Virtual-U Development Plan: Issues and Process

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Abstract: This paper reports on key issues examined by a cross-disciplinary research team involved in the development of Virtual-U, a Web-based intentional learning environment for post-secondary course delivery which supports collaborative learning and knowledge building. Section 1 describes Virtual-U itself. Key research issues are presented in section 2. These range from user interface design questions such as navigation support and use of multimedia to the pragmatics of communication and social interaction in shared workspaces. Addressing these issues necessitates a broad cross-disciplinary research approach that informs the design process in an iterative testing/design cycle described in section 3. In section 4, we discuss a possible course for the evolution of Virtual-U into a more richly textured collaborative learning environment, using a smooth upgrade path and interactive design to maximize transfer of knowledge and experience as the system grows.

1) Background

Virtual-U is a World Wide Web-based integrated set of software tools and templates enabling the creation, delivery and enhancement of on-line courses that is being developed under the direction of Linda Harasim and Tom Calvert by the Telelearning National Centre of Excellence. Virtual-U is intentionally designed to enable and facilitate asynchronous discussions, collaborative learning and knowledge building (see [Harasim, Hiltz, Teles, and Turoff 1995] for background). Users require a workstation, a Web browser (Netscape Navigator or Microsoft Internet Explorer), and access to the internet. Course delivery requires setting up the course on a Web server hosting the Virtual-U software. Virtual-U's current functionality includes the following components:

- Creating course Web pages
- Structuring interactive discussions and collaborative activities among students, teacher and external participants
- Creating shared resources for knowledge building
- Class management and evaluation

Course design support includes guidelines for setting learning outcomes, instructional techniques, evaluating learning outcomes, “netiquette”, discussion or project group design, learning activity design, and course syllabus creation. Ancillary discussion groups can be set up within Virtual-U to allow groups of teachers and/or support staff to discuss instructional strategies, support issues, etc. Course design support consists of guidelines for setting learning outcomes, instructional techniques, evaluating learning outcomes, netiquette, group design, activity design, and course syllabus design. There is also a facility to allow users to share their own tips and experiences with other users.

VGroups is Virtual-U's Web-based computer conferencing component. Using Vgroups teachers can create discussion groups that mediate students' on-line communication according to different discussion modes such as topical discussion, debate structure, role playing, etc. Activity templates and tags can help to scaffold particular activity types. Discussions can be set up as course-related or entirely social (as in the students' informal “Cafe” discussion environment). Messages can be sorted and viewed by topic (i.e. “thread”), date or author (See Figure 1.). Users can imbed either URLs or HTML in messages to incorporate hypermedia links to other Virtual-U Web pages or other Web sites. This is one of the ways in which Virtual-U supports the learners' interaction with shared resources. Other means include a file manager for uploading or downloading files, tools for creating concept maps and tools for annotating documents. Virtual-U's on-line grade book provides a class management tool that is configurable to allow students to view their own grades as well as a graphical representation of the class distribution, or to read a qualitative assessment of their work by their teacher.

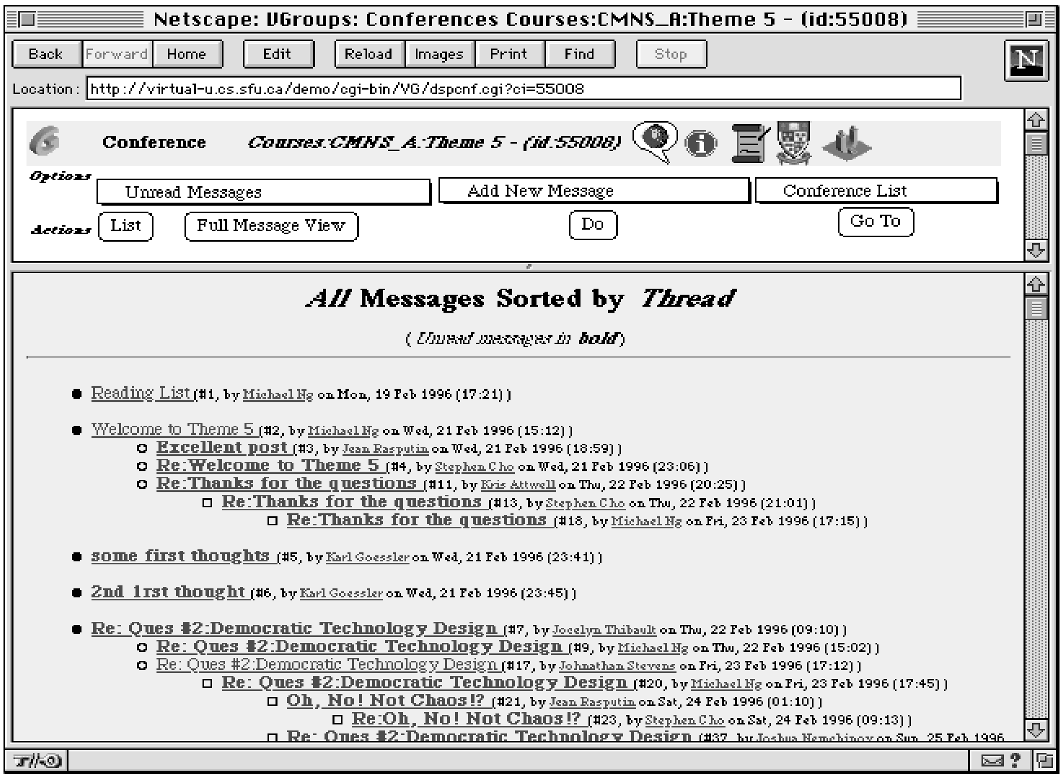

Figure 1: V-Groups conference messages sorted by thread.

Class management and evaluation is supported with an on-line grade book which can allow students to view their grades, the distribution of grades as a bar chart, and qualitative assessment of their work. Instructors may manage grades entirely on-line or upload from a local spreadsheet to the grade book.

Navigation of Virtual-U is based on a campus metaphor (see Figure 2) to create a sense of familiarity for newcomers to on-line learning.

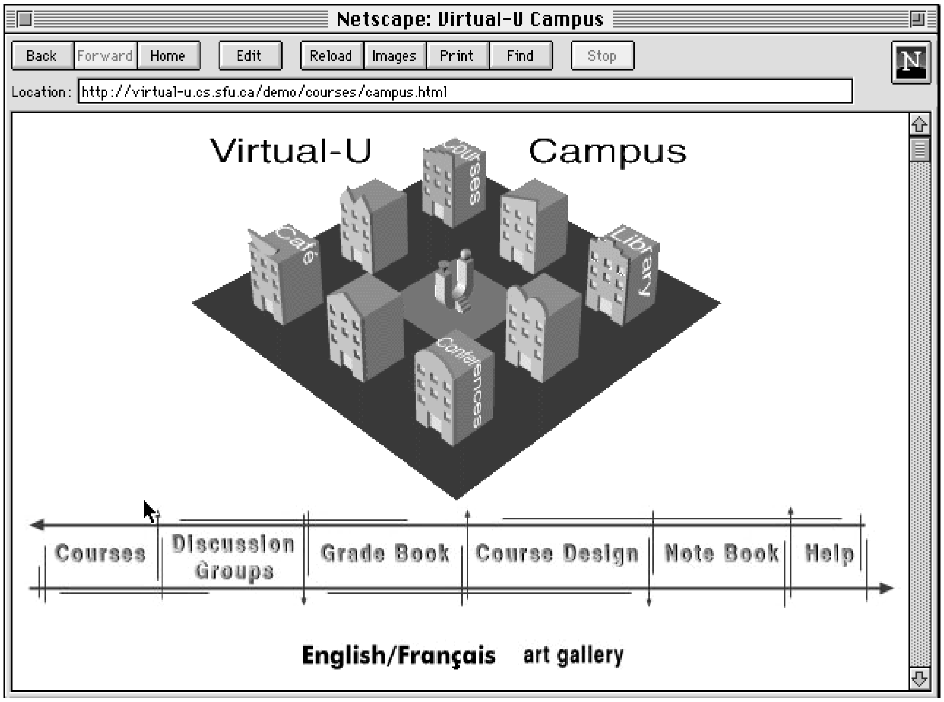

Figure2: The Virtual-U campus main page

2) Research and design issues

Virtual-U is being developed within an academic context to provide a tool specialized for the delivery of post-secondary courses. The developers are sensitive to the broad range of design issues that might determine the success or failure of the software in mediating the learning process. In order to insure that Virtual-U effectively supports the pedagogical principles of knowledge building and collaborative learning, a Cross-Disciplinary Research Design group (CDDR) was assembled. Current members of the group are drawn from Communication/Education, Cognitive Science/Psychology and Computer Science. Our intention is to expand this group to include a broader range of the Social Sciences (e.g. Sociology/Ethnic Studies).

In collaboration with the Human-Machine Interface group of the Institute for Robotics and Intelligent Systems, CDDR is applying new methodologies to the study of the perceptual, cognitive, and social aspects of shared multimedia learning environments. Much of this work is at an early stage of development, but it has already had a significant impact on the design of Virtual-U.

a) Navigating in the virtual university.

One focus of work deals with the interaction of perceptual systems and higher-order mental representations (the so called “cognitive architecture”; [Pylyshyn 1991]) of events in space. A major cognitive framework for individuating, visualizing, and keeping track of different items of knowledge (such as who said what in a conference or what items of data go with what) is the use of real 3D spatial locations. We use space both literally (as in the desktop or office model of data organization) and also figuratively. Examples of the latter includes such techniques as mentally locating different facts and premises in certain imagined spatial loci -- a technique widely used in mnemonic aids, and the use of spatial location in reasoning where so- called “spatial paralogic” provides an important scheme for keeping track of different components of a problem. Understanding and supporting the effective use of spatial reasoning with perceptual cues could greatly enhance users' ability to understand complex problem domains.

Existing hypermedia navigation tools utilize high-level cues (e.g. landmarks, memory aids, and shortcuts) to aid users in determining their position within a complex hypermedia document. This often requires a difficult cognitively mediated dynamic mapping task to be done in tandem with users' main tasks, straining users' attentional capacity. In daily life, a set of low-level mechanisms enables us maintain a consistent mental model of a stable world despite rapid and frequent shifts of retinal images due to eye, head and body movements. Recent work in Cognitive Science [Pylyshyn 1994]; [Goodale and Milner 1992]; [Bridgeman and van der Hejiden 1994] has led to a better understanding of the interaction of perceptual events in visual space and central processes. In collaboration with basic researchers, we are applying these theories to the design of data spaces for improved understanding and easier navigation. One example of this is a Web navigation tool called CZWeb, which uses animation, hierarchial organization, and detail-in-context views to provide a dynamic spatial representation of portions of the Web.

b) Understanding modes of interaction of multiple users in shared spaces

Optimizing social facilitation and active collaboration in educational environments requires users to integrate the synchronous/asynchronous actions of multiple users in the same knowledge space. This requires users to accurately attribute repercussions of an action to the correct cause and the correct actor. The critical theoretical issues again revolve around users' internal representations of objects and events in shared perceptual, cognitive, and motor space. Spatial indexing (FINST) theory can help us to find low- level cues to tie together effects and actions, allowing multiple users to operate on the same information set in a cooperative manner. These mechanisms have been examined in the laboratory [Pylyshyn, Burkell, Fisher, Sears, Schmidt, and Trick 1993], but remain to be tested within the context of Virtual-U.

c) Information channeling in a multimedia environment.

Knowledge building tools need not be limited to graphical displays. The effective use of sound can increase the amount of information that can be understood, while reducing the demands placed upon the already overburdened visual channel. Optimal use of auditory displays requires a greater understanding of how they interact with visual displays in scene understanding, active perception, and direct manipulation tasks. Previous work by [Fisher and Pylyshyn 1994] and others has suggested that different tasks appear to utilize different multimodal integration cues, and so may evaluate visual and auditory sources of information in different ways. Since computer display environments often produce errors in these cues (e.g. asynchronies, location errors and poor quality renditions) this can affect the interaction of sonic and visual displays. Ongoing research by the IRIS human interface group on spatial sound displays and sonification of work environments should transfer to a variety of telelearning applications, particularly in the development of virtual laboratories for learning technical and performance skills.

d) Communication strategies for collaborative learning.

The low-bandwidth of computer-mediated communication tools can give rise to conflict and misunderstanding among users. The impact of this on existing networks (such as USENET) is great, and extension of networked communication technology to new user groups exacerbates the problem. Another focus of our work applies Psycholinguistics models [Grice 1975]; [Clark and Wilkes-Gibbs 1986] to address the pragmatics of social interaction and communication over limited bandwidth channels. Face-to-face communication is to a great degree mediated by conversants' knowledge of their common ground of shared referents, which is largely created and maintained by the use of non-verbal cues such as expression and gesture. In designing a collaborative environment, care must be taken to insure that the “social bandwidth” that enables users to disambiguate their language (a process known as “grounding” [Clark, and Brennan 1991]) is maintained. An examination of the V-Groups productions from different groups of users (i.e. completely on-line vs. mixed-mode) combined with laboratory testing will help us to determine the effects of the bandwidth limitations that are imposed by technology on communication, and how students compensate for these limitations. This in turn will help us to better design the interface for more effective communication.

e) Cultural and social factors in the use and acceptance of distributed education.

Acceptable metaphors for learning may differ between various ethnic groups, socio-economic strata, and age cohorts. In addition, computer-supported collaborative learning will result in the formation of study groups that may include users who differ in age, sex, ethnic and cultural backgrounds. We are actively seeking to expand the diversity of our user community so as to learn ways to better support the inclusion of diverse user populations. Ongoing assessment should be conducted during implementation in order to insure that the interface is optimized for a diversity of users.

3) Process

a) Iterative design.

A lack of data from large-scale real-world use of comparable collaborative learning environments required us to begin by building a relatively simple system in a short time frame that could be tested in a broad-based field testing program. Results of these tests would lead to design changes that would in turn be tested in field sites and in our interface testing laboratory. This insures that design changes benefit from the input of real users of the system.

b) Large-scale field tests

A major difficulty in building a robust general-use computer-supported collaborative learning environment is that it must serve a broad diversity of students, instructors, subject materials and instructional styles. Small-scale user tests are unlikely to provide a representative sample of this heterogeneous population. Our current field testing program serves approximately 730 students, and is as broad-based as possible.

c) Integrated data analysis

Converging evidence from a variety of measures and testing situations is combined to give the broadest possible perspective on the utility of Virtual-U. Field site participants are surveyed by questionnaire, and their interactions (i.e. server requests) with the Virtual-U Web server are recorded. Parsing the server requests into user actions is problematic, as a simple activity may generate a number of hits. User testing data can help to establish correspondence between activities and server requests by comparing patterns of Web server requests in the field and in the laboratory. Identification of characteristic patterns of server requests that are associated with particular situations and user actions allows us to bridge the gap between laboratory and field studies, allowing more precise analysis of events in the field.

Taken by itself, this data set provides useful information about overall user satisfaction and use patterns. In addition, the quantitative data set can be used as a window into the rich qualitative dataset of instructors' and students' productions in conferences and elsewhere in Virtual-U. By identifying specific populations of users and situations, the quantitative data analysis can select subsets of conference productions for the more resource-demanding qualitative content analysis using Nudist or similar analysis tools.

Field testing provides us with a dataset which has excellent external validity, insuring representative sampling of the broad population of users and uses. It has three drawbacks, however. First, it is difficult to conduct true experiments due to the overhead in distributing and supporting multiple versions of the system (e.g. control and experimental versions). Second, collection of useful performance variables such as reaction time, individual keystrokes, etc. is impractical due to the number and wide distribution of users over the Internet. Finally, the lack of control over (or even knowledge of) obscuring variables such as location, data transmission speed, system characteristics, etc. limits our ability to assign observed differences in performance to system variables. Thus,"fine tuning" the system requires laboratory testing, which must then be examined within the context of the field site data.

4) Future Work/Enhancements/Directions

The final aspect of the Virtual-U design philosophy that we would like to discuss is the need for a smooth upgrade path. Current field site students and instructors should benefit from their expertise with older releases as they make the transition to our more advanced designs. While the final design of each release will be determined by laboratory and field testing results, current design plans are to augment the collaborative aspects of Virtual-U by the use of specialized activity scaffolds.

Our current version of V-Groups is relatively unstructured to provide maximal utility for a wide variety of collaborative tasks and methods. Structure is provided by topics, threads, and keywords within a conference, and conferences themselves are structured heirarchially. Within a discussion, students and instructors have complete freedom of use of these organizational cues. This free-form discussion requires users to exhibit considerable discipline in their implementation of the organizational cues provided.

Future versions of V-Groups are likely to maintain this level of freedom for “brainstorming”, while providing a richer language of reference to previous messages. We can then use the pattern of interconnections between messages to structure a graphical depiction of the knowledge space created by the free-form discussion. We are currently testing CZWeb, a Web structure visualization tool developed at SFU that provides many of these functions. CZWeb provides users with an animated map of a potion of Web space, where pages and groups of pages are displayed graphically with visible links. Users can manipulate this map, grouping pages in nodes, zooming in and out of regions of the map and so on.

The graphical depiction of a largely text-based set of collaborative messages is the first step towards the creation of a graphical knowledge space, which can then be manipulated by more structured collaborative tools such a planned debate tool. The knowledge space thus created provides a conceptual “lumber yard” which can be used for hypothesis creation and testing, as users create new links that may themselves contain meaning (e.g. “is an example of”, “supports”, “is a test of” etc.). Other types of tools might instantiate specific roles or perspectives on the data space with a customized quiver of specialized productions possible. Students might adopt the role of the Skeptic, or the Empiricist (or the Fool), operating upon the data space in the appropriate manner.

Much of this work is in the early stages, and will benefit from the experience of the field site participants and from input from colleagues in a wide variety of fields. We are seeking to expand the number and diversity of CDDR members, particularly in the neglected areas of the Social Sciences that deal with cultural and social issues. As we succeed in this, we will no doubt experience increased difficulty in bridging the gaps between our own members. Our hope is that this effort will bear its rewards in an effective collaborative learning environment, deeply rooted in the theoretical and practical aspects of distributed collaborative learning.

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