Virtual-U™: A Web-Based Environment Customized to Support Collaborative Learning and Knowledge Building in Post Secondary Courses

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Abstract: Virtual-U™ is a World Wide Web-based networked learning environment customized for the design, delivery, and enhancement of post-secondary education. One of the main design goals is to provide a flexible framework to support advanced pedagogies based on principles of active learning, collaboration, multiplicity, and knowledge building. The framework consists of tools to support core activities including course design, individual and group learning activities, knowledge structuring, class management, and evaluation. The design of Virtual-U™ builds on lessons learned from a decade of field research in online course delivery. A brief history of that experience is presented to illustrate the motivation behind some of the decisions made in the design of the system. A description of Virtual-U™ and lessons learned from initial experiences with users are reported.

1. Introduction

Virtual-U™ is a World Wide Web-based networked learning environment customized for the design, delivery, and enhancement of post-secondary education. One of the main design goals is to provide a flexible framework to support advanced pedagogies based on principles of active learning, collaboration, multiplicity, and knowledge building, varied content areas including sciences and the arts, and varied instructional formats including seminars, tutorials, group projects, and labs [Harasim 1995]. The framework consists of tools to support core activities including course design, individual and group learning activities, knowledge structuring, class management, and evaluation.

The design of Virtual-U™ builds on advanced research in online education, engineering, and human-computer interface design. The educational principles are defined in [Educational Principles and Models of Learning]. A brief history of online education is presented and the educational outcomes examined in [History of Online Education]. A description of Virtual-U™ is presented in [Virtual-U™] including design decisions made based on the outcomes of the previous work in online education. Initial experience with Virtual-U™ is described in [Initial Experience with Virtual-U™], and conclusions are presented in [Conclusions].

2. Educational Principles and Models of Learning

The main goal is to shape Virtual-U™ into a learning environment by structuring and organizing online interactions based on principles of active and collaborative learning, multiple perspectives, and knowledge building. *Collaborative* or group learning refers to instructional methods whereby students are encouraged or required to work together on academic tasks. While there are important differences among various theoretical and practical understandings of collaborative learning [Damon and Phelps 1989], all distinguish collaborative learning from the traditional 'direct transfer' model in which the instructor is assumed to be the sole source of knowledge and skills. Unlike the teacher-centered models that view the learner primarily as a passive recipient of knowledge from an expert, collaborative or group learning is based upon a learner-centered model that treats the learner as an active participant. The conversation (verbalizing), multiple perspectives (cognitive restructuring), and argument (conceptual conflict resolution) that arise in cooperative groups may explain why collaborative groups facilitate greater

cognitive development than the same individuals achieve when working alone [Sharan 1980; Slavin 1980; Webb 1982, 1989; Stodolsky 1984].

Knowledge building is a learning strategy in which active articulation, sharing and organizing of ideas and information into individual and group knowledge structures is encouraged. Koschmann et al. [1993] note that as knowledge is complex, dynamic, and interactively related, it is critical that instruction promote multiple perspectives, representations, and strategies. Scardamalia and Bereiter [1993] distinguish between knowledge reproduction strategies (copy-delete summarization), and knowledge building strategies which

> "are, by contrast, focussed centrally on understanding...In this view, learning---like scientific discovery and theorizing---is a process of working toward more complete and coherent understanding. The kind of discourse that supports such learning is not discourse in which students display or reproduce what they have learned. It is the kind of discourse that advances knowledge in the sciences and disciplines. It is the discourse of 'conjectures and refutations' as Popper called it." [pp.37-38]

3. History of Online Education

Research and field experience generated over the past decade indicate that computer networking, especially computer conferencing, can support post-secondary course delivery entirely or partially online effectively, with significant user satisfaction, and with low rates of attrition [Kaye 1991; Mason 1989; Hiltz 1990, 1993; Harasim et al. 1995]. Online delivery of courses can enrich and expand traditional educational activities and outcomes; perhaps more importantly, networking has demonstrated the potential to support entirely new types of educational interaction and outcomes. There are, nonetheless, important constraints and challenges.

3.1 The Early Challenges of Online Education

One of the earliest field experiments in online course delivery was at the Ontario Institute for Studies in Education (OISE) in the mid-1980s. At that time there were no models, theoretical or practical, to guide course design and delivery online. Pioneering those first online courses (graduate courses and a non-credit professional development course for teachers) involved conceptualizing, designing, and delivering courses entirely online, using a computer conferencing system to connect students who were geographically distributed. The educational approach taken reformulated collaborative learning activities for a networked environment characterized by five key attributes: an asynchronous, place-independent, many-to-many, text-based computer-mediated system [Harasim 1989, 1990]. These five attributes have subsequently proven to be both constraints and opportunities for enabling effective collaborative learning online. The educational design, tested and refined by ongoing research, has proven robust and effective in over ten years of iterations and has been adopted by educators and institutions worldwide.

3.2 Educational Outcomes

Analysis of data collected over ten years of application of this approach to graduate and undergraduate courses, delivered both entirely and partially online, indicates important outcomes, such as active participation, peer interaction, multiple perspectives and divergent thinking. Problems associated with collaborating online, especially as related to information management and lack of educational supports, were also identified.

Significant outcomes of the experience with online collaborative course design were:

- Active learning: specifically, active participation by students.
- Interactive learning: specifically, in peer-to-peer discussion and exchange.
- Multiple perspectives: specifically, through reading input from all the other online students as well as the instructor.
- Metaphor: e.g., a spatial metaphor to ease the transition from traditional face-to-face classrooms to structured online classrooms.

System generated data showed a high volume and number of conference messages written by the students. Students regularly input large amounts of original text, generating a rich database of information. Not only was the overall volume of messaging high in the online classes, but it was fairly evenly distributed among the students in each class. Most students participated most of the time, sending several messages each week. The major factor supporting the participation noted by students was the increased access opportunities offered by the asynchronous, place-independent environment.

Group interaction was also motivating to students. Student interviews and feedback comments emphasized that the group interaction was intellectually stimulating and fun, and that they worked harder and produced higher quality work online. The online courses developed, in varying degrees, strong communities of friendship.

Students also reported that they appreciated the exposure to a diverse range of perspectives in the group learning design: online students read input from all other students, rather than only the ideas of the instructor and a few students. Student interaction was not only significant in term of message volume, but also in quality of intellectual content. Analysis of selected contents of the online courses indicates that learners formulated positions and responded to their peers with active questioning, elaboration, and/or debate. Transcript analysis and message map analysis of interaction patterns showed that students used the online seminars and small group activities to build on one another's ideas [Harasim 1991] and that students referred to one another's messages, adding to and building on the ideas posed [Winkelmans 1988].

In the early weeks of online discussion, many students reported communication anxiety and feeling 'lost in space'; nonetheless, they soon learned how to direct their comments to the appropriate conference space. Students reported that the existence of conferences for different topics and types of activities helped to orient them to the course curriculum and facilitated their navigation through the conferencing system.

These early field studies on networked learning environments suggest that it is important that participants form mental models of the "spaces" where they are working - the virtual seminar, the virtual discussion group, the virtual laboratory, the café for social interactions, etc. [Feenberg 1993; Harasim 1993b]. This is important if they are to apply appropriate "social factors" to their interactions.

3.3 Problems

While research has demonstrated the potential of networked technologies to support active collaborative learning and interaction [Harasim 1990, 1993], important problems were also identified. Until recently online course delivery was based on generic networking tools such as email, computer conferencing, or newsgroups. The use of generic networking tools has imposed significant overhead on the user, since these tools were not designed specifically to support educational activities [Feenberg 1993; Smith 1988; Harasim 1993].

Key problems in using generic networking environments for education included the lack of tools to support instructional activities such as course design and group design, and lack of tools to support key learning strategies such as knowledge building and multiple representations of ideas and knowledge structures [Harasim 1990, 1991, 1993].

There was an urgent need to create network environments specially customized for education, which could facilitate easy adoption and adaptation (tailoring of individual courses) by the educators and which provide embedded tools to support specific instructor and learner activities. There was also a need for the development of discipline specific tools, to expand the types of course content that could be delivered over networks, especially those related to mathematics and lab-science instruction, and to the cultural and fine arts.

4. Virtual-U™

Based on the decade of field research in online course delivery described above, the design and development of the system now known as Virtual-U™ was initiated in 1994. The goal was to provide a flexible framework to support advanced pedagogies based on principles of active learning, collaboration, multiplicity, and knowledge building, varied content areas including sciences and the arts, and varied instructional formats including seminars, tutorials, group projects, and labs [Harasim 1995]. The

framework consists of tools to support core activities including course design, individual and group learning activities, knowledge structuring, class management, and evaluation.

The attention to pedagogy is what distinguishes Virtual-U™ from other virtual universities. The Web has typically been used as a publishing environment characterized by a correspondence course model or a broadcast model of learning in which faculty post lecture notes or students post assignments online.

4.1. Design Directions

The designers and implementors of Virtual-U™ comprise a multidisciplinary team of educators, HCI specialists, engineers, computing scientists, database designers, instructional designers, implementors, instructors, learners, and researchers. The initial design is based on networked muultimedia workstations (PC's or Macs) and a unix server. The decision was made to build on widely available World Wide Web (WWW) tools since there is active interest in developing these tools for multiple platforms. Thus the students and instructors using Virtual-U™ need only a Netscape browser on their workstation because all of the Virtual-U™ software resides on a central server. The major components of the system include the architecture, campus spaces, and tools, all of which contribute to shaping the environment specifically for online learning.

4.2. Web-Based Client-Server Architecture

The architecture is a hybrid distributed-star configuration consisting of a central server, a set of local servers, and a set of networked multimedia workstations in which local servers may also communicate with each other directly. Multimedia resources and specialized knowledge are distributed throughout the system (and beyond). In order to use the system, the student activates the browser and contacts the server WWW address. A security system allows registered students to access materials for the course in which they have enrolled. Users can also link directly to other WWW resources.

The conferencing system is based on a structured file system. This works well for a limited number of users, but for large scale deployment it will be reimplemented with a database structure. The user interface and the tools available are evolving as the Web-based tools evolve. For example, the next release of the Netscape browser will support frames and other techniques which allow a more intuitive interface. The use of Java, Director, and other software makes it possible to play animations and simulations which greatly enhances the potential content for specialized areas such as laboratory experiments and dance instruction.

4.3. Spatial Metaphor

Until recently online learning environments were completely text based - much like reading prose, the participants form their own imagery of the virtual environments. With multimedia which provide 2-dimensional images of 3-d scenes, and even video or animation, it is possible to provide the students with explicit cues which help them orient themselves, both in terms of navigating around the virtual environment as well as in setting social norms as to the appropriate behaviour expected in each virtual space.

The approach is to use a spatial metaphor in which users navigate using images of university buildings, offices and study areas [see Fig. 1]. While the key spaces are instructional, such as virtual classrooms for seminars and discussion groups and spaces for team projects, labs, etc., the Virtual-U™ environment also includes spaces for academic advice, for administrative activities such as registration and fee payment, for access to library and other information resources (including an art gallery [see Fig. 2]) and for social interchange (the virtual cafe).

While a spatial metaphor may be helpful during a transitional stage, more experienced users sometimes find that it gets in the way of efficiency. Therefore, users are provided with five ways of navigating Virtual-U™ and accessing tools: spaces (graphic imagery), a navigation map, menus, a control panel, and hot-key alternatives.

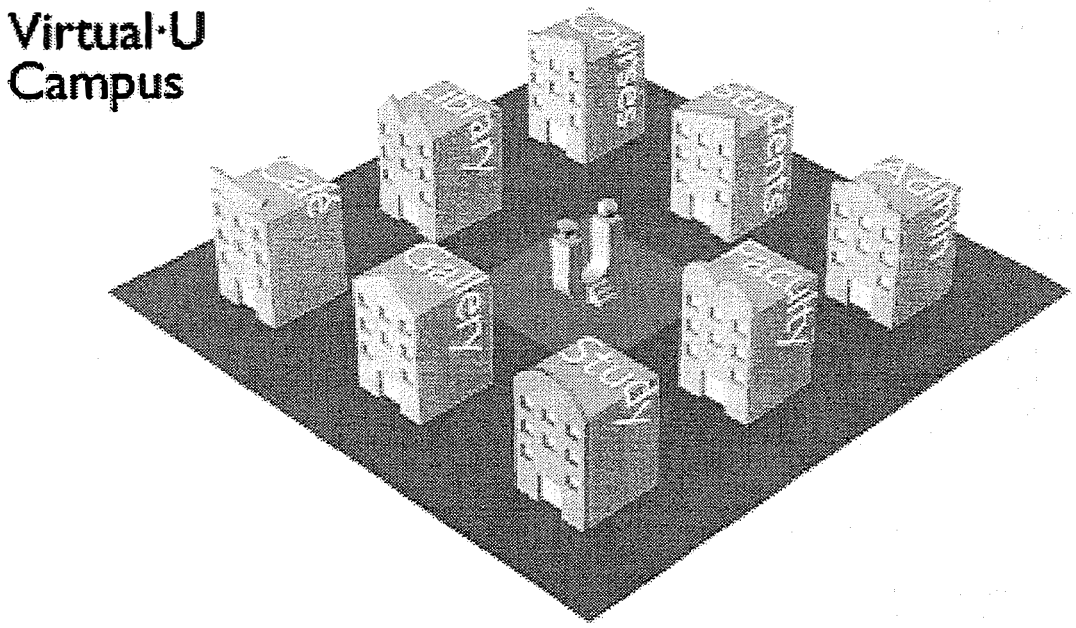

Figure 1: Map of the Virtual-U[M] campus.

Figure 2: An exhibit room in the Virtual-U[M] art gallery.

4.4. Functional Components to Support New Pedagogies

Another major component of Virtual-U™ is the set of tools to support core activities including course design, individual and group learning activities, knowledge structuring, class management, and evaluation. Tools to support course design include a course structure tool and a group design tool. The course structure tool consists of a template for the course syllabus. Instructors fill in the template obviating the need for knowledge of HTML in constructing the syllabus. The group design tool facilitates the shaping of conferences for effective online collaboration and communication.

Virtual Groups, a Web-based conferencing system designed and developed by the Virtual-U™ team, mediates online group interaction. The annotation tool and the tool for creating concept maps provide ways of organizing ideas and structuring knowledge. The hypermedia environment also supports knowledge structuring through hyperlinks and multiple media, namely, text, graphics, images, video, and sound. An online grade book assists in class management [see Fig. 3], and evaluation is supported by the polling facility, conference logs, and logs of usage statistics.

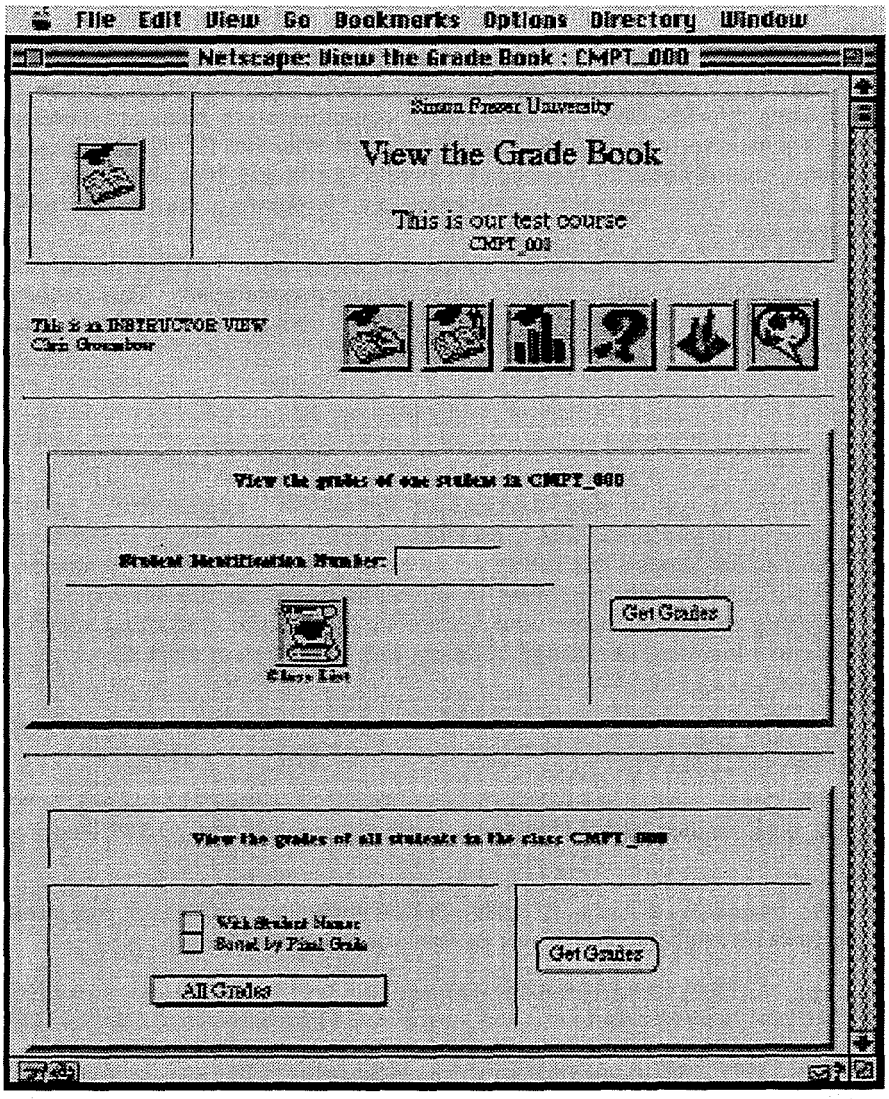

Figure 3: Interface for an instructor to view the Grade Book.

5. Initial Experience with Virtual-U™

Current pilot course offerings on Virtual-U™ include two communication courses which focus on student-moderated online seminars, project teams, debates, and projects which involve inquiry, goal-setting, group dynamics, analysis, and reflection; an engineering course (with a virtual lab component), and various courses from business, education, and computer science. The results of data captured from user reports and usage statistics are being applied to the next iteration of Virtual-U™ development.

An iterative method of development for Virtual-U™ has worked well because feedback and newly available technology can be incorporated early on. For example, on the Web, the sense of 'place' users reported experiencing with previous versions of computer conferencing systems was lost. With the release of Netscape 2.0, new features such as frames, multiple windowing, and Java support were adapted to provide context. The message list in a conference can now be accessed in one window, a particular message selected, and the contents of the message displayed in another window.

Other refinements such as easier navigation and multiple views of conference discussions are contributing to development of this new generation of Web-based conferencing systems. For example, conference messages can be text, graphics, or animation -- the next version of the conferencing system allows HTML in the body of a message. The need for a submit form for submitting work to the server has also been identified.

In addition, multimedia forms of collaboration and conferencing are being explored, such as real-time video conferencing, image conferencing (shared white boards, many of which include video), and 3-d real-time messaging using Worlds Chat. As multimedia communication becomes increasingly possible over networks, there is a need to identify which media are most effective for which educational activities. Appropriate and effective use of powerful broadband networks is critical. It is also imperative that tools be developed to assist educators and learners in designing and integrating multimedia products into the virtual learning environments.

Efforts in developing a virtual lab and a virtual art gallery have met with initial success and will continue to evolve. Currently an online dance course is being developed. This project raises many interesting issues and challenges for technology regarding how certain some types of instruction can be done online.

6. Conclusions

Observations from the use of early versions of Virtual-U™ suggest that a spatial metaphor is necessary to provide a sense of place and that it provides a useful mental model to assist navigation. The nature of the cues that can best support this metaphor range from text to explicit 3-d spaces, and these are being investigated. Significant activity continues in further customizing the Web space into a learning environment by developing advanced teacher and learner tools. Specific embedded supports to facilitate course design, collaborative learning, knowledge building, and visualization tools are currently underway.

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