost. In fact, four of 82 subjects failed to find the topic at all in 20 minutes.

In short, efficient searchers successfully used a few features, while inefficient searchers either explored many features or got bogged down in features which were inappropriate for the search. This suggests some implications for design of interactive materials. First, "bells and whistles" such as a "time machine," may help sell multimedia software, but they may not be very useful. Also, too many features seemed to create a kind of anomie in our subjects, who then were distracted by them at the cost of finding information. Content analysis of the sessions reveals that many of the iconic conventions of the interface are unclear to the user. The feature that seemed to most help searchers is the hypertext link, in which a user can jump from one article to another, related, article, without having to navigate back through earlier menus.

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Structured Authoring in the Hyper-PC Environment

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By looking at the current state of Computer Based Learning we see that we definitely deal with a new type of computer related product which is called *courseware*. Although there exist sophisticated and well-established methods of hardware and software design, there do not exist such methods for courseware preparation. In other words, in courseware design we face a situation similar to the very early stages of software design when authors developed their own isolated programs without taking into consideration reusability and modularity of the software developed. In analogy a new technique of courseware design has to be implemented in up-to-date authoring systems.

Hyper-PC is a comprehensive software tool running on PCs under MS-Windows for developing interactive multimedia courseware. It brings together text, graphics, animation, sound; images and answer-judging procedures in order to create computer-based training courses. It should be especially noted that the creation of all components of courseware is a programming-free process. Even quite sophisticated animation and answer-judging algorithms can be defined by means of a special non-procedural model of courseware being developed.

The frame-channel model is a paradigm which allows to formally define the structure of a large courseware product and thus manage the process of its development. Within this model, the internal structure of a courseware system is perceived as a *frame structure* which includes: a number of so-called *frames* and a number of *channels*, which are functional relationships ("links") between frames. A certain frame can be defined in the form of either a primitive node or a frame structure. Note the recursive definition which allows to apply the same model on different levels of abstraction. In analogy, channels can be seen as an unified approach to the interface between functional parts of a courseware product.

The main action which can be applied to a frame is to activate it. When a certain frame is activated, its body is evaluated. If the body is a primitive node, then this chunk of educational information is visualised on the screen. If the body is another frame structure, then the activation procedure is recursively applied to this structure. Channels serve as a predefined message passing mechanism.

Three levels of detail exist during the definition of a certain courseware object. On the first level, the prototype developer deals with a number of basic functions, and with the rules of frame type definition. On the second level, the prototype developers deal only with previously defined types of frames, i.e. with the current library of types. They can apply simple rules in order to build new frame types on the basis of the current library of types. On the third level, the user has got a number of frame types which can be interpreted as complete courseware objects. The subset of such courseware objects is a user's own courseware design philosophy.

There are some properties of our model which are of potential benefit from the point of view of the management of courseware projects:

- the model includes a clear and convenient graphic notation and can be easily metaphorised;
- the model can be applied on the different levels of courseware specification and implementation;
- the model supports rapid *prototyping*, including the possibility to apply a previous version of the courseware system within the latest version.

On Adventure Gaming as an Interface of an Educational Microworld

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One of the main form of teaching natural sciences is an experiment, practical and laboratory researches. But our experience tells that a participation in the real experiment and even successful completion of it does not mean successful acquirement of a knowledge minimum which is assumed to be obligatory. The main goal of the system of a computer support of an educational experiment on mechanics "Labquest" described below is to induce students to apply all required knowledge and, in that way, to ensure its acquirement.

Learning and gaming

The intercourse of the students with the system is realized in the form of a computer game. There exists a number of reasons which justify this choice.

Both at teaching and at the knowledge control a student must feel himself free and liberated, and the game gives an opportunity to eliminate superfluous tension and nervousness. The game-like form of the system leads to a stimulation of an interest and to substantial increase of motivation. The process of joint computer gaming assists to the students in closer unity of their working group. From various types of existing computer games we have chosen so called adventure games. The characteristic feature of these games is almost full freedom of game's hero to choose ways to his targets. This feature is very attractive for the creation of educational "world" somehow adequate to real.

Educational and gaming problems

During the game a student has to solve educational problems of different types.

(i) Construction of a sentence. The student makes up sentences, formulae or diagrams by means of a given set of words, mathematical expressions and picture elements.

(ii) Calculation by formula. The student simply has to enter a number (e.g., value of critical load) which must be found beforehand by means of one of the main theoretical formulae.

(iii) Measurements. The aim of the player is to superpose screen images of the object and measuring tool, make necessary adjusting and read and interpret the readings.

Concrete representation of each problem may significantly changes even within the one type. It seems to be very important to coordinate with the plot an origin of every problem and necessity of its solution for further advancement.

When developing a game-like system it is not easy to resist the temptation to use some elements of traditional arcade games. But, as mentioned by G.Jones (1991), the criteria for success or failure in the simulation must be determined not by good hand-eye coordination but by the learning objectives. In the "Labquest" system arcade game sequences give an opportunity to cause the student to repeat some set of educational exercises and so to consolidate acquired habits and learned facts.

During the game the system constantly keeps a score. Such scoring allows a teacher to make prompt analysis of current situation, to determine the working stage at which students are situated. Moreover the increase of the score is an additional stimulus to the students.

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Teachers as Developers of Multimedia Learning Environments: a Vehicle for Professional Development

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Multimedia systems can be classified under the categories identified by Joyce (1988) as either 'exploratory' or 'constructive'. In the former category, users interact with a previously developed multimedia system, often by merely browsing the information. In the latter, users are involved more actively with the multimedia system either using it to construct knowledge while completing some specific task or to participate in the development of the multimedia system itself. A number of authors (Hutchings, et al., 1992; Kass and McGee, 1993) propose that significant learning only occurs when users are involved in 'constructive' multimedia experiences.

This proposition underpins the approach adopted in this study involving nineteen practising teachers enrolled in a post-graduate course at the Queensland University of Technology. The aim of the study was to investigate how requiring teachers to develop and evaluate multimedia learning environments affects their understandings of, and confidence in, using multimedia systems.

Procedure

This study involved three stages: (1) Evaluating teachers' initial conceptions of multimedia by analysing the data collected from a free-write exercise using grounded theory techniques (Strauss & Corbin, 1990). Teachers also completed a *Survey of Concerns (SoC) Questionnaire* (Hall et al., 1977) which provided a quick-scoring measure of stages of concern associated with their use of multimedia as part of their teaching. (2) Training teachers in multimedia materials development by requiring them to conceptualise, develop, and implement a multimedia-based learning environment. (3) Repeating the free-write and SoC activities and their analyses on completion of the course.

Main Findings

- F1: On completion of the course, conceptions of multimedia focussed less on the technology involved and more on educational and people-related characteristics.
- F2: Initial non-specific conceptions of interactivity were replaced by specific statements defining interactivity as a means by which users take control of what is learnt and how it is learnt.
- F3: The SoC questionnaire responses indicated that the course of study was a useful form of professional development in satisfying teachers' initial concerns relating to awareness of and information on educational applications of interactive multimedia.

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A methodology for configuring simulation-based learning environments

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Whether building information systems in general, or simulation-based learning environments (SLEs) in specific, it is preferable to avoid writing low-level code. The SMISLE (System for Multimedia Integrated Simulation Learning Environments) (de Jong et al, 1993) workbench aims to offer the author predefined tailored building blocks for building SLEs. A building block can be seen as a generic template for filling in knowledge about the subject matter, instructional measures, learner assessment or the interface.

With these building blocks in hand the author is faced with basically three tasks. He has to (i) analyse the required knowledge, (ii) mold the knowledge into a conceptual structure that is compatible with the existing building blocks and (iii) configure the building blocks into a consistent structure. To guide and monitor this process of analysis, conceptualisation and configuration the author is offered a methodology (Kuyper et al, 1993).

As with every design process, the authoring process is seen as an iterative process. Interim and partial solutions are constructed during the development process which are not part of the final solution. Design, in attempting to satisfy an initial set of goals, always results in the discovery of new goals. A workbench therefore should cater for change. The SMISLE achieves this by means of the modularity of its building blocks.

In addition, the authoring process is inherently unpredictable due to the idiosyncratic attributes of each individual situation and designer. That is why it seems ill-advised to prescribe the process of design. Well-advised support to an author should be directed at solving the local problems he faces, while leaving him the freedom of choosing his own path of development. This methodological viewpoint will be operationalised in the workbench by three different tools.

Firstly, the workbench contains a process-based entrance to the development task. Here, a decomposition of authoring tasks is displayed. The author can relate his current task to the overall development process and can denote the status of development of the different tasks. Also, representations of tasks that are computer supported give access to this support.

Secondly, an agenda mechanism is devised to support the author in linking building blocks. This mechanism keeps track of all the open plugs and provides immediate access to them by name at any desired position in the SLEs architecture. In this way, the burden of switching between parts of the SLE while searching for open plugs is removed.

Finally, monitors in the workbench see to it that the author does not fill in wrong values in building block slots. Because authors are watched on this syntactical level, they are spared the tediousness of having to debug unnecessary errors.

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A computer-managed learning environment for students of anatomy

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Research has shown a Computer Managed Learning Environment (CMLE) to be most effective when learners are empowered to access materials to meet their own needs (Lee & Allison, 1992 & 1993; Lee & Cameron, 1994). Rates of progress can be accelerated by the ability to monitor individual levels of competence by instant feed-back (Lee, 1994). In a project funded by the Committee for the Advancement of University Teaching (CAUT) in Australia, a Self Operated Computer Controlled Educational Resource (SOCCER) was developed to provide a cost-efficient navigational instrument to Interactive Computer-assisted Learning Programs (ICALP) to enable physiotherapy students to assess their own performance whilst learning anatomy (Lee, 1994). Using SOCCER, each individual is registered by password with unlimited access to learning and testing materials. All activities are continuously tracked and recorded for evaluation thereafter. These data acquire information about learning from pre-tests and the acquisition of new information during progression to post-tests under controlled conditions for continuous review by learners and administrators alike. In this way SOCCER provides access to ICALP's, interactive Multiple Choice Question Test Items and interactive True-False Test Items in a sensitive learning environment with a Feed-Back Instrument to evaluate learner reactions to the CMLE.

Learning anatomy and validation of SOCCER by comparative studies

Jones, Olafson and Sutin (1978) compared freshmen medical students with those in traditional classes to show that they could learn gross anatomy equally well without lectures or dissection. Walsh and Bohn (1990) used CAL to teach gross anatomy to 48 medical students from a class of 151, to find no significant difference between the two groups. In the same way, Lee & Allison (1992) could find no differences between randomly selected groups of physiotherapy students whilst learning anatomy of the lower limbs, either by lecture or by ICALP.

In a further comparative study, Lee & Allison (1993) converted identical neuroanatomical information from ICALP's into lectures for computerised overhead projection to 41 students by lectures and to 37 students by ICALP. At pre-test, the mean for each group was 43.58 and 44.81, with a standard deviation of 8.67 and 6.54 respectively. At post-test, the lecture group achieved a mean of 73.19, with a 7.76 SD, whilst the ICALP group achieved a mean of 75.42, with a SD of 6.76. The same test was unexpectedly re-applied at 60 and 120 day intervals. The lecture group obtained 68.04, with a SD of 8.49 after 60 days, and 68.06 and 8.24 after 120 days. Whilst the ICALP group achieved 70.34, with a SD of 9.58 after 60 days, and 69.68 and 9.02 after 120 days. These results were validated by replication studies in neuro and cardio-pulmonary anatomy to subsequent student groups (Lee, 1994). From this, it is clear that SOCCER in a CMLE can facilitate ICALP software to provide individual learners with a continual review of the rate and quality of their progress together with instant feedback at the end of each procedure. These methods provide a continuous source of research data to empower learners to take responsibility for their own rate of progress, setting aside the need for formal lectures in anatomy in a climate of problem-based learning and thinking at a more advanced level than could otherwise be expected.

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Continuing distance education tools: Relevance of a contextual evaluation

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Adult education and training are increasingly relying on telecommunication and information technologies to support continuing distance education, on-the-job training and even on-the-job performance. Models of adult education suggest that the learner's motivation to learn is not simply instrumental and situational but in a large part developmental (Berbaum 1984; Piaget in Inhelder *et al.*, 1977). Adult training innovations have to take this into account and go beyond mere instrumental support that can take the form of a "crutch" instead of an educational tool. These on-the-job educational/training tools are highly context dependant, whether for their design, their use, or their impacts. Questions have arisen as to whether the sophisticated technologies designed to support performance can contribute to developmental as well as instrumental educational goals, how, to what extent and under what conditions. We addressed these questions by conducting a contextual evaluation of the implementation of a continuing medical education technological tool for on-the-job performance support during a 14 month pilot project. The tool was a networked based information system aimed at developing competence and interest of general practitioners in the diagnosis and treatment of mental health problems through support of their day-to-day practice. The system had three components: 1) an expert consulting network using electronic mail; 2) an electronic education bulletin in the mental health field; and 3) a clinical pharmacology databank, which was a complementary incentive service. The implicit educational objective was to induce a shift in physicians' patterns of practice (a developmental goal, not a mere instrumental objective), away from a dependance upon prescription of drugs and towards adoption of alternative approaches through easy distance access to specialists (psychiatrists, psychologists, legal experts, etc.). As mental health problems are not exclusively treated by general practitioners, 62 professionals in 9 different types of healthcare settings participated in our case-study type evaluation: 25 physicians, 16 social workers, 14 nurses and 7 psychologists. We adopted an interpretive approach relying on the institutional aspects and interpretive flexibility of technologies (Kling & Iacono, 1989; Orlikowski, 1992) and on the search for the significances which different groups of actors involved in the process attribute to professional training and to the technological change (Jodelet, 1989).

In order for the expected changes in users' behavior or attitudes to occur as the result of using the training technology, the evaluation showed that it is important that the general practitioners themselves, and not just the experts or the promoters, consider the new pattern of practice supported by the technology as a best practice in the domain and as a possible practice in their organizational context. Otherwise, the users divert the technology from its intended purpose to reinforce their own current behavior. We found that confirmation of this diversion effect of the technology was related to the professionals' conception of training, to the constraints of their work context and to the stakes they invested in the tool. On-the-job intervention support was used to reinforce existing practice patterns of the physicians and did not encourage developmental learning and associated broadening of perspectives in treating mental health problems.

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Smart Instructor's Resources: Make Lectures Interactive Using Computer-Generated Projections

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Performing the experiments that support even one of the many principles in a typical introductory course would, in most cases, take a lifetime. Attempts to set up a "discovery learning" laboratory usually result in the discovery of why it took thousands of very intelligent scientists several hundred years to work out all of the observations and principles that make up the content of a typical introductory University course.

One way to alleviate this problem, and put a significant amount of laboratory evidence into a course, is to use simulations. These allow one to put before a class experimental evidence that would normally be too expensive, time-consuming or dangerous. There are many excellent audiovisual presentations, in a great number of media, that allow a lecturer to bring into class realistic representations of critical experiments. The difficulty is that they generally are "canned" performances, complete in themselves, so that the lecturer must adapt his or her presentation to them, and follow their pedagogical strategy.

Now that many lecture halls have computer projection equipment, it is possible to take advantage of the intelligence and graphical capabilities of computers. I have designed interactive computer animations which simulate a laboratory, and provide unlimited and immediate access to any appropriate experimental apparatus. The lecturer has complete control over the on-screen events, so that they support rather than constrain his or her pedagogical approach.

These programs are called "Smart Instructor's Resources" or SIRs. They run on any modern DOS-based micro-computer with high resolution colour graphics (vga) and a mouse. SIRs use an intuitive mouse-based interface. This is critical in a classroom setting. An instructor is entirely occupied with instructional material and interaction with the class; it is unreasonable to expect her or him to puzzle over the operation of the computer as well. The interface is simple enough that the instructor can think of chemistry and instructional strategy, and be confident that whatever is needed can be called up onto the screen immediately.

The instructor and class together may explore a phenomenon as if they were in the laboratory, and thus retrace the actual discovery of physical and chemical principles. They may decide what to do next: in effect, ask "What would happen if...", and, if their question is properly framed (here instructors earn their pay!) immediately receive a meaningful answer from the simulation. After a suitable sequence of experiments, the class and instructor together may attempt to infer the underlying chemical principles. Students identify with and retain better scientific principles which in some measure they have found out themselves, rather than have had dictated to them by authority.

During the 1993-94 academic year I have used about twenty of these SIRs in my classes. They cover most of the topics of a standard introductory Chemistry course: reaction stoichiometry, atomic structure and the periodic table, behaviour of liquids and gases, calorimetry, acid-base equilibrium, redox and electrochemistry and chemical kinetics.

Students' reactions have been mainly enthusiastic, although some seem rather startled by being asked to switch to active learning in place of their customary passive note-taking role.

This work was begun while the author held a CATALYST Fellowship from IBM and the American Chemical Society, at the University of Texas in Austin in 1992-93. The Smart Instructors' Resources have been submitted to the *Journal of Chemical Education: Software*, which makes available executable copies of software that it publishes.

A Prototype Digital Science Center

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By the end of this century large scale digital libraries containing the collective legacy of human knowledge and information will be accessed on-demand over gigabit networks. Books, videos and other traditional sources of information will be incorporated into these digital libraries in an almost straight forward move towards exploitation of the new technologies. That will not be so with other equally valuable sources of information, such as museums and science and technology centers. And, much research will be needed in order to understand how to effectively capture and represent learning experiences in digital libraries. But when we do this, equity access to such experiences will become a reality.

The intent of a science and technology center is to engage its young patrons in stimulating multi-sensory experiences in the hope of imparting knowledge and encouraging curiosity. The most obvious problem in doing that is access to the facilities. Thus, the educational value of museums and science and technology centers is currently minimally exploited. Teachers could make use of the educational value of the exhibits many times during the course of a single school year. But in fact students may visit a particular center only once during their entire K-12 years.

Capturing these experiences as interactive multimedia documents would facilitate integration of specific exhibits or groups of exhibits on related topics, into lesson plans. It would permit gathering related exhibits (in various center) for comparison and reinforcement of ideas. But most of all, it would bring these experiences to students that might never otherwise have access to them. Using technology it will be possible to extend the cultural power of museums, and science and technology centers beyond their physical boundaries. It will be possible to reach students and teachers with a wealth of information, for repeated analysis at individual pace. And, it will be possible to access them when they would be most relevant and integrate them with curriculum.

But, bringing these experiences to a remote site using multimedia technology presents some significant problems. The most obvious problem is the lack of interaction with the physical objects contained in the museum itself. The challenge is to come up with ways to capture the spirit of the museum and convey it to the remote user. Another problem is that it requires a lot of planning and effort to integrate these experiences (in its existing physical form) into lesson plans and in general curriculum. Therefore, in general these experiences are sometimes regarded as close to casual educational activities, undertaken only as class trips and family outings, and viewed mostly as only motivational. The digital museum and science technology center have the potential of changing that, but it will require the development of curriculum models that help to integrate digital experiences with classroom activities.

The Discovery Museum and IBM's T.J. Watson Research Center have collaborated to explore these issues. Experimentally, various exhibits have been captured using full-motion video, audio, graphics and text to create multimedia documents representing many experiences in digital form. The digital experiences are interactive and stimulating, much like the physical ones. Work is still in progress, but early results suggest much promise for the approach.

The Study of Student Conceptions in Geological Mapping: A Phenomenographic Approach

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This study of student conceptions in interpreting geological maps was carried out following the tradition of a research methodology referred to as phenomenography which seeks to discover and describe the qualitatively different ways in which students think about a particular topic as they are in the process of learning. The general aim of phenomenography is to use samples of student conceptions to construct categories which are expected to have some generality in terms of the student population as a whole. (Francis, 1993). These categories of description, also referred to as an 'outcome space of conceptions' reflect a researchers' analysis of emerging patterns in the way students describe both their approach to a task or problem presented and the reasoning they apply to the problem.

There were two aims for this study. The first was to gain insight into the difficulties students experience in learning to interpret geological maps. The second was to consider how the results of this kind of study could be used to inform the instructional design decision-making process.

Conceptual Difficulties and Learning Approaches

The study of geological maps requires the ability to "infer the meanings of patterns found in rocks" (Chadwick, 1978) and the ability to visualize three-dimensional structures which have changed with respect to the dimension of time. Students in this study experienced three types of conceptual difficulties in learning to interpret maps:

1. Students confuse the relationship between present-day topography and sub-surface geological structures.
2. Students have difficulty in determining whether a sub-surface structure is an anticline or syncline.
3. Students have difficulty in visualizing three-dimensional sub-structures.

Students also displayed two types of approaches to learning to interpret maps. The first and most common approach, referred to as 'surface' (Entwistle & Marton, 1984) was characterised by the student attending to discrete features of the map. A 'deep' approach was characterised as the student first gaining an overall idea of what the map represented, followed by positing a theory of the history of the events which may have occurred, then looking for features on the map which supported the theory.

A number of implications for instructional design can be drawn from these results, including clarifying instructional goals, developing sequencing, developing graphical representations, and guiding the student in their approach to the task.

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Student demographic composition in a multi-media class: Effects on attitudes towards computer-assisted teaching

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This paper is based on the findings of an evaluation of the attitudes and opinions of students towards the use of multi-media in a plant biology course. The course selected for the case study was an introductory plant biology class that was a requirement for all university students. The course was taught in a large classroom to about 230 students. The lecture used a multi-media platform for projecting a variety of images on a large back-projection screen. The Focus-Question-Analyze-Recommend (FQAR) methodology was used to do the evaluation. The process consisted of five focus group discussions with randomly selected students from the class. The final questionnaire consisted of four pages with separate sections that addressed student attitude and opinions, perceptions of the effectiveness of the tools, perception of the competence of the instructors, suggestions for improving the course and student demographics.

It was found that the students had differential exposure to computer and computer use. In general it was found that most of the students either frequently or very frequently used word processing. The results also indicated that a private dormitory or apartment room was the place where computers were most often used. Moreover, about 53% of the students indicated that they had taken at least one course in the year prior to the study where computer-assistance was used in teaching. Based on such findings it is possible to categorize the audience of multi-media assisted courses into several different groups and then ascertain if indeed there is a difference between their attitudes towards the introduction of computers in teaching. The primary categories are: 1) students who have taken computer assisted courses compared those who have not, 2) students who have taken courses that require computer use as compared to those who have not 3) students who are regular users of computers outside of the classroom as compared to those who are not, 4) gender and 5) year in school.

Those who had been enrolled in computer assisted courses agreed that they felt comfortable using computers while the students who were not in such classes felt less agreeable towards the same issue. This suggests that other than attitudes towards personal use of computers, attitudes towards other computer-related issues are not particularly influenced by prior attendance in computer-assisted courses. This finding is supported by the fact that no significant differences were observed between the groups of students who were previously exposed to courses that had computer use as a requirement and students who had never taken such courses.

Noticeable differences were also observed between male and female students in terms of how the different genders felt about computer use and the introduction of computing in the work place. Women consistently had a negative image about the introduction of computers in teaching. This is a trend that needs to be observed carefully since this could suggest that instructors and course administrators need to pay more careful attention to the gender composition of their classes to see if indeed there is a need to modify the message or the computing techniques being used to teach the course. Finally, there were some significant differences between the ways the lower level students (Freshmen and Sophomore) and upper level students felt about computing in education and teaching. In general, the lower level students were less excited about the rapid introduction of computers in teaching and felt less comfortable using computers themselves. These findings highlight two specific issues. First, the classroom of the nineties is indeed a varied one and there are a large number of vectors of difference that cut across the classroom. This is important since the second finding of this study is that there are several instances where it is possible to find significant difference in attitudes of the students based on their demographic background. It is particularly important to know these differentials since this could ultimately impact the level of learning and the overall evaluation of a particular learning tool.

Towards a Hypermedia System for Teaching an Introduction to Computer Systems

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Multimedia systems are receiving a great deal of attention. Hypermedia systems is a combination of such systems and hypertext. These systems have a great potential in education and in particular in computer science education. This paper reports on the developement of a hypermedia system for teaching an introductory course to computer system which will provide an ideal interactive environment for learning, teaching, designing and implementing students projects in related topics. The system consists of 10 nodes covering most of the traditional topics in the course. These are the History node, the Elementary Circuits node, the Digital Functions node, the Data node, the Organization node, the Peripherals node, the Simple Computer node and the Laboratory node. Finally, two more nodes, the Applications node and the IC Industry node, can be added to the system. A node may hold links to one or more sub-nodes each of which is designated for a sub-area of the topic involved.

MPW Object Pascal was used to develop several nodes such as the simple Computer. Other subnodes are built using Authorware Professional, Hypercard and MacApp. Ready packages such MacCAD, LogicWork and DigSim will be integrated into the design and analysis subnodes. Parts of the movies will be produced using existing software such as Macromind Director, Film maker and QuickTime. It is expected that the complete hypermedia prototype will be a living laboratory allowing students to navigate through the materials and to interactively modify the parameter of an environment in a particular node and study the results obtained.

Combining Hypermedia Authoring and Classroom Networking in One Software Environment

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Studies show that whereas people retain only about 10 percent of what they see and 20 percent of what they hear, they can remember about half of what they see and hear together and even 80 per cent of what they see, hear, and do. The educational advantages of multimedia presentation like television or movies (sight and sound) are obvious but even more so for interactive multimedia, with its component of interaction and response provided by the learner (Begley, 1993). Main advantages include the ability to share different sorts of resources on a computer, all stored in a similar technology, and user interactivity among different sources of information. A hypertext document is a wonderful multimedia tool, blending a variety of related materials into an interactive, highly visual mode of delivery. Readers can move around in a hypertext document at their own pace and direction, interacting with the material in a nonlinear fashion. But hypermedia applications are normally single-user and do not support collaboration and groupwork.

The educational software development group led by Dr. Robert Oakman focuses on multimedia authoring and groupwork editing tools. Since 1986 this laboratory has completed three nationally distributed pieces of educational software for the Macintosh. LiveWriter (Research Design Associates, 1990) provides interactive networked writing instruction. In LiveWriter a teacher can log onto a student's computer, see what he or she is writing, carry on dialogue about the work, and actually do editing simultaneously with the student. In 1991 LanguageWriter (Research Design Associates) added digitized voice recording and transmission features to the LiveWriter foundation. Teachers can record foreign language lessons in both text and voice; then students can read and listen to them and respond with either a written or voice response.

Expanding on the pedagogical ideas of the earlier programs, MediaLink (1993) allows teachers and students to author multimedia lessons (text, sound, graphics, digitized photographs, and movies) and then enter on-line collaboration for group work about these materials. Teachers and students can prepare their own Macintosh multimedia lessons by assembling a variety of text materials, sound files, digitized photos, or QuickTime movies. The program then becomes a collaborative learning environment with shared files and group work in a networked classroom. MediaLink allows sharing different sorts of resources on a computer, all stored in a similar technology, and user interactivity among different sources of information. The "drag and drop" interface used for linking resources and network users remains simple enough so that teachers and students can avoid the steeper learning curve of other hypermedia authoring tools and still be able to work together collaboratively. With MediaLink, the research paper of the future can be collaboratively created by several students and include a variety of multimedia materials.

Adding multimedia transmission and student feedback through the TCP/IP protocols of the Internet will make MediaLink a powerful distance learning tool. In fact, we are currently in the process of expanding these capabilities for the program to work in a long-distance environment. We are aiming for the same seamless delivery of multimedia materials and rapid user feedback through a broad band communication channel that we already have in a local area network. Research issues include the possibility of getting lost in cyberspace and the etiquette for turn-taking when multiple users are working cooperatively on the same MediaLink lesson.

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A development of multimedia CAI software with the expert system for learning environment problems

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Recently, the rapid technological advancement, the industrial activities, the sharp increases in population among developing countries, and the more mutually-dependent-international relations are altering many environments such as the one surrounding the earth.

In line with this trend, the necessity of preservation of the earth environment as a whole has begun to be recognized. How to make a balance between the environmental effects of human activities and preservation of the environment is a serious issue. To solve the environmental problems, the promotion of environmental education is necessary to educate the people to have good sensitivity and knowledge about the environment.

To reach these goals, we have developed a multimedia-based educational software which focuses on the environmental problem. This software has been developed for 5th and 6th grade students of a elementary school. In this study, cognitive science theory such as situated learning and knowledge-constructivism is considered. It is significant to provide the learning environment in which students can reconstruct their own knowledge through hypothesis-verification under the similar situated contexts.

The learning environment of this system is comprised of phase 1 and phase 2. Firstly, the students study the environment problems in the phase 1. Secondly, They go on the phase 2. In the phase 1, a student is requested to be a mayor who has the intelligence to improve the environment appropriately. The student can study the schemata and the causal relationship of environmental problems, which are classified and ordered systematically. In the phase 2, a simulator of designing a city is provided. A student becomes a mayor and is asked to make the city harmonized with nature under some constraints. The system illustrates the specified positions to become problem on the map, and gives the explanation of the consulting result by using the effective multimedia. The system shows the line of reasoning, and instructs the basic knowledge related to the situation of the region, with hypermedia of phase 1. In this manner, a student can learn the environment problems by himself. Moreover, the phase 2 is linked with the objects in the phase 1. Therefore, the system can give some advices which is suitable for each student utilizing the search method of objects-linkage in the phase 1. The teacher can arbitrarily set the system parameters by which the details-level of explanation is customized according to a educational purpose.

This system can teach a student the qualitative concept and superordinate knowledge of environmental problems. We have developed this system aiming to provide the learning environment under which students could raise up their critical mind and construct the profound knowledge of problem solving. Our further tasks are to develop the planning typed expert system in this frame work. Moreover, we need the function to have a student understood the scientific knowledge of environmental problems with qualitative simulators.

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A Multiple Knowledge Organization Environment The Case of "The Emergence of the State of Israel"

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The project presented in this paper is based on the following theoretical assumptions:

1. Computers perform in learning environments as knowledge tools (Chen & Oren, 1991). This concept is manifested in the environment hereby discussed through the variety of information items and the inclusion of various tools needed for producing knowledge out of any information item.
2. People differ in the way they interact with Information systems. Factors like cognitive styles, search objectives, former experience with computers and the type of learning assignments might have an influence on the search strategy they use (Marchionini & Shneiderman, 1988; McNeer, 1991; Oren & Chen, 1992). The knowledge environment described supports these differences by classifying information in various ways, as well as create hypertext links.
3. Developing an autonomous learner is a main goal of an educational system. A learning environment, as the one we describe, allows the students to control the information search process and the knowledge production.
4. Developing historical thinking is a main goal of history instruction. Analysis of these objectives shows that learning by research and discovery is basically information handling like: searching for relevant information, analyzing different sources and evaluating relevance of information (Morris, 1991; Egartua, 1991).

The knowledge environment we developed has three main features enabling to realize it's learning potential:
A flexible knowledge organization, a curriculum orientation and a self-content structure.

* The flexible knowledge organization is achieved through various ways of information accessing: a menu-driven content list or Boolean queries, different modes of knowledge presentation or levels of information complexity, as well as browsing around in an hypertext mode.

* The curriculum orientation is manifested through the selection, amount and variance of information items which are important for comprehending the historical subjects: texts (written especially for the system, documents and historical research, memories and dairies, poetry and literature), graphical items (pictures, map, caricatures, schemes and diagrams) and voices (speeches and songs).

* The self-content structure of the system is manifested through a dictionary explaining difficult words, a lexicon supplying information about people, institutions and terms, atlas of maps, a synchronic time-line and authentic voices. A note book integrated enables the students, while collecting information, to write down their ideas or to copy extracts from information items.

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Remote Learning and Training Services: How Disabled People can use Multimedia Applications

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The multimedia systems can be particularly suitable for the intervention for people with special needs. This intervention should comprise the following aspects: restoring the loss of functions, compensating for the disability by enhancing other skills, compensating for disability through the use of technical and not-technical aids and changing the environment to adapt it to the skills of the person.

The TeleCommunity project in the context of RACE II (Research and technology development in Advanced Communications technologies in Europe) is a set of Advanced Communications Experiments (ACEs) which aim to carry out work in advanced communications and is concerned with how the transition to Integrated Broadband Communication (IBC) affects the implementation of advanced services for people with special needs. Within TeleCommunity, the Portuguese ACE exploits the potential of ISDN in the support of disabled people, namely visual, mental impaired and elderly, both in the social centres' context and in the support of residential patient. The different provided services, namely Learning and Training services, allow the target users the access to further specialise support (Pereira L.M., Rocha, N.P., Cidade, C., Lebre, P., Purificação, J., 1993).

The terminal equipment for these remote care services are modular multimedia terminals, based in personal computers with video codecs (Tandberg Vision Model 15), and whose development is one of the goals of our participation. Each terminal offers an integrated capability to set-up, simultaneously, point-to-point videophony and data connections, typically between a service provider and a client.

For the user interface, both the service centre and client terminal user interface, a consistent metaphor has been established: the Virtual Resources Centre (Rocha, N., Cidade, C., 1993). This metaphor is based on the notion of a three dimensional room with different pieces of furniture and equipment, each one representing a different application (tool) with functions to establish connections over ISDN and with hypermedia facilities for preparing, presenting, accessing and discussing information. These hypermedia facilities obey to a server-client scheme that has been implemented with Object Linking and Embedding (OLE) technology, which able the use of commercial OLE servers.

During the pilot experience most of the users had demonstrated satisfaction (only 11% of the users had show inhibition, insecurity or tension behaviours), and they present good performance in the use of the facilities (Pereira L.M., Rocha, N.P., Cidade, C., Lebre, P., Purificação, J., 1993). Considering the staff opinion, they considered easy to use the equipment and when asked about the viability of the services they referred that the disabled users could benefit very much from these types of services. Furthermore, they considered essential the use of the videophony, otherwise they could not see the users that could cause a lack of "human contact".

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The Active User

(Some) Advantages and Disadvantages of Educational Hypertext

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The active participation of readers/authors is generally supposed to be one of the major advantages of hypertext systems (e.g. Landow, 1992). This is especially important for educational systems as there is some agreement that active involvement in learning leads to better results than traditional styles of instruction (Cunningham, Duffy, & Knuth, 1993). We therefore asked the students attending lectures at our department to develop their own hypertext documents. The students had technical as well as conceptual problems. To overcome their difficulties we decided to develop our own hypertext authoring tool. Many of the students' technical problems can be solved by this system, but some of the conceptual problems still remain. We have found out that there are basically three different areas which have to be considered when creating a hypertext authoring tool for inexperienced users: structure, text, and layout.

Many students apparently found it difficult to give their documents a clear *structure*. Especially the development of meaningful non-hierarchical links seems to be a complicated task. At an early stage of our project, most of the students made no non-hierarchical links at all. After the introduction of our authoring tool, link-making became much easier and students made many more links. But these links are very often quite irrelevant for the topic discussed at the source node.

The production of *hypertext* and of traditional linear *text* are two different tasks. In an essay, an argument can evolve over several pages or even chapters. In a hypertext document, text has to be self-contained and fragmented. It is necessary to be rather short and precise, and to restrict oneself to the essential points of a topic. This can be seen as an advantage of hypertext because it makes authors think in terms of structure. On the other hand, the fragmentation in hypertext documents can also be considered a disadvantage. Users of hypertext might learn to see information only as small separate chunks of text without any relation to a larger context. Students apparently found it difficult to adapt to the fragmented and self-contained nature of hypertext.

Some of the students had problems to create an acceptable *layout* for their documents. Generally, there is too little awareness of the importance of good user interfaces. In the context of hypertext, this is all the more detrimental. A good layout can convey much of the necessary structural information to give readers a comprehensive overview about the information available. In the documents we have analysed, good structure and good layout usually go together.

The authoring tool provides means which can be used to overcome these difficulties. There is an overview editor which not only gives students feedback about the structure of their documents but enables them to edit the structure of their documents immediately. To aid students in the link creation process we use "Typed links". "Typed links" are supposed to offer students outstanding link types they never thought of before and help them avoid irrelevant links. The authoring tool provides certain standard layout features to enable students to concentrate on the text. In the last version of our system we also included an automated monitoring system which can assist students and staff of the department in the analysis of the hypertext authoring process.

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Evaluation of a HyperCard-Based Application to Enhance ESL Interactions

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Although there has been a recent explosion of Hypermedia and Multimedia related applications in the last five years, and there are a great number of articles and books on the market about the advantages and disadvantages of such devices for education (Jonassen & Mandl, 1990; Ambron & Hooper, 1988, & 1990), we have little empirical research which shows the effectiveness of such applications for educational purposes. In this study, four pairs of Hispanic intermediate ESL (English as a Second Language) learners explored a HyperCard-based software application which was developed to generate learners' oral interactions in English. Users were audio and videotaped on three different occasions while exploring the application to see to what degree they interacted with each other in English while they interacted with the software.

Description of the Software

This HyperCard software application consists of a 12-unit package where English is presented through dialogues in everyday contexts. There are four main activities in the software:

- the lesson, where users listen to and read a dialogue in context and learn the specific vocabulary of the setting;
- the vocabulary test, where users are questioned on the vocabulary learned previously;
- the writing of the dialogue that allows users to type and print their own version of a dialogue;
- the scrambled dialogue game, where users are supposed to put a scrambled dialogue into the correct order.

Findings

The four different activities proved to be very different as far as English interactions are concerned. In activity 1, the lesson, users were highly engaged in navigating the application and exploring the different options built in the software, but little oral talk occurred. When talk occurred, it was mainly procedural and in Spanish. In activity 2, the vocabulary test, users' interactions with the software were clearly merged with their negotiation of meaning with one another. Users needed to discuss the answers with each other in order to successfully interact with the software. Their interactions, however, were reduced to one or two isolated words in English. This was due to the nature of the activity, which did not require users to create more sophisticated structures in English. In activity 3, the writing of the dialogue, users mainly interacted with each other to reproduce a dialogue in English. This activity produced the most English use. Users continuously rehearsed the dialogue to be typed and read aloud what they had written in English. In activity 4, the scrambled dialogue game, users interacted with the text on the screen by arranging the boxes of text correctly on the screen. Their talk was basically procedural and in Spanish in this activity.

Conclusions

Hypermedia and multimedia computer applications can be used to create communicative activities for ESL learners. However, users should not simply navigate these programs; they also need to take an active role in the production, oral or written, of long stretches of discourse in order to carry out a specific task at the computer.

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Software Tutorials vs. Instructional Video Sessions for Introducing Educational Technology to Teachers in a Chilean Elementary School Network

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The school network which is presently in growth, began with 6 school-nodes in Santiago during 1992 (see Hepp, et al., 1993), and it was then given full support and a decentralized implementation in Araucanía, one of the poorest and educationally worse-off regions of the country. The project, best known as "Proyecto Enlaces" represents the first official attempt ever done by the State of Chile, through its Ministry of Education, to generate new and pertinent answers to questions pertaining the role of technology, particularly that of computers and communications, in improving the quality and equity of education in the Chilean elementary school system. Until now, once admitted in the network, teachers have received on-site face-to-face training on each software application put at their disposal.

Our cumulated data thus far indicates that, before training began, 25% of the teachers thought they were incapable of ever learning to use a computer; 23.3% believed that, given their cost, computers would never become part of their schools; 18.7% believed computers were meant for any other use but education; a similar proportion of teachers (18.5%) feared that if he/she made a mistake, the machine would brake apart or explode; and, a 12% of them feared computers could take over the role of the teacher. Only 0.2% had prior knowledge and experience with computers.

Two months after training, 97% of participating teachers declared having developed a significantly more positive attitude towards computers than the one they had at the beginning, and 70% of them felt that, even though they needed considerable more practice, they could successfully use the computer in support of their regular teaching requirements.

In quest for a new approach to teacher training

The training scheme which has just been discussed proved to be beneficial while there was just a dozen schools in the network, and all of them located within a reasonable geographical distance. The planned expansion of the network for 1994 will mean at least a fourfold increase in the number of schools, and quite probably a similar increase in the number of teachers in need training. Furthermore, new schools will be distributed an area of approximately 31,850 Km². Any attempt to give live, on-site, teacher training in this new scenario, would be completely impossible.

From these new conditions, there derives an extreme need for implementing a new teachers training program: One that would not require the presence of specialized professionals for it to be successful and, at the same time, one that would retain the quality and avoid the errors of the previously implemented program. Two proposals for such a program are briefly sketched along the following paragraphs. Both programs will be put into test during the next expansion of the network in march, and their effectiveness assessed and compared, by may 1994.

Briefly, this proposal implies to compare, under as similar conditions as possible, the effectiveness of two self-administered instructional packages: One, consisting in an interactive software developed as a Macromedia Director application. The other, consisting in an instructional video containing exactly the same information contained by the software, but with emphasis on referencing actual recorded information from previous training programs.

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Research on conventional dictionary usage as insight for the design of online dictionaries in scholarly workstations

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Dictionaries are integral to hypermedia workstations (Weissman, 1988). These online resources would seem to be especially welcome in areas such as foreign language study where dictionary use is heavy. However, one cannot automatically assume that more resources guarantee more learning. This paper summarizes studies of the use of both conventional and computer dictionaries and glosses in foreign language learning. It is argued that the conclusions drawn from them may inform the design of online dictionaries on academic workstations.

Benoussan, Sim, & Weiss (1984) concluded that "less proficient students lack the language skills to benefit from the dictionary, whereas more proficient students know enough to do without it." (p. 271). Lantolf, Labarca, and den Tuinder (1985) identified three usage strategies: an avoidance strategy, a semantic field strategy, and a lexical formalism strategy. Aust, Kelley, and Roby (1993) found that subjects using computerized versions of dictionaries looked up significantly more words ($F=26.96, p<.000$) than those using the paper versions of the same dictionaries. In a followup study, Roby and Aust (1994) replicated this finding and also found that subjects who had text-specific glosses in addition to the dictionary read significantly faster ($F=4.62; p=.034$) than subjects who only had access to a dictionary (be it paper or computerized). No comprehension differences between the various kinds and formats of dictionaries were discovered in the Aust and Roby studies, but subjects preferred bilingual versions to monolingual ones. Davis (1989) found that subjects who received glosses understood significantly more of a passage than those who had no reading support.

Book dictionaries are said to be "arduous" to use, whereas on-line dictionaries are supposedly fast and easy (Keller, 1987). If such is the case (evidence to that effect has been cited above), it may be that users employ different strategies in their interactions with these aids depending on the media they are in (Daniel & Reinking, 1987). There is almost certainly a novelty effect for many users of computerized aids; this suggests that advisement needs to be built into online dictionaries to encourage their proper usage. Learners need to be counseled by teachers and reminded by online systems that a lexical "quick fix" is no substitute for careful reading and inferring from context. Although both bilingual and monolingual (e.g. Spanish-to-Spanish) dictionaries and glosses can exist online, language learners need to be nudged away from overdependence on the former.

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Hypermedia project: Audio, video, and HyperCard combined to improve student strategies for foreign language comprehension

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The Input Hypothesis, an integral component of Krashen's Natural Approach to language acquisition, contends that conversational fluency is acquired when learners are exposed to and understand verbal messages that are a little beyond their current ability. Language is "picked up" from target language input which is comprehensible enough for the listener to connect meaning to new linguistic forms through context. For second language acquisition to take place, both texts and tasks must be matched to the listeners' abilities.

A 1984 Texas study finds that 74.8% of college seniors with second language degrees achieve an Intermediate High rating on the ACTFL scale (Hiple & Manley, 1987). This means they leave the learning environment dependent on simplified speech, without sufficient receptive skills to interact comfortably with native speakers in a natural environment or to benefit from authentic language input provided by media. If graduates are to avoid stagnation of their communicative skills upon leaving the classroom, they must develop comprehension strategies which allow them to take advantage of authentic language in the real world.

ACCESS, an interactive audio program designed to help second language students develop comprehension strategies, uses subtitled films as the source of input. It interrelates key sequences recreated in audio and text form, vocabulary helps, cultural explanations, and comprehension questions with feedback. The aural segment, temporarily accessed through tape players, will be script-linked upon resolution of program/hardware incompatibilities. The program will serve as a template for use with other foreign language films whose content is beyond student skills. The pilot project is based on a film version of the Argentine epic poem Martin Fierro which evolves around a single character, maintains a limited point of view, and focuses on a single sequence of events narrated in chronological order. ACCESS is tailored to deal with the specific regionalisms and unfamiliar cultural material to be expected in subtitled foreign films.

In the pilot study, Martin Fierro was viewed by thirty second-year and twenty fourth-year Spanish students who wrote questions after the first viewing which they answered after the second. Between viewings, half of each group explored the computer program and half participated in class discussion.

Initial results show surprisingly little difference in expressed frustration and incomprehension among second and fourth-year students after their first exposure to Martin Fierro, though questions written by the latter indicate much greater actual comprehension. Plot summaries written by students who spent time on the computer are less accurate but more individual than essays written by students who participated in discussion groups. Self-evaluation of comprehension based on a 1-5 scale indicates that second-year students felt they improved by an average of 1.4 points, and fourth-year students rated their average improvement at .9.

Text reduction through cloze activities and the addition of audio input, even under less than optimum circumstances, significantly improves student evaluations. Text alone rates 3.6 whereas the combination of text and audio rates 4.4. Cloze exercises rate 4.6. Self-evaluation of comprehension does not increase significantly with access to audio, but whereas only 20% of general comments are positive from the groups accessing computer text only, 80% are positive when students can see the text and control the audio.

Students tend to consider unsatisfactory anything less than complete comprehension. Preparation for real-world comprehension tasks must include increasing student tolerance for the unknown and decreasing frustration thresholds. Student satisfaction and the reduction of frustration levels are more significant than measures of comprehension when the goal is an increase in voluntary exposure to authentic language input.

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The Design of an Effective Software Interface for Interactive Video

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In this paper, guidelines for designing an effective software interface for interactive video are examined. At a basic level, *software interface* is defined as the communication system between the computer and the user. At a higher level, interface is the process whereby the learner interacts, participates in, and contributes to the learning event (Rieber, 1994, 211). The design of the interface can significantly effect the quality of interaction that the learner has with the learning environment as well as the construction of one's own knowledge base. From a constructivist view, one's knowledge is constructed while interacting with the learning environment. Thus, the design of the interface with which the learner interacts impacts the kind and quality of knowledge and learning experiences derived from this interaction.

Interactivity, cueing strategies, global control, local control, learner control and pacing, use of symbols for navigating, and the use of consistent applications are interface design factors that are examined for their relationship to interactive video.

Interactive video should allow students to select from various options and to branch, as well as to create their own material--demonstrating imagination, critical thinking, and problem-solving skills. If the interactive video does not attempt to provide directions for students, be concerned with levels of student achievement, or account for different individual learning styles, then whatever interactivity exists is of limited worth in an educational setting (Semrau, P. & Boyer, B. A., 1994). Passive video viewing, lecture formats, the use of drill and practice, and student-chosen paths without direction or feedback tend to be the poorest use of interactive video (Yoshii, Milne, & Bork, 1991).

The issue of how to relate abstract, formal knowledge to particular real world situations can be addressed by the interface design. Students have difficulty linking their abstract understanding to actual applications. Being able to alter and manipulate microworlds in interactive video programs allows students to use both formal cognitive information to applied knowledge in the sciences, the arts and humanities.

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Authoring Considerations in the Imaginary Museum Project: The Sistine Chapel A Case Study

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The Sistine Chapel Project has been created based on Andre Malraux's (Malraux, 1947) conception of a virtual, or imaginary museum. Its basic idea is that given the invention of photography and mass production of picture books, it is no longer necessary to travel to see a museum. Each book containing a reproduction of a work of art is itself a virtual museum. The project extended this conception from books to multimedia. Among the many educational goals envisioned by it, the most important ones concern the integration of cultural and artistic aspects into a regular curriculum scenario. The inherent complexities involved demanded the use of two authoring methods. Both authoring-in-the-large and authoring-in-the-small approaches had to be used to model the application. The methods chosen were HDM (Garzotto, 1990) and Hiper Autor (Breitman, 1993) respectively. The authoring-in-the-large approach allowed us to create a framework where other applications can be developed, e.g. The Brazilian Museum of Folklore, while the authoring-in-the-small approach helped us in modeling the Sistine Chapel application in particular.

The conjunction of both methods proved to be a very useful strategy. The combination of the advantages offered by both approaches have resulted in the production of a high quality and reliable application that is being used now by students at schools. Among the benefits are:

completeness, in the sense that it is possible to model the application in two levels of abstraction, given by authoring-in-the-large and authoring-in-the-small, providing total understanding of the application's objectives while avoiding inconsistencies and mistakes,

expression, allowing the description of concepts and structures at the appropriate level,

simplicity, so that the methods can be used by any authoring team, independent of their previous experience in developing hypermedia applications (Garzotto, 1991; Breitman, 1993; Alty, 1993).

We believe that in the near future we will continue to use the strategy derived from the use of both methods to underline the construction of new applications in the imaginary museum context. Among the possibilities are the production of an application concerning the works of art in the Brazilian Museum of Modern Art.

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Interactive Video in Preservice Physical Education Instruction: Comparing Two Interaction Approaches

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The purposes of this study were twofold. The first purpose was to develop an interactive video system designed to introduce preservice teachers to potential discipline issues experienced in physical education. The second purpose of the study was to determine the impact of an interactive video system and group decision support systems technology on the acquisition of discipline content knowledge. Specifically, the study examined (a) the effectiveness of an interactive video system in acquiring discipline content knowledge; (b) the effectiveness of group decision support systems technology in acquiring discipline content knowledge; and (c) the effectiveness of interactive video in combination with group decision support systems technology in acquiring discipline content knowledge.

Subjects were 55 college students enrolled in two Analysis and Movements of Volleyball courses during the 1993 spring semester at the University of Northern Colorado. The subjects were assigned to one of three treatment groups based upon two characteristics--gender and pretest scores on a Discipline Content Knowledge Test.

The interactive video (IV) group consisted of six females and twelve males received instruction in discipline content knowledge using interactive video. The decision support (GDSS) group viewed the discipline scenarios using the group decision support laboratory. Six females and twelve males comprised the second group. The combined (COMB) group consisted of seven females and twelve males who received instruction using interactive video and the group decision support laboratory.

Results

A one-way analysis of covariance (pretest for content knowledge was the covariate) indicated no significant differences among the three treatments groups on posttest scores, $F(2,51) = 0.33$, $p = 0.717$. However, all three groups did show improvement from pretest to posttest with only the IV group showing a significant increase in discipline content knowledge as shown by t-test, $t = -2.81$, $p = 0.006$. Both the GDSS and COMB groups required 135 minutes to complete all six scenarios, while the IV group averaged 45 minutes with range from 32.6 to 65.6 minutes.

From these results, it is evident that the IV treatment is at least as effective as the other two treatments. In addition, the IV group completed the material in one third of the time and without instructor intervention. This time savings and the fact that the material was learned without the instructor suggests that implementation of this type of instruction will reduce training time and provide opportunities for instructors to either cover more material or cover material to a greater depth, concentrating on problem solving or other "high level" skills that benefit from instructor intervention.

Designing Effective Multimedia: Guidelines for the Interface

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Multimedia is fast becoming THE buzzword of the interactive training world leaving both consumers and developers of interactive training confused by the vast array of widely differing products and options with little guidance for selection or implementation. Practitioners involved in developing multimedia computer-based interactive training systems are currently producing their systems in a standardless world. The lack of standards creates more uncertainty for students, end users, and novice developers than is desirable. For example, students may be unfamiliar with icons that developers take for granted. The "return" icon may be confused with the "previous page" icon. In addition to the possible unfamiliarity with the interface conventions used, the students also bring their own preconceived notions of how a system should work. When the interface and the student's mental model match, the student may find the system easy to use and effective. When there is no match, the student may find a system difficult and possibly frustrating to use. In general, the goals of interface design for the instructional/educational use of multimedia are: an environment that supports learning; a system that does not frustrate the user; and a system that allows the user to accomplish learner goals. A set of guidelines would be helpful in meeting these goals. However, Shneiderman (1992) cautions that "A clever design for one community of users may be inappropriate for another community. An efficient design for one class of tasks may be inefficient for another class" (p. 12). Our search for guidelines examined information structures, navigation structures, and icon use.

There are two general types of information structures for multimedia design the physical structure for the development environment and the cognitive information structure (concept map). While a number of different ways to analyze and design these structures have been identified, there is little empirical guidance for the effective use of the structures. Several studies have investigated navigation structures but, the results appear to be user purpose and context dependent. Little is known and even less has been investigated concerning icons used for instructional/educational multimedia. Icons should be intuitive representations of the object or action for which they stand. Where confusion may arise, the icon should be replaced by either a different icon or unambiguous words.

In searching for a "better way" to develop multimedia documents for learning/instruction, many offers of guidance have been found, but few with any empirical basis. For the most part, guidelines derive from two sources, theory (whether untested or based on what works for individual media) and experience. While experience can often lead in the right direction, it can just as often lead in the wrong direction. Those studies that are reported suggest that many of the techniques tested made little or no difference in learning performance. However, the short duration of the treatments in many studies may provide misleading results. Only with long duration treatments can the actual impact of multimedia designs on learning and attitudes be determined. Until validated guidelines for the design of hypermedia and multimedia documents are developed, the facilitation of the learning process will be hit or miss at best. While the available, largely untested, guidelines are useful, they should be used with a "grain of salt". To be effective, any interface must be thoroughly tested. Where the guidelines are accurate, follow them. Where they are not, experiment and test using your audience until an adequate solution is found.

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So What If It's In Color and Moves? A Critique of Multimedia

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Educators have used the term multimedia in a global sense for years: outside the classroom the term was rarely heard. Research in multimedia was spurred after the second World War by the military interested in increasing training effectiveness and conducted by new research graduates eager to carry out the studies.

In recent years, the prospects of huge businesses to be spun out of the multimedia and information superhighway efforts has brought the term multimedia out of the closet and into the public view. For example, Naisbitt (1994) has written that multimedia will become a dominant force in the next decade and the two most significant applications will consist of entertainment and education.

Multimedia may be defined as the components of conventional media (computer, video, graphics, animation, audio, color) along with their path to complete integration, which is now just in its infancy.

This paper examines research and guidelines for use for the multimedia components of color and animation. Color was chosen because there is so much incorrect information in common folklore about the alleged effects of color on achievement. Animation is examined as it is the new kid on the block which will likely grow quickly as the hardware and software systems bring us desk top animation. The paper will conclude with a summary of a research study which demonstrates positive learning effects of animation on learning and attitude.

Most instructors would agree that color used in instruction (1) increases learning, (2) makes the instructional environment more appealing and therefore increases attention and motivation to learn, and (3) does not distract from the learning tasks at hand. Unfortunately, they are not completely correct. Extensive research on using color to increase the level of reality in an instructional situation shows that learning is not generally enhanced by color (Wise, 1982; Dwyer, 1967, 1968, 1970), with certain exceptions. Several recommendations for the use of color will be provided.

Animation refers to the use of a series of graphics which change over time or space. There is a significant body of research on graphics in instruction in training with considerable evidence as to their effectiveness. Although animation does not have the rich research history that is associated with color and graphics, the results are encouraging. For example, Baek and Layne (1988) compared learning conditions of text only, text plus graphics, and text plus animation. The adults in the study scored higher in the animation condition than either text or graphics. The animation condition also resulted in less study time, suggesting that animation results in more efficient learning. In another study with adult learners, Mayton (1991) found increased scores in the animation condition immediately after study persisted and were measurable one week later. The authors recently found that animation results in increased achievement of the learning task and improved attitude.

A major recommendation presented in this paper is to analyze the relevance of graphics/animation and color cues to the learning outcome and use those cues appropriately in the instructional, practice, and testing situations relative to the particular learning objectives.

Knowledge Based Tutoring System for Learning Lithuanian Language

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The purpose of this work is to build up Computer Based Lithuanian Language Learning System which will satisfy needs of various users (school-children, students, etc.). The Computer Based Lithuanian Language Learning System is considered as a part of the general Intelligent Tutoring System (ITS), which include the following modules: subject oriented tutoring modules, subject oriented data base modules (vocabularies, tables, specific subject information), tasks and lessons making data base modules, and knowledge based students modules. The project of ITS for learning Lithuanian language includes such steps: 1) building up the vocabulary; 2) filling in the vocabulary; 3) making lessons; 4) learning process control.

The main goal of the computerized vocabulary is to accumulate and supply systematized and classified information about words and their constituent parts. Commonly, a word can have more than one constituent part of the same type. On the other hand, the same constituent part can be a member of a great variety of words. Therefore, to avoid redundancy we have used a relational form of the vocabulary. Within the limits of the School Orthographic Dictionary of Lithuanian (about 16000 words), classification, structurization and characterization of information presented in the dictionary was made. Classification means assigning each word to one of the parts of the language (e.g. Noun, Verb, etc.). Structurization means singling out syllables and parts of a word and indication of stress. Characterization is connected with indication of certain attributes and additional information, and is performed for each of the parts of the language according to a separate pattern. The Lithuanian language model implemented in the vocabulary base allows to perform syntactical and morphological analysis of student answer (Baniulis, Dmuchovska, & Tamulynas, 1993).

The tutor designs lessons using vocabulary and task bases, forms his own teaching strategies preparing compound lessons. The teacher can use an ability to add new subject knowledge into the data bases if necessary. Traditional exercises, game situations and dynamic models are being employed for the lessons modules, using various techniques: to answer, fill in the gaps, compose the answer from separate elements. In the game-play approach traditional tasks are supplemented with visual illustrations (a train, stairs, a balloon etc.). Dynamic models make the original graphic illustration of the verbal text. The special authorized editorial programs and modules are used to make easy the design process of all types of these lessons.

The ideal behaviour of an ITS system for knowledge based learning process control is required to be similar with that of human tutor. This purpose is achieved by making references to a human tutor's desired characteristics and simulating natural learning process. ITS consists of the four types of knowledge based modules. They are the problem-solving expertise, the knowledge based student model, the tutoring strategies and the model of natural interaction process student-computer.

All these ITS's modules as well as another constituent parts and data bases are implemented in C++ object-oriented manner. So, they are closely interconnected with each another and have possibility for corrections and additions. Currently the ITS for learning Lithuanian language is on going research under testing and verification presented modules and data bases. We hope the first version of this system soon will be used in Lithuanian schools and universities for training school-children or teaching foreign students.

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Changing the Way Electromagentics is Taught: Precision Teaching + Interactive Simulations

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An introductory physics course is taken by approximately 100,000 pre-engineering students in the United States each year. More than 30% of these students fail to graduate as engineers. Most of that attrition occurs during the first two years, in part because of struggles with basic mathematics and science courses. The present effort focuses on developing and assessing computer-based instructional systems for enhancing student performance in the second-quarter physics course in electricity and magnetism. This course is perceived as the most difficult of a three-quarter sequence, with some 30% of students making 'D', 'F', or withdrawing.

Part of the difficulty of the course resides in erroneous notions about concepts such as voltage, current, and electrical energy brought to the course by students [3]. While a basic course in mechanics deals largely with forces and moving objects accessible to everybody in everyday life, electricity and magnetism are phenomena generally accessible only through complex measuring devices. Thus, establishing intuitions about such concepts is a hard task when only traditional materials are available. Another problem identified by veteran instructors and a diagnostic test is a less than automatic application of basic mathematics. Students spend a great deal of cognitive energy executing routine calculus procedures.

Two very different instructional strategies are currently being applied to these problems, precision teaching of basic skills and interactive simulation. Precision teaching, a concept pioneered by Lindsley [4] is a technique for the enhancement of basic skills and achieving fluency. Students undertake a large group of simple problems and their success is measured by the number of correct responses in a fixed time interval. Fluency of correct responding, or the rate of correct responses, is a critical feature of the evaluation [1]. With repeated exposure to different problem sets, rate of correct responses typically increases. The rate is actively recorded by the student. It has been demonstrated that using this approach basic skills are enhanced, performance in standard courses is improved and the improvement is retained for extended periods [2]. A prototype exploratory simulation microworld, Electroworld, is currently under development as well. This environment allows students to interact with forces, fields, and charges in a concrete visual manner. As a result of engaging this simulation environment students are learning to visualize many abstract concepts of electromagnetism for the first time. Preliminary analysis of a group of students using the precision teaching material as compared to a more traditional approach of assigning additional homework problems has shown a significant shift in final grade distributions from D and F to A and B.

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Computer Based Instruction in Traffic Theory

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Traffic legislation is the primary source for deriving education in traffic theory in the Netherlands. Consequently, programs are formal and abstract, emphasizing definitions, the meaning of signs, and right-of-way rules. For example, students learn to identify the sign indicating a motor-way, learn that a car belongs to the category of motor-vehicles, and that the speed-limit for motor-vehicles on motor-ways is 55 miles/hour. It is up to the student to acknowledge the implications of the newly acquired knowledge for driving behavior in actual task situations. Thus, the relation between theory and practice is very indirect. This approach appears to fail at teaching students the necessary knowledge and skills for driving a car, as indicated by a non-existent or low contribution to driving performance (Brown, Groeger, & Biehl, 1987). It is our belief that if instructional material is selected on its relevance for every day traffic behavior, education in traffic theory can contribute much more to the development of proficient driving.

This paper reports the development of a program for teaching traffic theory, based upon principles of learning and instruction. Recent technology offers ample opportunity for effective application of these principles. The program is therefore designed for use in a multi-media environment. The project is carried out under contract to, and in collaboration with, the driving schools of the Royal Netherlands Army.

Cognitive psychology has shown that the prerequisite knowledge and skills to perform a certain task are best attained if the material to be learned is selected according to its relevance for actual task behavior, and presented in a representative context ('situated action', e.g. Norman, 1993). The present program meets these principles by giving instruction on how to recognize traffic situations, how to identify potential problems and conflicts, and how to act appropriately when in such situations. To illustrate for the example presented above: students are instructed how to recognize motorways (on formal, but also on informal characteristics, like dual carriageway) and how actual task behavior is affected by various factors (such as speed limit, road- and weather conditions, traffic intensity, etc.).

The situated action framework indicates that students can make the link between theoretical knowledge and practice more readily if the information is presented in real-life like contexts. The efficacy of instruction can be further increased by comprehensive student activity. Recent technology is utilized to accomplish these objectives. For example, digitized photo's offer new possibilities for instruction in road classification; features of a road category can be added or deleted at will, thus allowing for effective highlighting of essential characteristics. Defining sensitive area's in the picture permits program-student interaction (e.g. by mouse-clicking). Until recently, dynamic aspects of driving could not easily be implemented in interactive learning situations. The present program utilizes digitized video to show (potential) problems and conflicts in traffic situations, to show the outcomes of different reactions to a certain problematic situation, and to show the antecedents that produced the problematic situation in the first place.

The development of the program is currently underway along the lines presented above. Two modules (of 12 in total) have been developed in full in a prototype. An evaluation that was subsequently carried out produced very promising results. Especially the video fragments turned out to be very instructive and motivating. Instructional materials for the other modules will be implemented in an inclusive program of which we hope to show that it optimizes actual driving performance by providing students with comprehensive and relevant knowledge and skills.

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MNP: A Multimedia-Based Project to Teach an Introductory Nutrition Course

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The Multimedia Nutrition Project (MNP) was designed and developed to improve the delivery of nutrition instruction by means of multimedia technology. MNP consists of a series of modules which are to be used in both lecture presentations and student labs. Some of the specific topics include dietary behavior modifications such as low fat food choices and low fat cooking methods, dietary guidelines, food guide pyramid, dietary fat and heart disease, and composition of foods. Each module had two levels of interactivity: 1) multimedia classroom presentation (MCP) used by faculty members to deliver instruction of a selected topic and 2) multimedia labs (ML) used by students for drilling and testing of concepts introduced in lectures.

MNP Modules

The following are some of the module highlights of MNP.

1. The MCPs were developed in Freelance Graphics 2.0 for Windows. Many link other customized applications created in Toolbook, Excel, 3D Studio Animations, and Digital Video Interactive (DVI). For example, one MCP embedded a graph produced in Excel depicting the fatty acid composition of oils in foods. As new formulations of products occur, the graph can be easily updated. Another interesting aspect of MCPs is the random student picker icon developed in Toolbook. When clicked, it displays name and image of a randomly selected student in the class. Another MCP focuses upon processing of fats. Hydrogenation becomes more than a word when the students view a three-dimensional animated model (developed in 3D Studio) of the fatty acid structure. The rotating carbon molecules demonstrate the difference between the cis and trans forms of the molecule. MCPs provide faculty members with the ability to incorporate relevant video material into a digital video library using DVI technology. At the touch of a button, such video clips can be retrieved and played when appropriate.
2. MLs were developed using Multimedia Toolbook, 3D-Studio, and DVI. One ML contains a variety of activities to reinforce the concept of lowering dietary fat. The activities include browsing through audio-visual material depicting appropriate meat serving sizes, low fat cuts and grades of meat as well as low fat cooking methods. Video clips pertaining to heart disease and artificial fats can be accessed to relate current research. In another ML students interactively review the U.S. Dietary Guidelines. Each of the 7 principles is presented using animation and hypertext capabilities. The student also can move through the Food Pyramid interacting with each of the food groups. Each group describes the appropriate serving size and number of servings. Voice over is used to present additional instructor comments. The student can also navigate further through the pyramid to learn about sample menus which illustrate the amounts of actual food recommended.

The purpose of this project was to design and develop an interactive multimedia system to aid instructors in teaching and their students in learning basic nutrition concepts. A pilot test involving twenty two students in an introductory nutrition course was carried out. The results from the post-evaluation were very promising. However, more research is needed to assess the impact of this method of instruction. The next step is to further explore the usefulness and acceptance of the system.

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Cost-Effectiveness in Decision Making about Media in Education and Training: An (Inter)active Decision Support Approach

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The main reasons that cost-effectiveness of media in education is so difficult to analyse are the different definitions of the term cost-effectiveness, measurement problems and interpretation problems. The first problem automatically causes the second which is additionally improved by differing measurement methods, criteria values and infrastructures within analysis takes place. Differences between people, cultures, systems improve the problem of using a consistent frame of reference (Kozma, 1991 and Clark, 1990). Because of these differences, assisting decision makers in the use of general frameworks should have priority then over the construction of more strictly defined methodologies that constrain the individual flexibility that is needed in personal and organisational settings which have the majority in decision making settings.

Cost analysis of educational media projects has been topic of research for a long time and there are some useful frameworks developed in the past (Levin, 1983). The effectiveness of educational media is a greater problem. Technical problems with measurement instruments, comparability and validity, and media which are often used as a part of a curriculum, make results, if available, rather questionable to draw reliable conclusions from (Strittmatter, 1992). The use of indicators of effectiveness like test score increase, change in attitudes or performance improvement and the expectation of decision makers about the potential of the media in reaching criteria values on these indicators can be a solution to reliability and interpretation problems in this area (Moonen, 1990).

To assist decision-makers in cost-effectiveness analysis an instrument has been developed. This instrument (called ESTIMA) is a computer program consisting of nine units. Three units deal with the selection and evaluation of media. Three units deal with the product level when a media selection has already been made. One unit is on resource allocation where decision makers can allocate their resources to a large set of cost items (people, equipment, etc.) and analyse also the sensitivity of certain allocations on other items. One unit deals with effectiveness estimation where expectations, empirical data and experience should be combined to come to a reliable estimation of the effectiveness of the use of a media application. The final unit deals with return on investment and here the decision maker can analyse the costs and returns of the use of modern interactive media compared to the use of traditional classroom teaching strategies. The program had to be flexible with regard to the users background, easy to learn, user friendly, well documented and not too much time consuming. The program has been developed with the Visual Basic programming environment under Windows. An evaluation of ESTIMA is planned where the value of the program will be evaluated and also the general usability of decision support systems in cost-effectiveness analysis and differences in the use of these systems between decision makers in commercial and in non-commercial organisations, between decision makers in large and in small organisations and between decision makers in different academic levels.

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A Decision-based Hyper-multi-media Case Environment for the Computer Productivity Initiative, a Large Undergraduate Project

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This paper describes our experience in using a multimedia project management and problem solving tool to support a multi-year Computer Productivity Initiative (CPI) project [1]. The purpose of the CPI project is to provide undergraduate students with a diverse set of skills required for the conception and development of solutions to large real world problems. In order to organize and develop a solution effectively, the students must work with a broad range of documents including video tape interviews of experts, presentation graphics for slide shows, computer drawn figures, charts and graphs, spreadsheets, as well as postscript of other forms of textual documentation. To organize and access the various media documents developed during the course of a CPI project, we are employing DHC (Decision based Hyper-multi-media CASE) tool developed to support the Decision Based Systems Development (DBSD) paradigm [2]. At the same time, DHC is used to guide and support the problem solving process the students employ to arrive at their solution. DBSD organizes the process of project management as well as the project document base around the decision making process. Our experience has demonstrated the value of a hyperlinked, multimedia project space in the development of large, group collaborative real world projects [3].

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Improving qualitative reasoning with an anchored computer simulation

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Research in cognitive science has demonstrated that expert problem solvers have "deep" knowledge about the structure of their domain, i.e., they understand the relationships among variables in the domain and know the general principles that help to make predictions and solve problems. In contrast, novices remember problems in terms of easily observable surface features that may not be important to the problem's solution. Interacting with computer-based simulations can help novices move from knowledge representations that are based on the surface features of specific problems to representations that are based on the deep structure of general classes of problems. In the typical instructional approach, novices create a series of related problems by changing the values of variables in the simulation and observe how the corresponding outcome changes when the simulation is run.

There are, however, several reasons that novices may fail to develop more expert knowledge representations while using simulations: First, using a simulation requires some initial knowledge. If novices do not have this knowledge, they may be unable to use the simulation or to understand the feedback that it provides. Second, they may be unsystematic in exploring the problem space and may create a series of unrelated problems. Third, even when problems are related, novices may fail to compare successive executions of the simulation appropriately.

Anchored simulations can minimize these problems by situating learning in the context of a single problem over an extended period of time (CTGV, 1992). First, prior to using the simulation, students view a video that presents a complex mathematics problem as a story and work with their classmates and teacher to learn to solve this "anchoring" problem. In this way, they acquire basic knowledge of the problem and its solution that provides a foundation for using and understanding the simulation. Second, students cannot create unrelated problems, because an anchored simulation only enables creation of variants of the anchoring problem. Third, an anchored simulation creates an activity that causes students to automatically reflect on differences between problems.

The prototype simulation is anchored in a trip planning problem in which the main character purchases a boat and must decide if he has sufficient daylight and gas to drive the boat home. The student learns to solve this 16-step problem in class before using the simulation. Within the simulation, the student is challenged to a race by the main character and must make a single modification to an otherwise identical boat in order to win the race. The student then makes qualitative predictions about the race and confirms them quantitatively. When the simulation is run, the two boats race against each other, giving the student feedback on the predictions and calculations. The student is encouraged to undertake a systematic series of changes to the parameters affecting the boat's performance. Through this process, the student acquires a general model of trip-planning problems.

An in-school evaluation was conducted with 62 high- and average-achieving 6th-grade students who used the anchored simulation following classroom instruction in the anchoring problem. Use of the simulation helped students at both levels of ability improve their qualitative predictions about the outcome of trip-planning problems in the context of the anchoring problem and in other contexts (Williams, Bransford, Vye, Goldman, & Hmelo, 1993).

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Hyper3D: Stereoscopic 3D Hypermedia

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Hyper3D is a novel approach to interactive multimedia and hypertext/hypermedia presentations. Through the use of stereoscopic 3D LCD computer panels, the images are presented in stereoscopic depth with the ability to perform searches. This allows students to have both a better understanding of the material as well as increase attention and possibly retention. Prior to Hyper3D, there was no method of displaying and selecting stereoscopic 3D images which would allow both a large audience and assure high quality stereoscopic 3D images.

The long term goal of Hyper3D is to develop a complete history of stereoscopic photography from 1850 to the present day in digitized form. An estimated 8 million different commercial stereocard titles were released in their 60 year history in addition the many Hollywood movies produced during the 1950's. This does not include the many millions taken by amateurs or for office or educational uses. Two prolific amateur stereophotographers include President Eisenhower and silent film star Harold Lloyd.

Prior to Hyper3D, the majority of the public have not been able to see truly good stereoscopic 3D images. Subsequently, they are unaware of the long and varied history of stereophotography and more importantly the wealth of images represented in that format. Consequently, they have not been exposed to an important part of history in its original format. Using the flexibility of a hypermedia front end, the same images can be used to illustrate the history of photography, the development of photography as an art form, historical events, historical figures, architecture and any subject the user would wish to explore.

The ALPHA version of Hyper3D was designed on IBM 80286 with a Tektronix stereoscopic 3D monitor with the support of the USAF. The BETA version was developed on a IBM 80386 with a StereoGraphics stereoscopic 3D monitor. The final, commercial version is being developed on the VRex, micro-Pol system. This allows the conversion of nearly any active matrix LCD panel including stand alone monitors, laptops and project panels to be used. Both individual use on a laptop and projection to a large audience are possible.

Current chapters in Hyper3D include: Introduction to Visual Perception, The Evolution of Photography, How to Make Your Own Stereophotographs, Wonders of the World (both natural and manmade), Famous Personalities, Fashion Through the Ages, Weddings Through History, Religion, Sports, and Humor. Each of these will be released separately with links to each other allowing the user to add to their title collection through the same interface.

Each of these chapters may be searched on key phrases as well as be the image title, photographer, publisher and geographic location. Using the same database of images, several interfaces are used for various age groups and interests. These include very simple GUIs in a 3D Atlas style, allowing the user to click on a map location and subsequently showing an image from that location. These include both antique stereoscopic images from the 19th century, contemporary stereoscopic 3D images and computer generated reconstructions.

Other interfaces include a modified VCR interface allowing the user to page and fast forward through sequences of stereocards. Many sequenced stereocard sets were released in the 19th century that would explain an event (or even tell a story or joke) through sequence of stereocards, sometimes numbering in the hundreds of views.

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CALL for German for Reading Knowledge

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Teaching foreign languages is often associated with a considerable degree of frustration: one seldom achieves a desired degree of fluency in a class, even after two or three years, let alone a single course. This certainly holds true for what one may term "standard language courses" - the kind through which one seeks to impart "total" knowledge of a language on a group of students. Considerable progress can, however, be made in the comparative short time of one academic year if one stresses solely one particular aspect of the language learning process, that of reading comprehension. At UBC we are currently producing a computer-based program that will enable students to gain competence in dealing with technical texts in German. With the aid of software that we are developing here, we hope to address the needs of students from various disciplines, assisting them in acquiring reading knowledge in German through working with texts from their particular field. We have also been careful to stress an approach through which students will master proper reading strategies so as to avoid the traditional pitfall of translation that is potentially destructive in the fostering of true reading ability.

Since we had emphasized reading strategies above all else, we were unable to find an authoring system that would meet all of our needs in the development of the software. We had envisioned a program through which the individual student would not only be tested on the content of a passage via short answer type questions, but also be given the opportunity to work with that particular passage in a way he or she desired, to mark the text in any of a number of different ways, identifying key elements as well as those which pose the most difficulty, or even (temporarily) deleting portions of the text. We have also developed the idea of answer screens with which students can, for example, compare their own summaries of a particular text with "standard" ones, that is to say, with our own. To integrate all of these features into our computer program, we were forced to link some form of word processing program to an normal authoring system. The result may be somewhat complex, but the program has already proved itself to be highly successful in our German for Reading Knowledge course. In the years to come, we hope to develop a new authoring system that will greatly simplify our present program.

Designing and Using Virtual Environments: The Advantage of Immersion.

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Although a variety of multimedia formats are now called "Virtual Reality" (Heim, 1993), the greatest innovation that the new VR technologies offer, and their greatest potential for educational applications, arise from those technologies that permit immersion. In an immersive environment, participants experience the illusion of being in another place in which they can move and look around in the same manner as in the real world.

An immersive environment has two advantages over non-immersive VR. First, it permits the participant what Clancey (1993) has called "first-person" experience of events. Much of formal education requires students to learn from descriptions of events and phenomena prepared by a third person. Immersive VR allows participants first-hand experiences. Second, interaction with a virtual environment can be achieved non-symbolically. Looking, pointing and manipulating objects in a virtual world are natural actions. It is not necessary to master a complex linguistic, mathematical or other symbol system before interacting with the virtual environment. It is therefore possible to master concepts before mastering symbols (Winn & Bricken, 1992), which is a great help to those who have difficulty thinking symbolically.

Because of these characteristics, the design of virtual environments for education has a different emphasis from "traditional" instructional design. Any knowledge or skill that are acquired from virtual environments are constructed by participants, not imparted didactically. This means that virtual world designers are concerned primarily with designing ways for participants to interact with worlds as easily, freely and imaginatively as they wish. The designer is therefore less concerned with presenting content so that it can be interpreted in one correct way, and is probably not concerned at all with the mastery of predetermined knowledge and skills described in performance objectives. Next, the designer is concerned with the appearance and behavior of objects, alone, in interaction with each other and with the participant. This is because the power of virtual environments stems not from their ability to simulate aspects of the real world but to make accessible to the senses and to interaction aspects of real and imaginary worlds that have hitherto not been represented. The designer is therefore concerned with such things as how to represent complex data sets, the inside of an atom, or the edge of the universe. Finally, the designer is concerned with how the participant may be guided -- not coerced -- along potentially fruitful paths. A virtual world without this kind of structure can be a disorienting place. This draws the designer's attention to the rules that govern the virtual world, and the extent to which they are enforced. For example, a world that obeys the laws of algebra rather than of physics could, if enforced, prevent participants from making mistakes when they factor algebraic expressions. Or they might be relaxed to allow mistakes from which participants will learn subsequently through "debugging". Varying the enforcement of rules governing virtual worlds provides a great variety of learning strategies for participants to employ.

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Design of An Inquiry Teaching Agenda Planner

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This paper describes a project to study the feasibility of implementing the inquiry teaching method of [Collins & Stevens 1982] as tutoring software. In building the Tutoring Agenda Planner (TAP), we seek to integrate the two sets of architecture presented in [Collins & Stevens 1982] and [Peachey & McCalla 1986]. Collins and Stevens illustrated their theory, which was developed almost inductively by "observing" expert teachers. The theory which is meant to be domain-independent contains three parts: the goals and subgoals of teachers; the strategies used to realize different goals and subgoals; and the control structure for selecting and pursuing different goals and subgoals. Teachers typically pursue several subgoals simultaneously. Each goal has associated with a set of strategies for selecting cases, asking questions, and giving comments. In pursuing goals simultaneously, teachers maintain an agenda that allows them to allocate their time among the various goals efficiently. There are two top-level goals that teachers in inquiry dialogues pursue: (a) teaching students particular rules or theories; (b) teaching students how to derive rules or theories. There are several subgoals associated with each of these top-level goals. The dialogue control structure that the teacher uses to allocate time between different goals and subgoals is a crucial aspect for effective teaching. The control structure consists of four basic parts: (a) a set of strategies for selecting cases with respect to the top-level goals; (b) a student model; (c) an agenda; (d) a set of priority rules for adding goals and subgoals to the agenda. Given a set of top-level goals, the teacher selects cases that optimize the ability of the student to master those goals.

Peachey & McCalla introduced a course planner which is capable of planning global teaching strategies by using local information. The work reported here attempts to combine the planner portion of both sets of architecture. The integrated planner is complemented by an executor of plans with various teaching strategies and a domain-dependent natural language processor.

TAP is intended to serve as a tool which can be used to design the tutoring component of an intelligent tutoring system using an inquiry approach of teaching. The focus of the work is the planning process involved in conducting an inquiry dialogue. It is also an application of AI state-space planning approaches to the domain of planning teaching actions for an inquiry approach of learning.

We have written several sample inquiry dialogues in the domain of teaching the causes of rice-growing. With the assistance of a local gifted education specialist, we created different dialogues by postulating responses of students at different levels of competence. We have been able to generate some of these dialogues using our implementation of TAP using a pseudo-dialogue NLP component (see [Wong 1994] for a fuller account). TAP is intended to demonstrate the basic integrated architecture of GCP and ITP which enables combination of macro- and micro-planning techniques. Finally, some issues and problems concerning the implementation of inquiry teaching within the framework of a global course plan will be discussed.

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Developing A Framework for Delivering Technology-Enhanced Physics Instruction

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The Technology-Enhanced Physics Instruction (TEPI) Project was established to research instructional strategies for introductory Physics instruction which implement "state-of-the-art" technology. A recurring problem in Physics education is the inherent conceptual difficulty of the subject for many secondary students. This problem has been the focus of much research and debate. Emerging technology has made it possible to put into Physics classrooms, rich, problem solving environments and powerful, mind-extending tools that enable students to define and solve complex problems unencumbered by the necessity of first mastering complex quantitative skills. Content can be represented through a multiplicity of "languages" - verbal, mathematical, symbolic and graphic. But while the introduction of such technology affords the possibility of producing change and educational benefits, none of them can be assumed to become automatically realized only because of the technology's presence. The implementation of technology requires major adjustments in the traditional roles and instructional procedures of teachers. It takes careful preparation and planning to realize the educational benefits of technology and to make innovative things happen.

The Project has established a Macintosh-based, technology-enhanced environment in two Physics classrooms. Both classrooms are equipped with 8 student computers and 1 teacher computer, a printer, an active matrix projection panel, MBL equipment, and a multimedia center consisting of a TV monitor, a VCR, a laserdisc player and a CD-ROM player. By having two schools and two teachers involved in the study, the Project expects to develop a "thicker" description of effective instructional strategies as well as a "richer" context in which to conduct the study and a strong environment for collaboration.

The instructional focus of the Project is the use of computer-based simulations as both instructional and learning tools. By making Physics more visual (concrete) animated, and manipulative, simulations promise to motivate students, broaden student understanding of scientific principles and encourage more students to enter and remain in scientific studies. In addition, the Project is incorporating laserdiscs as both teaching and learning tools. multimedia technology for classroom presentations, MBL applications, and computer-based evaluation procedures. Plans and materials for implementing these resources are being developed and evaluated collaboratively by all three team members. The actual classroom teaching is being done by the two teachers as an integral part of their classroom instruction. The participating students view their use of technology, and that of their teachers, as part of the normal, year-long procedures of the classroom, not as some short-term novelty introduced for the purpose of research.

Results and Findings

1. A framework for integrating the many forms of technology-enhanced instruction and learning has been developed and successfully implemented.
2. Comprehensive Study Guides based upon this framework have been produced for eight Physics 11 units and eight Physics 12 units.
3. Student attitudes toward science and technology showed a significant increase.
4. The collaborative nature of the Project design has been extremely effective and perhaps essential in reaching the goals of the Project.
5. Both teachers have experienced a major shift in their instructional strategies.
6. The implementation of the technology engendered positive student collaboration, much increased on-task behaviour and increased student responsibility.

Natural Language Interface of Chinese on Multimedia and Education

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The purpose of studying the natural language interface is to help the users to obtain the information from the system conveniently. Through many years' study, we have developed a regulated power-supply circuit trouble-diagnosis system (TEACH). This system can understand eleven English sentence patterns. Chinese is different from English, as the Chinese words are usually complexly combined and one word usually has several meanings, and it has no definite part of speech. There are no special dividing symbols between the Chinese words. All these make the natural language of Chinese difficult for a computer to understand. In practice we have put forward a set of rules based on the contained parts of speech in the multimedia education system. Thus the natural Chinese language interface has been developed.

The contained parts of speech can be divided into seven parts. Based on the above division, we can establish the dictionary bank with three segments: containing words, parts of speech and words meaning.

The application of the multimedia education system has achieved evident successes in class teaching and analogue training, and both the teaching efficiency and the training result have raised. The rules based on the contained parts of speech have been applied to the multimedia education system, which has broken down the conventions and has redivided the parts of speech. Thus the natural language understanding of the basic sentence patterns has been achieved and a feasible plan has been put forward in view of the specified branch of learning in natural language understanding. But whether this method is perfect or feasible to other domains has yet to be further proved in the future work.

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Learning Units and their Realisation Using New Media

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Programmes of study are complex systems of teaching-learning activities which generally reflect current understandings and practices of a discipline, and anticipate future needs. Programmes, by this philosophy, must have built-in mechanisms and flexibility to react appropriately. However, many current programme designs are typically based on defining a set of courses. Courses are either subject-based or integrative, but nonetheless prescribed by the teacher. Such design frameworks suffer several shortcomings, for example (1) it is committed to a didactic, teacher-led mode, (2) the aggregation of educational material into courses and that they exist only in such a form hinders any significant form of individualised or negotiated learning, and (3) a course in practice is too large to be adapted quickly to advances in the discipline, changing market needs or social relevance.

Learning Units

Our approach to overcoming these is to uncouple the subject matter from their aggregation into meaningful courses, i.e. devise a high degree of independence between educational material and courses that utilise them. The creation and upkeep of such material are then not driven by course requirements but by the current body of knowledge. We call such educational resources "Learning Units" (LU). Such units may be broadly categorised as one of: (1) *Knowledge Units* (KU), with emphasis on the exposition of theories, abstractions and facts of the subject matter, (2) *Activity Units* (AU), with emphasis on know-how or skills acquisition, and are developed through active learning situations such as games or laboratories, and (3) *Experiential Units* (EU), with emphasis on real life application of acquired knowledge and skills, and are the opportunities created via project work or industry residency.

LUs are like *tangram* pieces that may be creatively juxtaposed later on to form interesting courses. They should be combined so that the composite subject matter forms a coherent body of topics. This approach provides greater flexibility than traditional course modules which tend to be of a fixed size and purpose. Different teaching-learning approaches can be supported, including problem-based/multi-disciplinary approach, learner managed learning, negotiated learning (Stephenson, J. & Laycock, M., 1993), and even traditional prescribed course delivery.

Global Digital Repository

Digital media integration, computers and communication systems define a *new media* to store and organise information for instant access, correlation, and assembly. Our basic strategy is to develop LUs on the new media, using for example the large hypermedia system, Hyper-G (Kappe, F. & Maurer, H., 1993). This will not only facilitate their maintenance, but also provide significant opportunities to realise new teaching-learning paradigms and innovative modes, more suitable perhaps to the Nintendo-generation. We seek international participation as this would help produce up-to-date repositories that can be made accessible to areas not having resident expertise. Such distribution and globalisation would therefore support true international cooperation in education.

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