Networks, Workstations, Multimedia, and Electronic Communities: Creating a University Learning Environment

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Abstract: The widespread availability of networked communication allows the educational community to provide students with skills needed for pervasive changes in information access and utilization that will occur over coming decades. These skills center on developing techniques for lifelong learning where a broad range of heterogeneous information resources are used in solving problems. The university learning environment we describe provides students with opportunities to acquire skills necessary for success in a distributed workplace where electronic tool use and information discovery, organization, and utilization are the principal activities. The approach we have adopted combines networks, workstations, student laboratories, and multimedia as instructional tools to enhance the students' learning experience. Structuring student activities through electronic communication creates small-scale electronic communities within which students work and provides a persistent focus on information discovery and integration. Tools that coordinate information access, pedagogy, and problem solving are at the core of students' learning and working environment. Though some elements of the environment we have implemented are specific to our discipline, most of the elements can be used in any domain.

Introduction

The widespread availability of networked communications, together with the changing nature of the workplace leading into the 21st century, present the educational community with a unique set of challenges and opportunities. The changes created by networked communication necessitates that students acquire skills needed for the pervasive changes that will occur over coming decades. These skills focus on developing both the techniques and an orientation to information that will allow them to engage in lifelong learning utilizing a broad range of heterogeneous information resources in solving problems. Such lifelong learning is not an option or an ideal, but a necessity required by the change in the nature of work and society. The required skills center on preparing students to become members of a learning society [Boshier, 1980] and on becoming an individual operating in an ubiquitous learning environment [Norrie, 1995].

One must be information literate in a learning society. An individual has to be able to know when information is required and have the skills to find, assess, and utilize information when it is needed. Such individuals have learned how to learn because they know how knowledge is organized, how to locate information, and how to make use of information. Those prepared for life-long learning have the skills to find information required for any task or decision. [Green, 1995].

All of the elements to create a learning environment preparing students for the 21st century work environment exist, are widely available, and in some cases inexpensive or even free. Many institutions have made major investments in technology infrastructure. However, a number of factors have prevented a rapid and pervasive shift in the educational model to one more in concert with an information intensive model of the future workplace. Among the factors are the continuous expense of upgrading the technology infrastructure and insufficient user support.

The project described below represents an example of the utilization of network facilities that are currently in wide use to implement some aspects of the move to a new model of education - a focus on information literacy and life long learning. Technology is used to enhance both the content of the curriculum and the opportunity for communication with and among students. It serves as a catalyst for teaching and learning. Finally, in our discipline, computer science, technology assists us in preparing students to be professional computer scientists rather than just computer programmers.

Learning Environment Activities and Design Goals

The university learning environment we have implemented is designed to provide students with the opportunity to acquire the skills necessary for success in a distributed workplace in which electronic tool use and information discovery, organization, and utilization are the principal activities. The environment is designed to foster a general orientation to learning that is self-directed, active, and group-oriented. The activities and types of interaction to be supported in the environment are presented below [Tab.1]. The list also characterizes activities and interactions of present and future information workers, and more generally, the information literate. The elements of the list are drawn from work on the future of the workplace and society [Bates, 1993; Boshier, 1980; Hiltz, 1984], as well as other's experiences in implementing such a learning environment [Andriole, 1995; Debreceny, 1995]. In addition, members of the computing industry, as early adopters of information technologies in the workplace, have provided important insights. Finally, our own experience of several years in using hypermedia in our classes [Fowler, 1993] and the unique needs of our student population have shaped the design goals.

- Work community relationships:
  - emergence of new communities and organizations
  - both distributed and in person communication
  - rapid electronic communication with instructors and group members
  - changing of roles from learner, to mentor, to collaborator
- Electronic tool use:
  - pervasive use of electronic tools
  - integration of tools with diverse functionality
- Information access and utilization:
  - reuse of information through time and across problem domains
  - iterative searching and culling of information
  - facility in manipulating diverse information sources and formats
  - joint use of information
- Efficient use of human resources:
  - recognition of individual learning style and situation
  - multiple mechanisms for learning and working
  - multiple sources and forms of information and work

Table 1. Activities supported to provide a university learning environment preparing students for self-directed learning in a distributed work environment

A University Learning Environment Integrating Networks, Workstations, Student Laboratories, and Multimedia

The approach we have adopted to provide a learning environment preparing students for self-directed learning in a distributed work environment utilizes networks, workstations, student laboratories, and multimedia. The structuring of student activities through laboratories and electronic communication is designed

to create small-scale communities within which the students work. These elements are used as part of an introductory computer science course focusing on software engineering techniques for program development, as well as the introduction of a programming language and algorithm development. Given the course content and industry practice, the extensive use of electronic tools for software development is natural, and is a cornerstone of the course. In other content areas analogous tool use is evident. The integration of common software applications packages and multimedia information sources developed specifically for a course with sources available on the Internet is occurring in an expanding range of disciplines. Finding the right mix of these components to design and cost-effectively implement a university learning environment has been the principal challenge of this project.

The approach described here builds on our previous work - a stand alone computer assisted learning (CAL) system using both tools which are modest in cost or free, and tools created specifically to address course requirements. The stand-alone system addresses several, but not all, of the goals outlined in section 2. It provides a sampling of the kinds of information available across networked systems by placing the user in a hypermedia environment containing "semi-structured" course content. The supposition is that the user gains understanding through exploration and the implicit (re)ordering of the information by actively interacting with the hypermedia; the user is actively engaged in constructing knowledge. Given that future networked learning materials are relatively seamlessly linked through the network, this stand alone system is a reasonable, albeit limited, emulation of a networked environment.

Designing and implementing a university learning environment which addresses the complete set of design goals and activities outlined above entails strategies which move beyond the conventional use of multimedia in stand alone CAL. It is necessary to create a distributed work environment which promotes interaction among students. Information sources and tools that support students in the distributed environment we have implemented include web [WWW] and ftp sites with instructional materials, web browsers, news groups, and e-mail. [Fig.1] below shows what a student's screen looks like when working in the distributed environment. Four windows are open on the screen. The upper left window contains the student CASE (computer assisted software engineering) tool displaying a programming team's design for a project. The complete design is visible in the smaller window within the CASE tool window. The Pascal editor running on the student's workstation is in the lower left window. Information describing a team member's progress, accessed through a local newsgroup, is viewed using a news reader in the upper right window. Hypertext explaining a programming construct is stored at the course's web site and is viewed through a web browser open in the lower right window. Whether local or networked, text can be transferred between the information access components (web browser and news reader) and the programming tools (student CASE tool and programming environment).

Work community relationships

The primary mechanism for implementing a distributed work environment for students is the structuring of student projects as group efforts with electronic communication as a primary means of interaction among group members outside of scheduled lectures and lab. The learning environment emulates the professional work environment of both today and tomorrow.

The actual structuring of the student projects must be done with care as students are typically in their first or second year, and this is often their first extensive experience with group projects at the university level. Initial group formation and project definition is completed during scheduled laboratories. Groups are systematically formed and reformed several times throughout the semester to represent a range of skills in each group based on student's performance on examinations and previous projects. Efforts are made so that each individual has an opportunity to fulfill both mentor and learner roles within groups.

The laboratory component of the course provides the benefits unique to bringing people together in the same place and at the same time. Whether lab work is completed independently or as a group, the opportunity exists for students to engage in informal discussions with faculty and peers through which they gain new perspectives. Group and project management lab exercises afford students the additional opportunity for systematic face to face or synchronous communication. This communication lets students gain experience in directly coordinating efforts with others whose skills and knowledge sets may differ greatly from their own. The lab interactions provide the foundation for the subsequent communication necessary to complete the group projects.

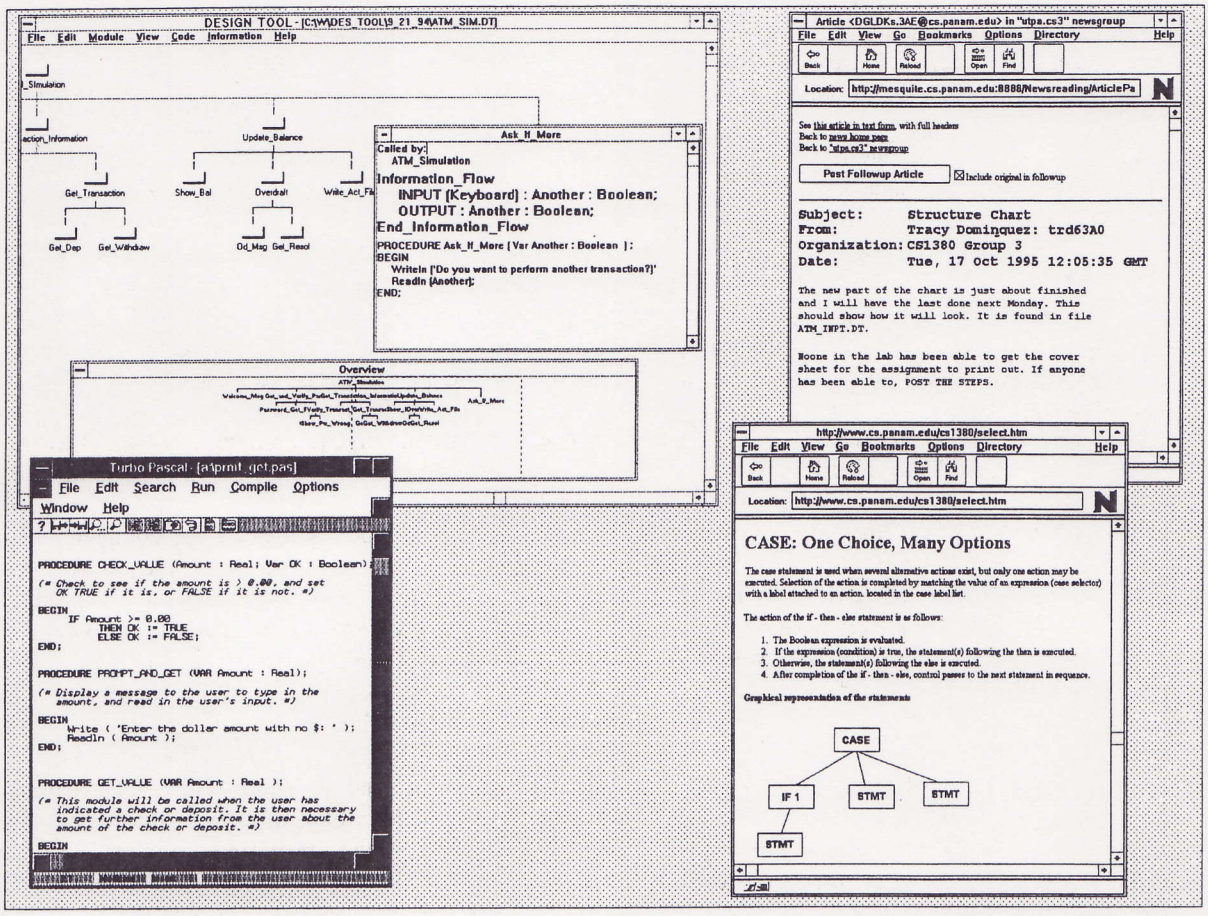

Figure 1. Some of the information sources and tools students use. Two web browser windows are shown on the right. The top browser is viewing a newsreader describing another team member's progress on her part of the project. The lower browser shows a part of the on-line hypertext concerned with programming. The upper left window is the student CASE tool with the team's complete design shown in the smaller window within the tool. The Pascal editor window on the lower right holds code transferred from the program design window. Text can also be transferred between web browsers and the programming tools.

Local newsgroups are used to foster the emergence of new communities - in this case, communities of computer science learners. At the outset of the course, a single course-wide newsgroup is used for communication concerning work assignments and for student commentary. Students are not only encouraged, but required to contribute to ongoing, unmoderated discussions. There is an element of immediacy, or at least relevance, embedded in the newsgroup and the well known synergy of newsgroups does develop. The more students respond, the more likely it is that a comment will trigger further discussion, thus opening lines of communication and eventually collaboration among students. The archival features of the newsgroup allow the electronic conversations to persist through time, thus supporting the formation of a community by eliminating the temporal constraint of face to face conversation. Ours is a commuter campus and these newsgroups are a significant factor in creating a computer science community.

Additional newsgroups are created and used as the primary means of communication about project work completed after the initial meeting. These newsgroups work well because they support asynchronous work, better suited to temporal availability and work patterns of a commuter campus. Further, the newsgroups serve

as a means for instructors to monitor individual student involvement and group progress in a convenient way as compared to group communications conducted exclusively via e-mail.

E-mail is reserved primarily for individual student communication with the instructor, though students can choose to post correspondence to a newsgroup if it is judged useful to a larger audience. The use of e-mail for instructor-student interaction has provided a different structuring of the instructor-student relation. It overcomes some of the practical difficulties of providing rapid feedback on questions. Moreover, students are required to be relatively thoughtful in framing their questions. Student messages tend to be brief, more to the point, and directed to a single or limited number of topics. In turn, faculty are able to more easily respond to the student at the appropriate skill and knowledge level.

Electronic tool use integrating information access and utilization

The range of tools used in the course integrate information access, pedagogy, and program development. These electronic tools are at the core of the student's learning and working environment and require the student to master several tools using different forms of information: the web browser accessing course hypermedia (problem statements in natural language), the CASE tool (formal program specification), the programming environment (Pascal language), the news groups (group progress and public commentary), and e-mail (personal communication). As with many "paperless courses", assignments and lecture content are available on-line. In our implementation this material is available on the Internet, and students can access it from off-campus. While not encouraged to do so, the student is able to complete most aspects of the course off-campus using the on-line course materials together with newsgroups and e-mail; the exceptions being structured lab experiences and testing.

One of the major emphases of the course is software engineering and much of the student's work centers on the use of the student CASE tool. The CASE tool is integrated with the other components in several ways. For example, program assignments stated as problems are first transferred from either the on-line hypermedia using the web browser or from an ftp site into the CASE tool for further development. The CASE tool supplies a visually-based system supporting problem decomposition following the process of structured program design. Using the editing capabilities and a pseudocode, the student creates a formal specification and design for the assigned problem. From the formal specification, the CASE tool automatically generates the basic Pascal source code, including module calls. The specification and skeletal code generated by the student CASE tool is transferred to the Pascal programming environment for further development. In this process of program creation, the student works with tools which access different forms of information and provide quite different functions in the work process.

It is the interaction among these tools and the transfer and transformation of information among these tools which creates the experience of working in an information intensive environment. Students become familiar with and facile in the transfer and translation of one form of information to another. In addition to information resources provided for the student, the stored problem solutions and code which can be accessed in the hypermedia form a repository which is systematically used throughout the course. The skill and care with which students create these 'information elements' impacts success in projects which reuse information created earlier in the course. In essence, students learn to use tools that facilitate the process of scholarship.

Efficient use of human resources

Time is a scarce resource, whether in the workplace or in the schedules of students and instructors; both our students and our faculty are time poor and commitment rich. Much of the advantage of asynchronous work afforded by network-based projects is realized for student projects and interaction. As mentioned, this style of work and interaction also seems particularly appropriate for institutions which have a large non-resident population. The use of hypermedia materials for course presentation which are *also* available outside the classroom shares the same advantage. It supplies the learner control and flexibility as to how and when the course material is reviewed. The learner control of content presentation available in hypermedia also accommodates individual's different learning styles and preferences. Nonetheless, the learning environment we have implemented retains a strong laboratory component. We view it as yet another mechanism for learning which should be provided for students in a university setting.

Conclusions

Widely accessible technologies and tools are available to implement a university learning environment which trains students for an information-intensive workplace. Though some elements of the environment we have implemented for our computer science classes are specific to the discipline, most of the elements might be used in any domain. For example, e-mail, publicly available news readers, and web browsers have been successful in creating communities centered in the course. Even where the particular tools used in this project are not appropriate, analogs to those tools which transform and integrate information exist for virtually all disciplines.

It is, however, important to remember that information technology is the medium to enable changes in curriculum, facilitating the development of life-long learners, and not the curricular content itself. Technology is used to support active learning by facilitating work on complex projects, rethinking assumptions, and discussion. In this project we use technology to implement educational strategies which include collaborative, project based learning in an information-rich, tool-rich environment where both synchronous and asynchronous communication occurs to improve student-faculty and student-student interaction, and various styles and preferences of student learning are supported. We believe that these strategies can influence the course of a student's development and better prepare them for entry into the workplace of tomorrow.

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