Supporting Collaborative Project-Based Learning on the WWW

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Abstract

Zebu is an educational groupware technology which facilitates the use of standard WWW software to support collaborative project-based learning. This paper discusses the promise of Zebu in helping teachers and students overcome some technical and practical, educational problems inherent in WWW-based technologies, allowing them to more fully realise the potentials of the WWW as a technology for collaboration in education. Illustrations of the software are included to provide further detail of how the software addresses these problems.

Keywords—educational groupware, collaborative learning strategies, design and interface issues, tools to support teaching in collaborative settings, WWW

Introduction

The WWW (World-Wide Web) has an enormous, yet largely untapped potential for supporting collaborative learning within and between schools. The original intent of the WWW was to support the constructive, collaborative work of academics and other knowledge workers (Berners-Lee, Cailliau, Luotonen, Nielsen & Secret, 1994) , yet in typical use, the WWW is found to be a rather passive communication medium. This orientation is unfortunate because it limits the everyday usefulness of the WWW for supporting collaborative educational activities. The bias toward non-constructive activities with WWW technologies can be explained in part by the nature of the tools which are commonly available for working with the WWW as a medium of communication—browsers are more common and simpler to use than editors. It has been a major goal of the ALiVE! Project (Active Learning in Virtual Environments) to design and build tools which make it easily possible to turn the WWW into a constructive medium which can be used by teachers and students to engage in collaborative project-based learning activities (Tiessen, 1996; Ward, 1996; Ward & Tiessen, 1997) .

Collaborative project-based learning is an instructional approach that attempts to engage students in the intentional pursuit of their own learning goals and in social interactions aimed toward the development of understanding. This approach draws from a variety of educational theories and instructional practices including collaborative learning (Brown, 1990; Kaye, 1992), active learning (Bork, 1992; Rakes, 1996), intentional learning (Scardamalia & Bereiter, 1985; Scardamalia & Bereiter, 1993; Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989), distributed expertise (Brown, 1994; Brown et al., 1993), resource-based learning (Brown & Smith, 1996; Lisewski & Settle, 1996; Race, 1996; Rakes, 1996; Taylor & Laurillard, 1995, and project-based instruction (Honebein, Duffy & Fishman, 1993) . In this approach, student research is a primary activity, and considerable effort is directed toward finding, collecting, and organizing information from various sources (Taylor & Laurillard, 1995). Students add intellectual value to existing information as they construct and manipulate representations of their own knowledge in pursuit of their learning goals. Teachers provide scaffolding to support and constrain students activities to those which are likely to be educationally profitable. Students share information, and communicate to coordinate activities and to collaborate in building communal knowledge products, as they take individual and group responsibilities in their projects. For the WWW to be a medium which directly supports these educationally desirable characteristics, new software tools are needed.

This paper briefly discusses some educational potentials of the WWW, problems with current WWW-based technologies, and promising solutions in the design of a new educational groupware environment called "Zebu."

Educational Potentials of the WWW

Vast multimedia information resources are available to teachers and students via the WWW. Despite the common difficulties in finding useful, appropriate information, the WWW is a rich information environment for teachers' and students' research activities (Rakes, 1996) . Due to this richness, there is considerable enthusiasm for bringing the WWW into classrooms by providing Internet connections so students can search and download information in their research activities. The WWW is seen as a valuable resource for locating up-to-date, authentic, primary information, whose potential for supporting student research extends far beyond the capabilities of the typical school library (Rakes, 1996; Trentin, 1996) .

In support of constructivist approaches, students can derive considerable value from the creation and sharing of representations of their own knowledge (Bellamy, 1996; Duin & Hansen, 1994; Trentin, 1996) , and the WWW provides a medium for students to publish and share documents with their peers. As students become authors, not mere surfers, the WWW can become a medium in which collaborative projects can be constructed and shared within or between groups of students who share the same learning goals, regardless of their physical locations.

Bringing the classroom into the WWW is as important as bringing the WWW into the classroom. As students become publishers, their own contributions to the WWW can become useful resources for the constructive work of themselves and others. In this way, students can begin to engage in the progressive processes of knowledge building (Bellamy, 1996; Duin & Hansen, 1994) . As well as engaging students in authentic constructive activities, this has the potential to transform students' conceptions of the nature and value of knowledge and information itself. As students contribute to the world's information resources, it becomes difficult to maintain views of published information as authoritative and necessarily true, so students can come to be more critical (Rakes, 1996) , and view knowledge construction as a social process.

Problems in Realising the Potentials

These potentials are not easy to realise in implementing a collaborative project-based learning approach. This section discusses the technical problems in using the WWW, as well as the educational problems in supporting the instructional approach. These "problems" are viewed as challenges for the design of better technologies, not as insurmountable obstacles to achieving the educational potentials.

Technical Challenges

Managing information resources

The management of WWW-based information resources presents difficulties for most WWW users, particularly in research activities (Rakes, 1996) . Search engines are improving, but finding useful information can often be difficult (Linn, 1996; Starr & Milheim, 1996), even when one knows exactly what to look for. Organizing and keeping track of found information is aided by a variety of "bookmark" manager programs, but these programs tend to be oriented toward an individual rather than a shared environment.

Production tools

Considerable technical overhead is involved in the production and publication of WWW documents. Since the introduction of WYSIWYG page editors, knowledge of HTML per se is no longer required, but such editors are not trivial to learn, particularly if any advanced multimedia or interactivity is to be included. As well, FTP or some other file transfer mechanism is also typically required to move documents from the user's computer to a WWW site for publication. The technologies for constructing documents tend not to be tightly integrated with those for communication, thus collaboration is difficult.

Site management

The organization and management of WWW sites also imposes considerable technical overhead. A large collection of categorized "pages" can be a formidable thing to manage for an experienced adult, let alone a young child. This problem is further amplified by a requirement to have groups of students work together, or perhaps have an entire school sharing a single WWW site. As well, there are trade-offs between security and publication of students' work both within sites and in the open WWW. It is possible to provide safe, private spaces for students to work on their ideas individually or in groups, but it is also

necessary to balance this with the need to share and publish their ideas at some point.

In general, although software for all aspects of WWW publication is becoming simpler and more powerful, most existing software requires the investment of significant cognitive overhead in focusing on the WWW technologies rather than the educational work of knowledge production.

Educational Challenges

Adding intellectual value to information

Whereas many educators agree that students must engage in personally meaningful activities which help them construct their own knowledge, much of schooling continues to have students focus on getting correct information from authoritative sources. To have students focus on adding intellectual value to existing information requires a substantial and often difficult reorientation of students' ideas about learning and the process of education. Conceptions of the WWW as a place to get information must be complemented with conceptions of it as a place to create and share new ideas for it to be a collaborative educational environment.

Scaffolding student work

Even students with explicit learning goals can waste considerable time and effort in not knowing what to do or how to proceed with aspects of their knowledge work. Providing some degree of scaffolding is a necessary part of a teacher's role in supporting and constraining students' efforts so that they can more easily focus on educationally profitable activities. In practice there is a difficult balance between providing sufficient support and maintaining the option for students to take charge of their own knowledge work. It is part of the art of teaching to determine how much and what form of scaffolding to provide, but it is clear that teachers need to be able to participate by providing supports within the medium in which students are doing their work.

Coordinating student work

For groups of students to effectively work together on different but related parts of a project, a great deal of coordination can be required. Teachers need to have simple ways to create supports for particular participant structures for student activities, so as to reduce the organizational overhead of coordinating group activities. As with other forms of scaffolding, a trade-off exists between the sufficiency and flexibility of such structural support, but the supports would likely be most effective if embedded within the medium of students' knowledge work.

Supporting collaboration

Collaboration requires a shared workspace where participants have equal access to building and manipulating shared representations (Schrage, 1990) . Communication environments, where students can exchange information about what they know, are becoming more common, but it is a significant challenge to support educational collaboration by providing a software environment for the WWW that serves as a fluid medium for the group construction of knowledge.

Solutions in a New Medium

The problems described in the previous section serve as challenges for the design of new collaborative technologies for education in general. These challenges have guided the design of a WWW-based educational groupware environment (Zebu) in the ALiVE! Project for the last two years. This section describes aspects of Zebu that address these design challenges, and aspects where further improvements are needed.

Zebu is a web-based groupware system designed specifically for education. Technically, the software is a set of CGI enhancements to a standard HTTP server, which allows users to construct and edit pages and other objects within a secure WWW site. Since the software is server-based, users only need a standard browser to view and edit site contents. More recent versions include simple Java interfaces for editing page contents. The site is organized into Projects and Project Collections which can be created dynamically by site administrators (typically teachers). Projects are collections of Pages, Templates, and Reference Collections. Pages are collections of Objects which may have one of eight different media types (text, graphic, video, sound, HTML, link, reference link, or discussion), and can have editable content and formatting. Templates can be cloned to create new pages with initial content and structure. Reference Collections function like bookmark files, and can be embedded into pages and templates. There are also Galleries for storing and organizing multimedia components. These components may be used directly in pages or templates, and users may upload new items into galleries directly from their local disks. There are also simple administrative tools for creating User accounts, Groups of users, Projects (and assigning Users and Groups to Projects), Project Collections, and Galleries. The interfaces for

working within a Zebu site are intended to be simple, and provide a conceptual model that corresponds to what teachers and students need to think about in order to engage in collaborative project-based learning, rather than focusing on the WWW technologies that are enabling their work.

The sections below describe in further detail the ways in which these aspects of the interface address the technical and educational challenges discussed above. As well, the figures show screen shots of various features of Zebu. The screen shots are taken from a project being worked on by a Grade 12 Geography class in Port Moody, BC. The project was centred around ecological crises. In this initial phase of the project, pairs of students chose an ecological crisis to research and share with the rest of the class.

Solutions to Technical Problems

Managing information resources

Zebu offers two main facilities for organizing and storing information resources. Galleries are used to store multimedia files (graphics, video, sound). They are accessible from anywhere in the site for uploading and organizing files, and they are integrated with the editing tools such that it is easy to place a gallery item directly into an object in a page. This makes it simple for users to build and share collections of content resources for their collaborative work (see Figure 1). Whereas Galleries store the actual items, Reference Collections store References to resources found elsewhere. References can include items on the WWW (accessible by clicking to follow the URLs), or more traditional items such as books, articles, videos, etc. References can be named and annotated, and organized into hierarchical categories within collections. Reference Collections can be linked to within pages or templates that teachers give to students, or compiled by one or more students and included in their own pages. Although Reference Collections contain no more than standard bookmark files, their benefits are derived from their tight object-oriented integration into the collaborative environment (see Figure 2).

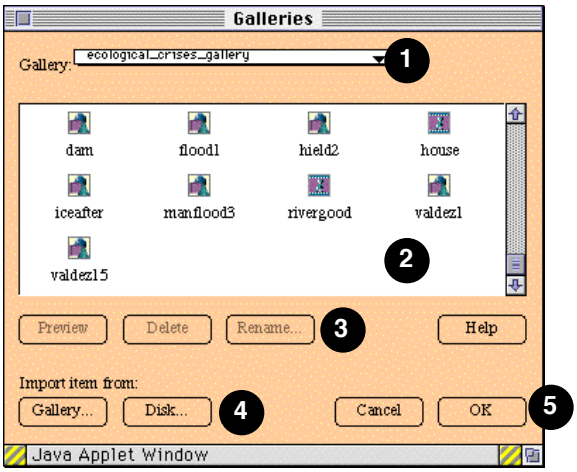

Figure 1. Gallery for "Ecological Crises" Project. Note the following: 1. Users can choose to access any of the Galleries from the pop-up menu. 2. Galleries contain graphics, sound, or video files. 3. The contents of Galleries can be easily viewed and managed. 4. Items can be added from another Gallery or from the local computer. 5. Users can select an item to include in their page.

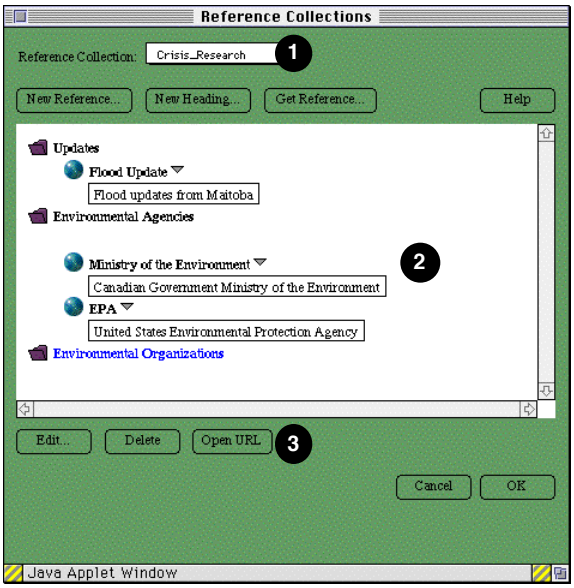

Figure 2. Reference Collection in "Ecological Crises" Project. Note the following: 1. Users can choose to access any of the Reference Collections from the pop-up menu. 2. References can be annotated and organized into hierarchies. Bookmark files can be imported as a Reference Collection. 3. The contents of Reference Collections can be easily managed. Web references can be opened in a new window.

Production tools

The primary simplicity of Zebu is derived from the non-moded integration of tools for constructing and sharing representations with existing tools for browsing. The browser becomes a window into a manipulable environment, with point-and-click remaining as the primary mode of interaction. For example to open a project or a page, the user simply clicks on an icon. To edit an object within a page, the user clicks the object's "edit" button (see Figure 3), and is then presented with a window with media type-specific options for altering content and formatting (see Figure 4). Changes to pages, projects, etc., are made directly to the server, so there is no need to transfer files to the correct directories, etc., and the ability to share pages and projects within work groups is automatic. The technical convergence of the tools for the production of representations and for communicating and sharing those representations makes Zebu a truly collaborative medium. Direct manipulation of objects and contents will be an important usability improvement for future versions, but it is already evident that the tools allow students to focus more directly on their knowledge work as opposed to focusing on the tools of standard WWW publishing.

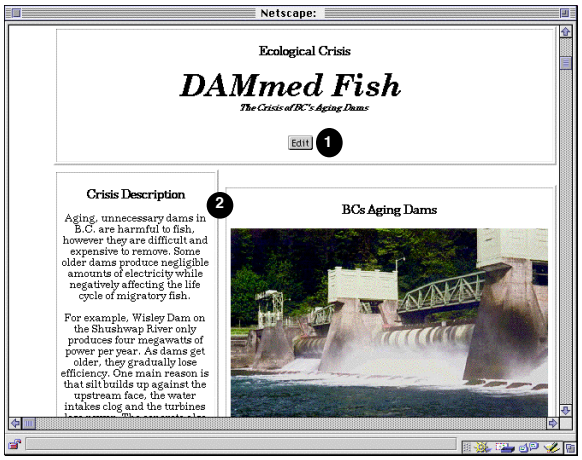

Figure 3. Part of student page in "Ecological Crises" Project. Note the following: 1. Users can click the *Edit* button to edit the contents and attributes of multimedia objects. A dialogue box will open for editing the object (see Figure 4). 2. Pages are collections of multimedia objects. These objects can be of different media types (text, graphic, video, sound, link, discussion, HTML, reference link). Each object is outlined by a box.

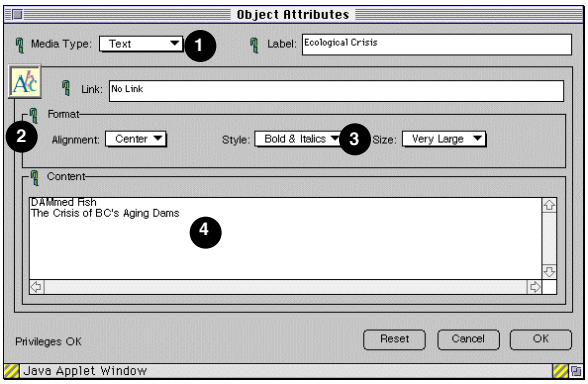

Figure 4. Dialogue for editing contents of object. Note the following: 1. Users can change the media type of the object by selecting another type from the pop-up menu. 2. Attributes of objects can be locked to prevent further editing. 3. Users can edit the media type-specific attributes of the object.

4. Users can edit the content of the object.Site Management

To the extent that site management is required, it is achieved through simple interfaces in the browser window. Site administrators can create user accounts, groups of users, projects, project collections, and galleries, and assign privileges to users or groups for working together on projects (see Figure 5). Users are required to log in to the site with their name and password, and the system provides them access only to the projects for which they have been given read or write privileges. Once users "enter" a project, the work that they do there—creating new pages, templates, or reference collections, or editing pages—is automatically stored within the project, and available to all other participants in the project (see Figure 6). Users need only consider to which projects their pages belong, or in which gallery an item might be stored, rather than negotiating the complex directory structures of the WWW site. Although site and project contents are protected by password access, it is simple to set the access privilege for a project to publish it with read-only access on the open WWW.

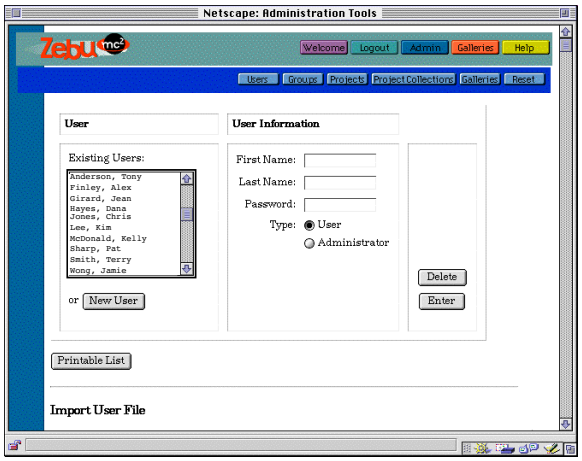

Figure 5. Interface for creating new user accounts in Zebu.

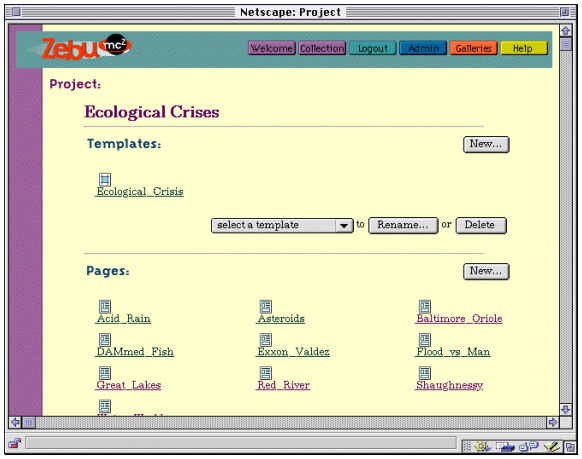

Figure 6. Table of contents for "Ecological Crises" project. The table of contents includes all Templates, Pages, and Reference Collections in the project. Project contents are automatically shared amongst all participants of the project. Pages, Templates, and Reference Collections can be created, renamed, and deleted from the table of contents.

Solutions to Educational Problems

Adding intellectual value to information

The availability of constructive, collaborative tools within the familiar WWW browser environment facilitates the shift in educational activities from simply retrieving and compiling information to adding some value to the retrieved information in the WWW. Students using Zebu are expected to create their own expressions of their own knowledge, by adding intellectual value to the resources that may be provided to them for their project work. It is possible to embed multimedia items from galleries (or elsewhere on the WWW) within pages, and to collect and annotate references to interesting information resources, thereby engaging in sense-making and knowledge-building activities based on existing information (see Figure 7). Since their own representations exist within the same environment as the provided or found information which forms the basis of their inquiries, simple re-presentation of content is obviously of little value, and it is easier for teachers to bias students toward deeper levels of processing.

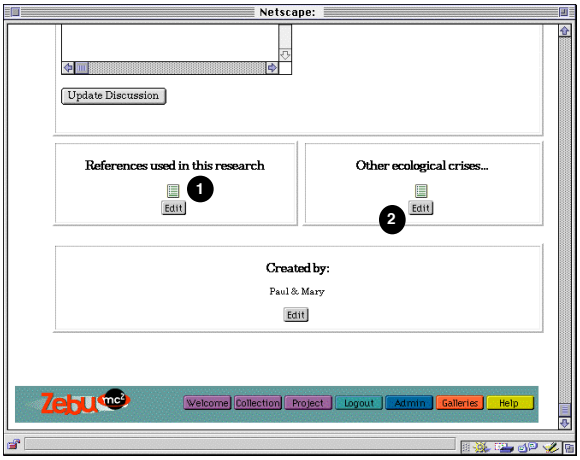

Figure 7. Part of student page in "Ecological Crises" Project. Note the following: 1. Links to Reference Collections can be embedded in Pages and Templates. (An example of a Reference Collection can be seen in Figure 2). Reference Collections are also automatically accessible from the project table of contents, and, hence, shared by all project participants. 2. These collections may be created and edited by students or teachers.

Scaffolding student work

Rather than giving students an empty project or blank page in which to do their constructive work, teachers can provide students with rich starting points for fruitful research and sense-making activity. Facilities for providing access to initial collections of information resources (Galleries and Reference Collections) are described above (see Figures 1 and 2). The most direct facility for scaffolding is the ability to create templates for page creation. Zebu templates are pages which automatically clone themselves, so that students can start with a page which already contains some content, as well as some structure (see Figure 8). For example, for a student to learn about a particular process, a teacher might provide a page with a graphic or video “placeholder” object for a student to replace with a graphic or video depicting the process, and

a text object with instructions to write a paragraph explaining how the process works. Within the same template, the teacher could provide a link to a collection of references to WWW resources which the student could use a starting points for researching the process to be explained (see Figure 7). Teachers can also lock objects (or certain attributes of objects) within templates to restrict the sorts of participation that students can engage in (see Figure 4). Different templates can be designed by teachers to provide different amounts and kinds of support to individuals and groups of students who are expected to work in particular ways in their project work. Of course, such scaffolding can fade as students become more competent on their own, and students can also use the facility to shape their own activities and interactions with each other.

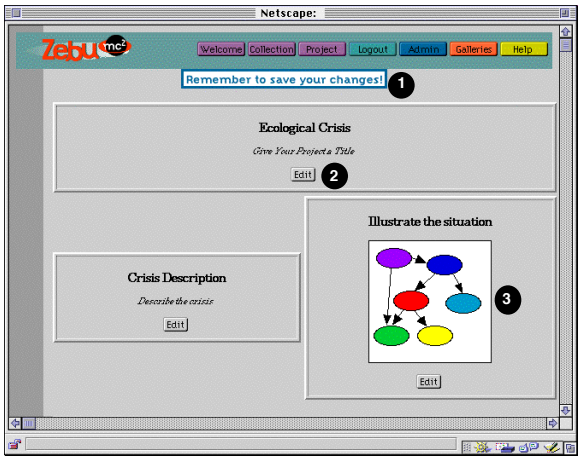

Figure 8. Teacher-created template for working on understanding of ecological crisis. This template was used to create the page shown in Figure 3. Note the following: 1. Whereas changes to Pages are automatically saved on the Zebu server, Templates create new Pages for students which they need to save. 2. Using templates, teachers are able to provide students with a predefined structure that students can use to enter and edit their own content. 3. Templates can provide both text and multimedia structure for students.

Coordinating student work

In working together on a project, a lot of effort might be spent by participants in coordination issues like where documents should be stored, who should work on which pieces, how to ensure consistency between contributions, etc. Zebu provides some simple facilities for the coordination of student project activities. Through the site administration tools, teachers can create groups of students, and assign them to specific projects, such that they can only see or edit content within certain projects (see Figure 9). Within the projects, templates can be established for use by each participant, or pages can be created with resources, instructions, and hints on how to make progress. As well, Discussion objects (like small computer conferences) can be embedded within pages for students to discuss project coordination issues (see Figure 10). Further planned developments include associating user privileges with pages and objects for finer-grained coordination support, tools for creating additional internal structure within projects, and teacher planning tools for visually creating participant and activity structures for supporting complex or lengthy projects.

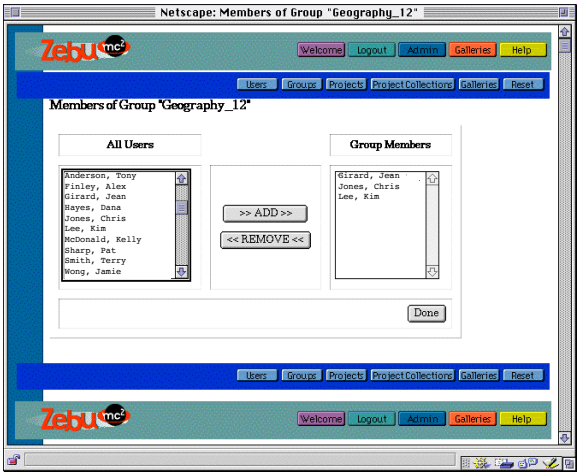

Figure 9. Interface for adding users to group.

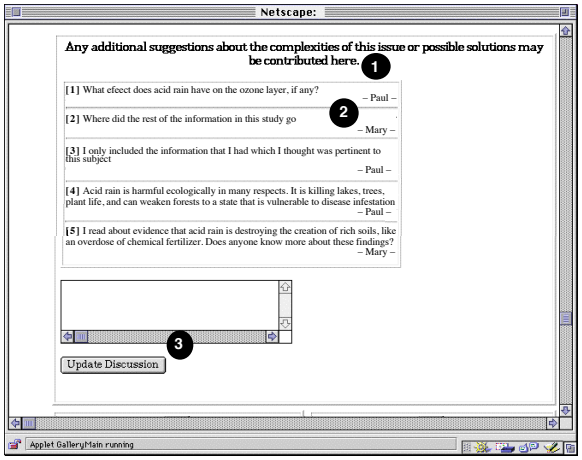

Figure 10. Discussion embedded within student page. Note the following: 1. The discussion has a problem or issue associated with it. If the discussion is not locked, the problem can be edited. 2. Each contribution to the discussion is automatically numbered and appended to the end of the discussion. The author of each contribution is automatically identified. 3. New entries are entered into the text field and appended when the *Update Discussion* button is pressed.

Supporting collaboration

Collaboration is supported in Zebu through shared creation and editing of pages and projects. Students with privileges to participate together in a project can create pages and edit any of the pages within the project, or any of the objects within the pages, thus a project is a shared space for the creation of representations. Communication between students is possible within Discussion objects that can be included in any page (see Figure 10). The discussions can be valuable for supporting discourse between students about the topics they are studying. In Zebu, the environment for constructive discourse is tightly integrated with the tools for resource-based activities.

Conclusions

Zebu is an educational groupware technology which facilitates the use of standard WWW software for collaborative project-based learning. It shows promise in helping teachers and students overcome some technical and practical, educational problems inherent in WWW-based technologies, allowing them to more fully realise the potentials of the WWW as a technology for collaboration in education.

Initial testing of a prototype of the Zebu system was carried out during the previous school year. Other projects which were conducted with the prototype included "BookTalk," a project for students to share and discuss reviews of books they had read, a creative writing project—"Monstres"—carried out by grade 1/2 French immersion students, and a joint project between a grade 3/4 and a grade 5/6 class to study tree species and habitats in British Columbia. Currently Zebu is being used at a variety of sites ranging from grade 1 to 12. Use of the Zebu software at these sites is being investigated in terms of the technical and educational challenges discussed above.

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