Journal of Information Technology for Teacher Education, Vol. 4, No. 2, 1995

Software Design and the Future of the *Virtual Classroom*®

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ABSTRACT This paper reviews the software functionality that has evolved over the past two decades of research in Computer Mediated Communications at New Jersey Institute of Technology (NJIT) to create a *Virtual Classroom*® to support distance education. Based upon many years of evaluating its effectiveness we also summarize our views about the software functionality needed for further improvement of this approach to distance education. This view of a future *Virtual Classroom*® allows the instructor complete control over the learning materials and the tools to easily to weave in the learners as co contributors to a growing web of course knowledge. Beyond the current basic tools of the *Virtual Classroom*® we discuss the future role for hypertext, gaming and simulation, animation and multimedia and the role of the educator as a facilitator of a collaborative learning process. Both the proper software and the proper pedagogical techniques are necessary in order to obtain maximum effectiveness in the asynchronous computer-mediated environment.

Introduction

Fundamental to computer mediated communication systems is the concept of uutilizing the capabilities of a computer to tailor a human communication process to the nature of the application and the nature of the group undertaking this application (Hiltz & Turoff, 1978, 1993; Turoff, 1991). In this context we consider electronic mail to be only one specific example of this technology and various computer conferencing systems, group decision support systems, electronic meeting systems, etc., to all be other examples. The issue addressed here is how to tailor specific functionality to allow a group of instructors and students to carry out the learning process in an electronic virtual environment that is meant to replace the physical class environment.

> Our objective is not merely to duplicate the characteristics and effectiveness of the face to face class. Rather, we can use the powers of the computer to actually do better than what normally occurs in the face to face class.

The sophistication and flexibility of software structures for supporting distance education vary widely, from simple electronic mail systems to conferencing systems that have been specially enhanced to support classroom-like experiences, particularly group discussions and joint projects. Currently, a large number of colleges offer remote courses utilizing various forms of computer mediated communications (Harasim et al, 1995; Paulsen & Rekkedal, 1990; Wells, 1990).

We (the many individuals at NJIT involved in the development, utilization, and evaluation of remote education) utilize a computer conferencing system with advanced features designed specifically to support Learning Networks: teachers and learners connected to each other and to vast resources of the Internet. The conferencing system, Electronic Information Exchange System (*EIES*), provides features for classroom discussions, a sophisticated question and response facility, an exam activity and other group learning tools.

Beginning in 1986, the *Virtual Classroom*®, a teaching and learning environment constructed in software and available via the Internet, has been developed with funding from the Corporation for Public Broadcasting, the Sloan Foundation, the state of New Jersey, and industrial partners including IBM and Apple. As part of this project, it is offering an entire degree program, the B.A. in Information Systems, via videotapes plus the *Virtual Classroom*®. An increasing number of graduate courses is also offered remotely.

Collaborative Learning and Active Participation

The educational methodology utilized for the concept of the *Virtual Classroom*® (a classroom in an electronic space) reflects asynchronous group communications and collaborative approaches to education and training. The student is an active part of a learning group but proceeds to learn and understand on an individual basis independent of the speed of other learners in the group.

The *Virtual Classroom*® is a teaching and learning environment located within a computer-mediated communication system. The objectives of a *Virtual Classroom*® are to improve access to advanced educational experiences by allowing students and instructors to participate in remote learning communities using personal computers at home or at work; and to improve the quality and effectiveness of education by using the computer to support a collaborative learning process. By collaborative learning is meant a learning process that emphasizes group or co-operative efforts among faculty and students, active participation and interaction on the part of both students and instructors, and new knowledge that emerges from an active dialog among those who are sharing ideas and information (Bouton and Garth, 1983; Whipple, 1987).

Learning can be perceived as a particular type of co-operative work. Studies of the use of computer-mediated communication facilities that form components of a *Virtual Classroom®* environment have tended to support the point of view that for mature, motivated learners, this mode of learning can be more interactive and more effective than the traditional (physical) classroom (see Welsch, 1982; Quinn, et al, 1983; Davie & Palmer, 1984; Harasim, 1990; Hiltz, 1988, 1990, 1992, 1993, 1995).

Pragmatics and Feedback

In our view the process of transferring knowledge from an instructor to the students is one of the student learning how the instructor thinks about and solves problems, within the application domain, and incorporating that process into the student's own cognitive processes. To accomplish this mental process, problem solving and task execution must be shared among the students and the instructor. The instructor must perceive the degree to which the knowledge has been incorporated by the students in order to proceed with effective delivery of further material.

One cannot, for example, learn to paint by viewing a finished painting; rather, one must see the evolution of the painting from blank canvas to finished product. The student must observe the instructor's mental process and the instructor must observe that of the student. It is this view that underlies much of the functionality for multimedia, hypertext, and group communications that comprise our current research into the evolution of the *Virtual Classroom®.*

Information Overload

Historically, the use of computers to facilitate human communication quickly introduces the key problem of "information overload" (Hiltz & Turoff, 1985). Those who have attempted to conduct remote education with a significant number of students utilizing electronic mail can appreciate the truth of this observation. A key element in the design of software to support distance education is the minimization of information overload for both the instructor and the students.

The Current Design

Rather than being built of steel and concrete, the *Virtual Classroom®* consists of a set of group communication and work 'spaces' and facilities that are constructed in software. Thus it is a 'virtual facility' for interaction among members of class, rather than a physical space (Hiltz, 1986, 1994). Our current system operates on UNIX platforms, and the interface is programmed mainly in a version of Smalltalk, which allows relatively rapid prototyping of new features (Whitescarver, 1987). The special software structures incorporated in this system were specifically designed to support collaborative learning, including discussions, student presentations, joint projects, debates, role-playing games, etc. Participation is generally asynchronous; that is, the *Virtual Classroom®* participants may dial in any time, around the clock, and from any location in the world accessible by a reliable telephone system.

As with other computer mediated communications tailored to support a specific type of application, some of these communication structures resemble facilities or procedures used in the off-line analogical world. Others support forms of interaction that would be difficult or impossible in the face-to-face environment. All are accessed, not by traveling to a university, but by typing and reading from a personal computer that connects by telephone to a computer acting as the 'group agent' for the *Virtual Classroom®* software.

A conference is a stored transcript of a discussion. It has a membership list that is controlled by the owner or the instructor and a comment-reply structure. In *EIES* there is a full indexing capability for each conference that allows easy retrieval of the discussion and is especially useful since a typical class discussion reaches 500 to 1000 comments in a single course (not counting assignments). The conference automatically tracks for the member what is new and what activities or assignments the member has or has not seen or done. A single activity like the "gradebook" eliminates a tremendous amount of message traffic that would have had to take place if one were using messages only.

An excellent illustration of a communication structure unique to the *Virtual Classroom®* environment is the Question-Answer Activity, where if the instructor asks a discussion question, every student must supply an answer before he or she can see the answers of the other students. The instructor can control whether the answer will be added with the regular name or anonymously. This is clearly a dramatic improvement over the face to face class where such discussions are usually dominated by the same small percentage of students. This feature in the *Virtual Classroom®* forces equal participation in any discussion issue the instructor triggers in this manner. It forces each student to do independent thinking about the issue.

Another key facility is the use of anonymity and/or pen names. For example, in design courses and management courses, many students with working experiences can point out mistakes made in their work environment without embarrassing their company. This sharing of experience is important to making many courses more relevant to the students who have not lived through such experiences. Many of the key features of the current system are summarized in Table I on communication structures (See also, Hiltz, 1994; Turoff et al, 1990; Turoff, 1991; Turoff et al, 1993).

Computer Facility	Utilization	Physical Analogy
Private conferences	Class discussions & lecture Student working groups Tutoring groups	Classroom Study groups
Public conferences	Teacher/Student Lounges	Coffee houses
Messages	Student to student Teacher to student Transitory material	Office hours "Hallway" conversations
Notifications	Reminders, Alerts, Transaction Tracking	Due date notices, Participation actions
Notebooks and personal files	Composition facilities	Work book
Membership status	Who has read and done what assignments (tracking)	Visual presence
Binary file attachments to comments	Diagrams, Spread sheets, etc.	Sharing of PC software results
Anonymous signatures Pen-name signatures	Encouraging self-disclosure and experimentation Presenting mistakes Game and role playing	Impossible in face-to-face classroom
Membership directory	Finding members by common interests	Clubs, interest group formulation
ACTIVITIES:		
Question/Response	Forces independent thinking and active participation	Face-to-face discussion questions
Selection	Manage distribution of unique assignments	Circulate sign up sheets
Document	Self selection of pieces and parts of long document	Printing press and copy machines
Exam	Time controlled question set	Written exam
Grade book	Access to student grade record	Asking instructor

Table I. Communication structures in the *Virtual Classrrom*®.

Many of the advanced features are incorporated into the system as 'Activities' that provide a common interface for faculty to create and students to do special activities through specific programs, e.g., a Gradebook Activity that is basically a spreadsheet with privileges. Any number and type of additional specialized programs could be incorporated through Activities. In addition, the total system currently includes an off-line *EIES* interface, operating under Windows, that automates the process of dialing in and downloading all waiting items, and allows off-line composition of replies, to decrease connect time.

Current Development Objectives

Currently lectures for all remote courses are available on video and delivered via cable TV, satellite transmission, or tapes that are sent by conventional mail. As bandwidth to the home increases, videos will be made available on-line. As an immediate step, to conserve the bandwidth we design lectures as a combination of picture slides and audio files. Rather than watching talking heads, students can view the slides (equivalent to a blackboard in the traditional classroom) and optionally hear the teacher's voice. The students are sent electronic forms of the slides that are used in the lectures so that they may amend these notes provided by the lecturer with their own notes, utilizing a word processor of their choice.

The authoring activity of the current *Virtual Classroom®* allows faculty and teachers to publish assignments, exams and lectures. An author can use almost any word processor and can include reference to multimedia objects on the Internet or on local systems. The back end of the authoring agent is a combination of various software tools which produce data in file formats recognized by the front end (X tools and Mosaic). Common image file formats can include GIF, JPEG and Postscript, which all can be displayed by Netscape or Mosaic along with text (HTML format) in a hyper-media environment.

We are currently planning to include a comment button allowing readers to submit feedback. Depending on the 'roles' assigned to validated users, additional capabilities will be provided, such as access to comments, modification of a database, membership and roles control. Comments and other group facilities will be collected using the forms capability of the World Wide Web (WWW) browsers and the comment function available in certain browsers (Lynx, Weies). The forms will provide a comment category button that can be used to help route the comment delivery appropriately. The HTML extension for this has been submitted as a potential HTML standard.

A more advanced approach is to consider the lecture notes as a non-linear knowledge base (hypertext) that can be distributed to the students and which acts as a foundation for the linking of the discussions, assignments, and evolution of the group. Furthermore, we can incorporate links to any media forms including animation and operational programs such as educational simulations. The difficulty of this objective is not in its technical feasibility but in the education of educators in how to design, prepare, and utilize such non-linear forms of material. It is in the technology of creating materials and aiding educators and students to create and utilize non linear materials that the true pragmatic challenge lies.

Multimedia Requirements

Computer aided interactive multimedia courseware is being developed at NJIT (Bengu, 1995) to introduce an early and comprehensive understanding of interdisciplinary applications of engineering systems, with a focus on manufacturing. The manufacturing engineering multimedia courseware will include on-line lectures, audio-video education tools, interactive computer software (process and equipment design, simulation and animation software). It will also make access available to related academic, industry, and government research and education information through the World Wide Web.

The initial course material is being prepared by faculty, with the modules referred to as topics. Each topic contains illustrations in various media such as text, still pictures and slides, video, and interactive software. The students will invoke the courseware through an activity link in the *Virtual Classroom®* or though a World Wide Web interface. An 'electronic blackboard' serves as the current interface metaphor.

The power of multimedia technology can be used to assemble course materials in various media forms such as text, slides, full motion audio-video, live video and interactive software on a single powerful interactive platform, referred to as simply "courseware." The introduction of multimedia into courseware allows the instructor complete freedom to incorporate into a remote course those learning situations that previously could only be accomplished in a face-to-face environment. An example would be, the manipulation of complicated machinery by simulation, animation and multimedia presentations.

The integration of *Virtual Classroom®* and multimedia on the Information Superhighway is also underway at NJIT (Kushwaha & Whitescarver, 1994, Deek & Kimmel, 1994). Current work is the enhancing of the media richness of the *Virtual Classroom®* using the standard protocols of the Internet (e.g. HTML and Mosaic). World Wide Web client software is utilized to integrate the virtual library resources of the information highway as well as the group communication facilities of *EIES* to provide a comprehensive fully interactive collaborative learning multimedia environment.

The multimedia *Virtual Classroom®* courseware can be viewed as a computer-mediated application, where the computer acts as a mediator between the application author, who publishes the on-line classroom courseware or 'encyclopedia', and the user, who browses the available information and contributes to the authoring as a participant. The author is not just restricted to publish his original work, but has capabilities to reference, include and publish all the relevant information available on the Internet in a multimedia environment.

In similar fashion, users of the courseware, in addition to their innovative contributions, have access to abundant information which can be easily referenced in the courseware discussions. The instructor has to have the ability to integrate new material generated by the current class for the benefit of future classes. The underlying semantic structure for the effective incorporation of material is still a research issue. The ultimate objective for the instructor is the evolution of a knowledge base with a learning oriented semantic and pragmatic topic structure oriented to the given subject matter. This synergetic paradigm creates an information garden for the subject topic under discussion and the author takes the role of a moderator, who communicates with the users in a group communication environment, to manage and organize the information.

The software architecture of the multimedia courseware may be viewed as having three components: the authoring agent, the user agent and the distributed database or group agent. The authoring agent consists of various tools which allow authors, such as instructors, to publish the course material in a manner which is easy and comprehensive. The text material from various sources which have multimedia objects can be submitted using a user friendly authoring environment. For this environment an extremely easy to use and integrated authoring and submitting tool needs to be developed. We cannot expect most educators to master the current confusing mix of protocols and software. Finally the educator must have the ability to manage efficiently the growing volume of information and communications resulting from the collaborative learning process.

There is a great deal of work still to be accomplished to make this distributed system appear to be completely transparent to both the educators and the students. Currently there is no comprehensive authoring system and no integration between the authoring tools that do exist and the browser type capabilities. In addition, a clearly missing piece is the ability of the educators to develop their courseware on their personal computers and to turn their machines into personal servers to control and regulate the communications environment with their students.

Hypertext Requirements

To aid the learning process the traditional ways of structuring conferences (temporal, discussion threads, and indexing) must be liberated to provide a full collaborative hypertext capability. The instructor must prepare initial course material in a hypertext form and allow the students to create contributions and discussions linked to the appropriate material supplied by the instructor.

In the use of hypertext to support collaborative learning applications we see the requirement for semantic typing of both nodes and links. We cannot add any form of intelligence to the course materials unless there is some standardized semantic typing of nodes and links. This would allow the instructor to form templates of information types that he or she is expecting the students to contribute (e.g. pro and con arguments linked to issues with alternative links between the pro and con arguments). It would also allow analysis aids for the members of the class that would hunt and point out patterns of relationships emerging in the class discussion.

Guilford:	Cognition	Convergent Production	Divergent Production
	HYPERTEXT:		
Product	Nodes	Convergent Links	Divergent Links
Units	Detail	Specification	Elaboration
Classes	Collection	Membership	Opposition
Relations	Proposition	Association	Speculation
Systems	Summary	Path	Branch
Transformation	Issue	Alternative	Lateral
Implications	Observation	Inference	Extrapolation

Table II. Hypertext morphology: theory of intellect model.

The goal of developing a general purpose hypertext semantic structure has been one of our on-going research efforts (Balasubramanian & Turoff, 1995). To this point in time the work has been largely theoretical but we have empirically tested our approach in terms of the ability of people to understand the semantic typing (Rao, 1992). We have developed and studied a hypertext semantic framework based upon Guilford's Theory of the Intellect (see Table II, and Turoff et al, 1991; Rao & Turoff, 1990).

Furthermore, the use of the intellectual process to represent nodes and links means that the use of these semantics becomes a learning process for the student and a learning design process for the educator. It has been shown (Hopkins, et al., 1987) that the degree of knowledge people have about a complex situation can be measured by the complexity of the relationship models they design. By capturing the paths a student takes in a hypertext database and the links that the student creates to improve learning, it may be possible to provide a very powerful form of feedback to the instructor on the student's state of learning.

In essence we have an opportunity to dynamically record portions of the student problem solving process and to provide an analysis of that as a feedback mechanism to the instructor. If further evaluation work determines any statistically significant relationship between the performance of the students on standard assignments and tests and these representations of the students' problem solving processes, we can use the technology to offer a rapid feedback mechanism on learning progress and a replacement for most testing.

The Instructor's Courseware Server

There should be no functional distinction between the instructor and the student when it comes to the composition of hypertext. This supports active, collaborative learning as contrasted with the passive receipt of text. The interface must enable the user to create any permissible annotation or modification. The instructor will be operating a personal courseware "server" tied into the network that reaches his or her student. The instructor sends out to the students a core of course material that has been designed as a multimedia hypertext system. Each of the students may modify it as he or she wishes and decide which modifications to send to the instructor or to selected other students for support of collaborative team projects. The instructor is presented incoming material and given the opportunity to fully accept new links to the core material and to decide whether or not to distribute it to the class.

Essentially an instructor needs an ability to maintain and offer his 'courseware' as a personal database that becomes a server to students. This view is also very consistent with the long standing tradition that the course notes and other learning materials (e.g. workbooks, text books) that an instructor develops are his or her property. The instructor's server is a combination of a bulletin board, printing press, and publishing/distribution system. There has been a trend on the part of some educational institutions to claim greater ownership of materials produced by faculty (e.g. video tapes) because of current production costs. The new PC based multi-media capabilities reverse this trend and provide the educator a much greater control over production and use of his or her materials.

Computation and Simulation

Many educational programs can be supported by computational aids as well as simulations. Current work on hypertext has focused mostly on interfaces to databases. People use computational applications primarily for their underlying analytic functionality, not for reading or navigating among large amounts of display information. Hypertext functionality can enhance an application's computational power (Bieber & Kacmar, 1995; Bieber & Kimbrough, 1992). Managing the myriad of interrelationships among an application's knowledge (data and calculated information) as well as enabling users to add to this set of interrelationships can increase user comprehension and thereby improve application learning. Augmenting an application with 'secondary' hypertext support should result in new ways to view the application's knowledge, navigate among items of interest, and annotate comments and relationships.

This means that we do not have to have a prior model of the application domain but can allow the educator to build one by relating the interface of the computational software to the hypertext semantic structure. The result is the ability of an educator to redesign the interface to any existing computational packages. Packages that were originally designed to be only entertainment could be redesigned to be educational if they happen to model valuable knowledge in their operation. A node in our view of hypertext can be extremely dynamic in nature, it can be a form the reader fills out which triggers any sort of computer program the instructor feels might be useful to the learner at that point in the web of course material. The student can also link in dynamic material that he or she has created for the benefit of the class.

Instructors need the ability to utilize existing software such as simulations and to create animations that employ existing software. As we have already observed, the instructor teaching art, architecture, or engineering design will want to allow the student to playback the actual creation process. Even for using a CAD/CAM system the instructor wants to be able to capture a sequence of interface actions and to be able to add or overlay explanatory material to that interface sequence. A general hypertext node in an integrated learning system can be a stored explained set of inputs to control and interface to any existing computational software.

As a result, we see the biggest payoff in the simulation area in providing both instructors and teachers with the ability to record their inputs to a simulation, to edit and to eliminate 'dead end' interactions, and to document their reasons for choices of input through direct comments and links to appropriate hypertext material. This means that an instructor can develop a recording of his 'playing' of a simulation and document the theory and abstractions he or she is using to make those choices. The student would then be able to play this back and use it as an input to the running of the game and be able to see how the problem solving process of the instructor unfolds as he or she goes through the process of dealing with some complex problem in that application domain.

Using the same software it becomes possible for the student to also record a simulation session to illustrate to the instructor and to the other students the intellectual process used for doing a problem or analysis. This generalized 'record and playback' software integrated with the hypertext and hypermedia capabilities described above would provide a completely new way of communicating in the remote learning environment. In many learning situations it has been observed that two people together at a computer learn more working together than either one separately. It is this ability to share the actual interaction process of 'creating the painting' that this approach entails. The educator will be free to incorporate the actual execution of any existing programs into his or her lesson material.

Gaming

Gaming is a well established training tool for managers and management students (Wolfe, 1985). Over 3,000 courses in the U.S. use business games and over 7,000 firms use them in training. With the introduction of personal computers there is a tremendous proliferation of management and other training games (Hsu, 1989). We have used dispersed asynchronous gaming through the *EIES Virtual Classroom®* in two major field trials. One was the use of gaming to have students compete in start up companies developing a new technical product (Hsu, 1991; Hsu & Hiltz, 1991).

The other is a game to teach accounting and auditing by having teams to protect and penetrate (for fraud) an inventory data base (Worrell, 1995). In both situations, with the introduction of the game there was greatly enhanced learning of the pragmatics of the situation. However, in both these instances the gaming facilities were tools that were not integrated with the other software components of the *Virtual Classroom®* and therefore rather difficult to use (unless one is a PhD student seeking a thesis through the development of the game and the proof of its utility).

The justification for the use of games as a learning device has been the possibility of presenting the complexity of real world situations in such a manner that people can see the results of their decisions (Jacobs & Baum, 1987). Most reviews of gaming effectiveness point to realism as a key parameter in the learning process (Cohen & Rhenmand, 1961). Jacobs and Baum (1987) expressed the belief that the dynamics of the interactions among the team players in a game may be as important to the learning process as the intended cognitive and affective outcomes. We subscribe fully to this view.

The important opportunity introduced by the merging of simulation with asynchronous computer mediated communications is that it becomes possible to add realism to the gaming process. The channels of communication among the players can be structured to reflect constraints in the communication process and multimedia based simulations can be a direct representation of real world situations. The focus of our work on collaborative gaming will be to provide a capability for games that will allow tailoring of the communication channels and the easy integration of existing models, simulations, and analysis tools to process gaming data. This will be in the form of a general event and role oriented gaming controller that allows communication tailoring by paths of communication and associated conditionals.

The same facilities that allow us to impose regulated gaming communication structures also allow us to use Delphi communication structures (Linstone & Turoff, 1975) as collaborative learning exercises. Most of these structures, originally designed for paper and pencil, were dependent upon graphical composition and graphical summarization. Therefore, this area has been largely underutilized because of the prior lack of graphical oriented personal computers in the hands of students.

The fact that people can play the game asynchronously over variable time periods also adds a high degree of efficiency to the effort involved in participating in a game.

Performance

Our evaluation studies over prior years have proven the effectiveness of the current *Virtual Classroom®* functionality and given us insight into future potential improvements.

It should also be noted that a *Virtual Classroom®* type of environment can be used successfully in many different media mixes:

- Face to Face plus *Virtual Classroom®*: This can vary from adding system use to enrich on-campus courses conducted by traditional means; to distance courses where system use is supplemented by one or two face-to-face meetings.
- *Virtual Classroom®* as the sole means of delivery: with the use of print media in the form of textbooks or course notes, in addition, of course.
- Multi-media: *Virtual Classroom®* plus Video; or *Virtual Classroom®* plus audio or audio-graphic media.

For example, in a current project, we are delivering an entire undergraduate degree in Information Systems, via *Virtual Classroom®* plus video. Between one and two hours of lecture are made available each week by videotape and/or broadcast; and the discussion and homework portions of the course take place on-line.

In fact, we mix our on campus face to face students with our distance students in one on-line *Virtual Classroom®*. We could not imagine denying our regular "face-to-face"students the ability to benefit from the far greater participatory environment this technology offers.

Our first extensive experimentation with the *Virtual Classroom®* began in 1986 and involved the comparison of a large number of courses over a period of two years in many different disciplines which used this medium of communication, including undergraduate courses in Sociology, Communication, English Composition, Management, Computer Science, and Statistics. For some of the courses, there was a 'matched' section of the same course offered by the same instructor in a traditional classroom and using the *Virtual Classroom®* (as the sole means of delivery, or in combination with a reduced number of face-to-face meetings). For other courses, there was no 'match', and the comparison was subjectively made by the students and instructors to previous, traditional courses.

For this study and the projects which have followed, we used a 'multi-method' approach to evaluation. This includes pre and post-course questionnaires completed by students, direct observation of on-line activities, interviews with selected students, comparison of test or course grades or other 'objective' measures of performance, and regular reports by faculty, which follow a common outline.

Despite a far-from-perfect implementation, the results of the first extensive field trial were generally positive, in terms of supporting the conclusion that the *Virtual Classroom®* mode of delivery can increase access to, and the effectiveness of, college level education. Among the hypotheses and findings for this field trial and for a subsequent field experiment involving 14 sections of a management course taught via a variety of modes are the following supported results (see Hiltz, 1994 for more details):

H1: Mastery of course material in the *Virtual Classroom®* will be equal or superior to that in the traditional classroom.

H2: *Virtual Classroom®* students will report higher subjective satisfaction with the *Virtual Classroom®* than the TC on a number of dimensions.

- Convenient access to educational experiences (supported).
- Improved access to their professor.
- Increased participation in a course.
- Improved ability to apply the material of the course in new contexts and express their own independent ideas relating to the material.
- Increased level of interest and involvement in the subject matter, which may carry beyond the end of the course.
- Improved ability to synthesize or 'see connection among diverse ideas and information'.
- Computer comfort - improved attitudes toward the use of computers and greater knowledge of the use of computers.
- Improved overall quality, whereby the student assesses the experience as being 'better' than the taught course in some way, involving learning more on the whole or getting more out of the course.

H3: Those students who experience 'group learning' in the *Virtual Classroom®* are most likely to judge the outcomes of on-line courses to be superior to the outcomes of traditional courses.

H4: High ability students will report more positive outcomes than low ability students.

H5: Students with more positive pre course attitudes towards computers in general and towards the specific system to be used will be more likely to participate actively online and to perceive greater benefits from the *Virtual Classroom®* mode.

Although the 'average' results supported most of the above predictions, there was a great deal of variation, particularly among courses. Generally, whether or not the above outcomes occurred was dependent more on variations among courses than on variations among modes of delivery. Instructors differed a great deal in terms of the amount and effectiveness of the efforts they put into organizing and conducting their online classes. Those who were most effective were responsive (on-line every day) and made extensive and creative use of collaborative learning assignments and strategies.

Conclusion

While one can conceptualize most of the functionality that would make up an advanced learning system and even point to ways to implement it, the integration into a single interface that is easy to learn is still a key challenge. An interesting and appropriate interface metaphor adds to the usability and user acceptance of software. That is one reason why we have viewed this as an evolutionary process that must be tied into an evaluation program that provides feedback to the design process. Furthermore, the objective of doing better than the standard approach to education requires that we evaluate effectiveness.

The resulting system must be viewed as a toolkit that gives the instructor full control of what aids and techniques to employ in delivering their course. That is one reason we have focused on the metaphor of 'activities' that can be chosen and integrated dynamically into a given class conference. The key expansion of the conference database to incorporate a full collaborative hypertext approach will provide complete freedom for the instructor to facilitate or 'weave' the conference discussion. We are beginning to refer to our advanced system as the 'ABC' (Activity Based Conference) system to reflect further the idea of tailoring and the idea of simplicity in structuring communications around the learning objectives of a group.

Currently many NJIT faculty use the technology to integrate our face-to-face classes with our remote students so they are all one class. In addition, there are opportunities for the use of the technology to facilitate multiple instructors, multiple courses, material used across different course sequences, training on the job, and numerous other requirements that in themselves can add to the requirements for software functionality. For example, a management game might involve a sequence of management courses where the more advanced students are assigned higher level management positions in the game.

Once we free ourselves from the mental limits of viewing this technology as a weak sister to face-to-face synchronous education, the potentials to revolutionize education and learning become readily apparent.

Acknowledgment

Virtual Classoom and *EIES* are trademarks of New Jersey Institute of Technology, which also markets the software, with special prices for non-profit educational institutions. The *Virtual Classroom®* project has received substantial support from the Annenberg/CPB Project, the Department of Higher Education of the state of New Jersey, The National Science Foundation program in Coordination Theory and Collaboration Technology, and several industrial partners, including IBM, Hewlett Packard, and Apple Computer. Development and research on the BAIS degree via a combination of video and *Virtual Classroom®* is supported by the Alfred P. Sloan Foundation.

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