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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.