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Supporting Workspace Awareness in Distance Learning Environments: Issues and Experiences in the Development of a Collaborative Learning System

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Abstract

In recent years, we have witnessed an enormous growth in networks and related technologies. Course materials are increasingly published on web servers, and students are encouraged to access these at leisure. Distance learning via the WWW shifted the education paradigm from teacher-centered instruction to user-centered collaborative learning. Systems that allow users to learn collaboratively are increasingly interesting to scientific communities and learning organizations. We initially designed and prototyped a collaborative system to support collaborative learning over the Internet. A usability study of the first prototype revealed the importance of awareness information. Our review of three well-known collaborative systems finds that such systems today also lack support for awareness information, especially workspace awareness. We then consider various types of awareness in collaborative learning situations and set out the design requirements of our system. From these requirements, we have designed and prototyped several awareness widgets for a typical collaborative tool: the shared electronic whiteboard. These widgets help learners maintain awareness of other learners' interactions with the shared workspace.

Keywords: collaborative learning, groupware, cooperative learning, user interface design, usability, user studies.

1 Introduction

Since 1991, the World Wide Web (WWW) has changed the Internet to the extent that it has become almost synonymous with the modern use of the Internet. In recent years, we have seen more open learning materials, distance learning programs, and virtual institutes springing up across the globe as education programs become increasingly distributed. Face-to-face teaching in classrooms is increasingly replaced by learners' interaction with learning materials through the Internet via the computer monitor, which replaces the teacher [7]. Distance learning via the WWW presents unique challenges because learning in such a distributed environment, where learners are physically removed from one another, completely transforms the learning experience. Feelings of isolation, of not being part of a community, and lack of motivation are often reported by students who study online [18]. Online learning engenders a shift toward learner-centeredness, transferring the ownership of learning to the learners. Often the criticism against online teaching is that the human element, the teacher, is absent, and learning becomes impersonal. A real challenge to designers revolves around how to retain as many useful traditional classroom "features" as possible in the design of online learning, and how to ensure that teachers and students see the benefits, and accept the approach as an effective, alternative form of learning. Therefore, a guiding philosophy that suggests principal changes in curriculum, and effective uses of technology as part of the changes is very much needed.

Ideas from constructivist theory can be applied in this case to translate the basic principles for successful learning experience into practical design. Constructivists believe that learning entails constructing knowledge from one's experiences rather than directly receiving and encoding information from the external world (e.g. [1], [4], [5]). Two specific features of constructivist philosophy hold particular promise. The first is the notion, borrowed from research in child development, that play and experimentation are valuable forms of learning. Play involves the consideration of novel combination of ideas, and the hypothetical outcomes of imagined situations and events. Experimentation, the manipulation and testing of ideas in reality, provides learners with direct, concrete feedback about the accuracy of their ideas as they work them out. Play and experimentation are powerful forces in the development of the individual mind, but social constructivism has led to the additional awareness that powerful gains are made when learners work together as well. A growing body of research on collaborative and cooperative learning has demonstrated the benefits of learners working with other learners in collective learning efforts [16]. The advantages of this collective effort are that learners are able to reflect on and elaborate not just on their own ideas, but on those of their peers as well. *C-VISions*, a simulation-oriented collaborative virtual learning environment, has been developed in an effort to promote the play and experimentation associated with constructivist learning [2]. It also allows users to collaborate in online learning by participating actively in the virtual worlds. However, the level of collaboration provided by this environment can be augmented further to better support distance learning. In order to maximize educational benefits, we are also developing a collaborative learning environment that provides additional tools and extensions as a complement to the collaborative virtual learning system.

In this paper we present the design of awareness widgets in our collaborative learning environment. Section 2 gives a brief overview of our first prototype, presents the usability study we performed with the first prototype, and discusses the results. Section 3 critically evaluates four collaborative learning systems, gives an overview of mutual awareness in collaborative learning, and sketches our collaboration tools design requirements. Section 4 presents the design of our awareness widgets. Section 5 discusses our continuing and future work.

2 A usability study of the first prototype

A usability study of our first system prototype was conducted to determine the user-friendliness and effectiveness of the prototype, and also to gather feedback for improvements. This section begins with an overview of the first prototype, and follows with a description of the method employed for the study. Lastly, a discussion of the results is presented.

2.1 Overview of the first prototype

The implementation of our collaborative learning system is being undertaken in stages. The first prototype of the environment implemented the basic system architecture, and two collaboration tools: shared electronic whiteboard and shared mind map editor. Our system supports collaborative learning through the use of a group construct, flexible session control, and various collaboration tools. A *group* resembles the classes we have in a school, but with a broader meaning. A group can either be a *non-ad hoc group* or an *ad hoc group*. A *non-ad hoc group* has a predefined list of members. It could be a class, a project group, a tutorial group etc. An *ad hoc group* is an informal transient group. Any system user can join an ad hoc group. Ad hoc groups are generally employed for discussions among people with similar interests. A *session* groups together users who wish to share in collaborative activities. A session commences at the time the first user enters the system, and it ends when the last user leaves. Any user can launch a *collaboration tool* for a session. The user who launches the tool automatically becomes the "owner" of that tool. The owner can set the mode of sharing for that tool. There are generally three modes of data sharing: no share, read-only, and read-and-write. The owner can also specify whether he wants the sharing to end when he closes the local shared application.

2.2 Methodology

The study used observation, self-report, and interview techniques to gather information about the prototype, thus, it was a structured investigation but not a traditional controlled experiment. This section describes the participants, the organization, and the setup of the study.

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Participants: Nine students participated in this study as paid volunteers. They were divided into three groups with each group having 3 persons. The first group consisted of three Computer Science university undergraduates. The second group consisted of three secondary school students. The last group consisted of three college students learning fine art. All students have basic knowledge of how to use a personal computer. Most students were unfamiliar with the notion of groupware, and none had experience with real-time distributed groupware or the particular system used in the study.

Physical setup: Participants worked at personal computers each having a 17-inch color monitor. The computers were arranged such that the participants could not see each other. One experimenter observed and provided assistance when needed. Each participant was recorded using a video camera.

Task: Two different kinds of tasks were used in the study. The first and the second student groups were presented with a discussion task. In this task, students were presented with a dilemma situation and a few questions to motivate their discussion of a resolution to the dilemma. This task was chosen because the problem has no correct answer, and thus created a natural collaboration discussion setting. The last group was presented with a newsletter design task. Design tasks are generally hard for students to perform on their own. Hence they encourage collaboration among the students.

Procedure: Participants were introduced to the study and were then given a guided tour of the system and its functions. When they felt comfortable with the system, they began the task. The time for completion of the task was two hours. Upon the completion of the task, we conducted a short interview to further investigate events that we had observed during the tasks and to explore particular responses.

Data collection: The experimenter recorded observations about the group interaction and the use of the system during the sessions. A short interview was also conducted and audio taped at the end of the session.

2.3 Results and discussion

We found that the student users were able to comprehend and successfully use the system to complete the given tasks, though a number of complaints were also made about the system. The complaints can be grouped into two categories: (1) lack of support for coordination, and (2) lack of support for communication. During the course of the experiment, we often observed conflict situations arise, e.g., one user could delete an object without being aware that another user actually still needed it. It was also observed that sometimes users ended up working on their own without communicating with the rest. Even if a user wanted to communicate with the others, they may not have noticed this.

From our observations, we learned that students often experienced difficulties because the system failed to support a sense of mutual awareness between the users. Awareness is taken for granted in everyday face-to-face environments, but when the setting changes to distributed groupware, many of the normal cues and information sources that people use to maintain mutual awareness are lost. This awareness is important in collaborative learning for two reasons [8]. First, it reduces the overhead of working together, allowing learners to interact more naturally and more effectively. Second, it enables learners to engage in the practices that allow collaborative learning to occur.

3 Providing support for mutual awareness

We conclude from our study that mutual awareness plays an important role in the usability of collaborative learning systems. In this section, we will briefly review three well-known collaborative systems. Then we will present an overview of mutual awareness in collaborative learning. This will be followed by a statement of the design requirements.

3.1 Critique of related applications

There have been many attempts to create similar collaborative systems. Microsoft *NetMeeting* offers several ways to exchange information between several people in an online meeting [9]. Despite its popularity, many criticisms have been raised. To name a few, *NetMeeting* is not platform-independent; it uses the shared display model for sharing general PC applications. Most importantly, *NetMeeting* provides no support for workspace awareness. NCSA *Habanero* is a Java-based collaborative system that provides a framework for sharing Java objects with colleagues on the Internet [12]. Launching an application of a certain type within a session causes remote opening of an application of the type for all the participants in a session. *Habanero* provides no support for workspace awareness. *GroupKit* is a groupware toolkit that lets developers build applications for synchronous and distributed computer-based conferencing implemented using Tcl/Tk [15]. Its best feature is that it provides *groupware widgets* that enable interface features of value to conference participants to be easily added to groupware applications. The design of the awareness widgets discussed in Section 5 is partially inspired by features of *GroupKit*. However, as *GroupKit* was not designed for educational purposes, it provides no special support for distance learning.

3.2 Awareness in collaborative learning

Gutwin and Greenberg identify four types of student awareness: social awareness, task awareness, concept awareness and workspace awareness [8]. Social awareness is the awareness that students have about the social connections within the group. Task awareness is the awareness of how the task will be completed. Concept awareness is the awareness of how a particular activity or piece of knowledge fits into the student's existing knowledge. Workspace awareness is the up-to-the-moment understanding of another person's interaction with a shared workspace. It involves knowledge about such things as who is in the workspace, where they are working, and what they are doing.

In our research, we examine workspace awareness as it is perceived to be an essential factor that allows learners to initiate meaningful interactions between themselves in real-time collaborations. When people are able to maintain mutual awareness, their collaborative activities are more natural, spontaneous, and unforced. In order to keep the research effort manageable and to narrow the focus of our investigation, we restrict our study to small groups and the workspace to medium sized.

3.3 Design requirements

The benefits that are gained by creating mutual awareness do not come for free. There are generally two problems associated with the provision of awareness information: privacy violations and user disruption. The aspect of privacy is very important in an environment designed to present one's actions to other people. Obviously, people do not necessarily want all details about what they are doing to be revealed to other people [3]. The issue of privacy violation is not easily to be settled, as pointed out by Dourish [6]. He concluded from a study of several media space systems that privacy issues cannot be settled by technical means alone because they necessarily involve social interactions that are beyond technical control. Information overloading is a general problem in an electronic environment with an ever-increasing information density. Too much awareness information will distract users from their work. Therefore, the designer of awareness widgets must be careful about the choices and presentation of awareness information.

Bandwidth and hardware present another constraint on awareness information provision. As most students cannot afford high bandwidth and expensive hardware, we aim to design low-cost awareness widgets.

Awareness information should preferably not be requested explicitly from users, as that will surely distract them from what they are doing. Instead, awareness information should be automatically collected in the course of users working with the system.

Therefore, we propose three basic guidelines for the design of awareness widgets: (1) presentation of the information should not distract users, (2) the provision of awareness information should be at low-cost, and (3) collection of the information should be transparent to users.

4 Design of awareness widgets

This section concentrates on the selection and design of various awareness widgets. It starts by presenting the framework that guides our design and follows with the detailed design of the various awareness widgets.

4.1 Framework guiding the design

We believe that different applications might require different types of awareness information. Therefore, the awareness widgets should be selected according to the requirements of the particular application. The application under study in our case is the shared electronic whiteboard. The reason why we choose the whiteboard is that it presents a typical workspace conforming to our constraints (medium-sized and used in small groups).

Gutwin and Greenberg [8] present a framework for the design of awareness widgets. This framework provides a good starting point for our design. The framework consists of three parts: (1) elements of knowledge, (2) process of maintaining WA, and (3) uses of workspace awareness. The first part of the framework divides workspace awareness into the types of information that people track in a shared workspace. The second part concerns the retrieval and presentation of the various awareness information identified in the first part. The third part helps the designers to learn the situations and activities where workspace awareness will be used, so as to better analyze collaborative tasks and to better determine when groupware support is called for. Based on this framework, we designed four awareness widgets (as shown in Table 1) for use in the shared whiteboard application, each conveying different aspects of awareness information needed in the whiteboard.

Elements	**Status indicator**	**Radar view**	**Telepointer**	**Object chat**
Who				
Presence		Presence of view rectangles	Existence of telepointer	The user starting the chat must be present
Identity		Color and name	Color, name	name
Authorship		Actions within a view rectangle are initiated by that person	Proximity of the telepointer to an action	
What				
Action		Show navigation actions		
Intention				
Artifact	Artifact locked is the object in use		Proximity of telepointer to artifact	
Where				
Location	Location of the object in use	Location of view rectangle	Telepointer indicates user's location in the workspace	
Gaze		Gaze is likely somewhere within the view rectangle	Gaze often follows telepointer	Gaze is likely somewhere around the object pointed at
View		Extents of view rectangle	Telepointer is always within the view	Object pointed at is likely within the view
Reach		People normally reach for things inside the view rectangle		

Table 1: Workspace awareness information provided by four kinds of awareness mechanisms

4.2 Radar view

The radar view displays workspace awareness information on a miniature representation of the entire shared workspace [9]. It allows individuals to move freely around the workspace while still providing information about others' whereabouts and activities. A usability study has shown radar views to be an effective way for people to maintain awareness of others in a spatial task [9].

A high-fidelity display is employed to represents workspace objects instead of a low-fidelity display, because a high-fidelity display allows people to differentiate between similar-looking objects in the radar view. Besides an overview of the entire workspace, each user's view port is represented as colored rectangles in the radar view with each user's ID attached to the corresponding rectangle for identification. The radar view is also designed to be fully interactive. Dragging one's view rectangle in the radar causes the main view to scroll to that location. Users are allowed to change the color of their own colored rectangle to identify themselves from other users.

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Figure 1 shows a sample whiteboard window with radar view and telepointer enabled. In this example, there are two students in the workspace: Bob is working on the upper side of the workspace, and Mary is working on the lower side of the workspace. Bob's application interface is shown. The radar view is in the top left corner of Bob's main view. The radar view shows each person's main view as a colored rectangle. Although Bob can move freely, the radar view provides him with immediate information about Mary's view location.

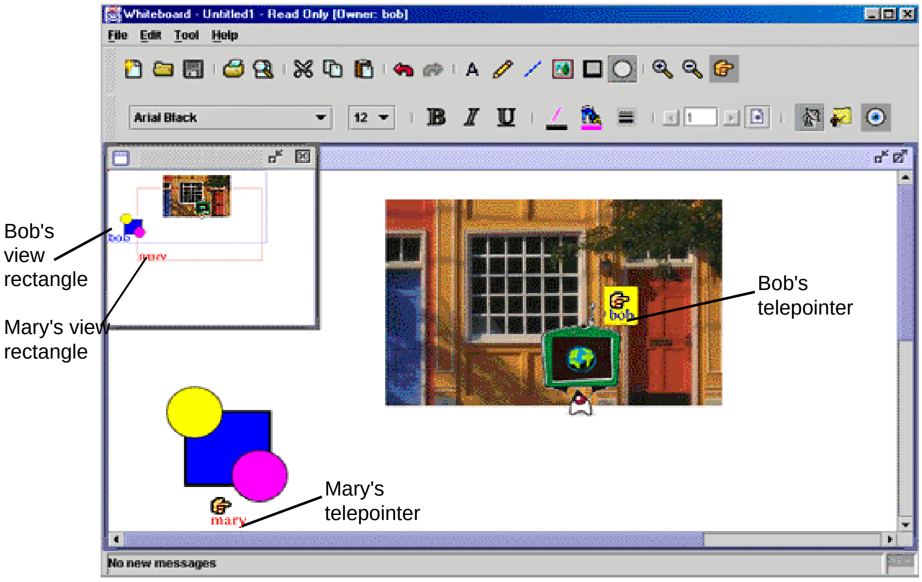

Figure 1: Radar view and telepointer awareness widgets

4.3 Telepointer

Telepointers act as a way to indicate one's location and to draw other users' attention to something. Users might want to use a telepointer to point to something they want others to look at. In addition, a user's ID is also shown with the telepointer to indicate the owner's identity. The user ID bears the same color as the rectangle representing that user in the radar view to enable easy association with the user. Figure 1, for example, shows the telepointers of Bob and Mary. Bob's ID is painted in blue, the same color as the rectangle representing his view port, while Mary chooses to represent herself with the color red. Bob's telepointer is highlighted in yellow as he moves his telepointer.

4.4 Status indicator

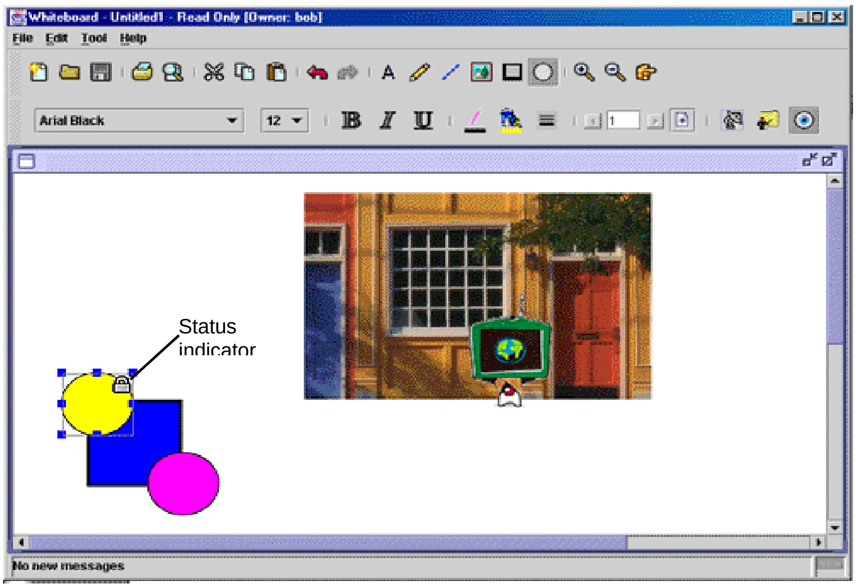

Figure 2: Status indicator awareness widget

In a collaborative learning system, it might often happen that one user tries to manipulate an object locked by another. In a locking-based collaborative environment, a user has to obtain a lock for a shared object before he can manipulate that object. To show a dialog box each time a user attempts to lock a particular object is obviously distracting. A better solution would be to signal to a user that that object is already locked before the user tries to acquire lock for it. We designed a widget called *status indicator* to specifically handle this problem. In our design, a transparent layer is employed to show the object status. However, to show the status of all locked objects will lead to considerable user clutter. In order not to distract users unnecessarily, the object status is shown only when the user clicks on the object, and the status is only shown for locked objects. Users are also allowed to decide whether they wish to see the lock or not. Figure 2 shows Bob's application interface with the status indicator enabled. The little lock over the yellow circle indicates that it is currently held by another user.

4.5 Object chat

Verbal communication, on its own, does not convey what people are pointing at or indicating when they say "this," "here," or "that." The practice of pointing or gesturing to indicate a noun used in conversation is called deictic reference and is ubiquitous in shared workspaces [17][18]. Deictic reference is a crucial part of the way we communicate in shared spaces. Object chat has been designed to facilitate deictic references. Referential communication involves composing a message that will allow another person to choose a thing from a set of objects [11]. When transcripts of a collaborative activity are reviewed, however, many of these messages become almost unintelligible without knowledge of what was going on in the workspace at the time. For example, consider a fragment from the newsletter layout task:

> A: What about moving this thing… <points to the diagram>… here? <points to another location>
> B: No, that's no good.
> A: <points to another location> here?
> B: That should be OK.

Object chat allows one person to select an object and send a message to others about that object. The message will be shown next to the object so that others in the collaborative work group will know which object the message sender is referring to. The sender's ID and a time stamp will be shown together with the message. Upon receiving a message, a sound is played and a light will flash on the status bar of the application to indicate that there is a new message. Figure 3 shows the application interface of the user Mary. The yellow rectangle in the whiteboard window shows Bob's chat message to Mary asking for her opinion on the Duke icon. On the bottom right corner of the window, a flashing light indicates that there is another incoming message. The status of the object chat message is also shown on the status bar.

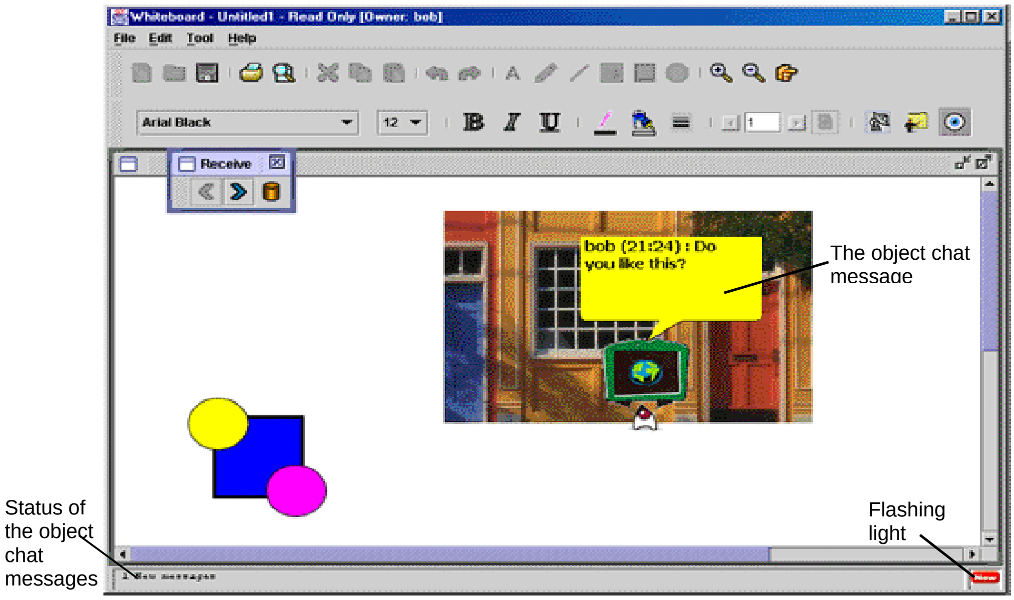

Figure 3: Object chat awareness widget

Though the current system implementation only provides the basic operation of object chat, we are designing a history mechanism that allows storing and retrieving of object chat messages in a flexible and efficient manner.

5 Future work

Our investigation into the use of workspace awareness in distance learning environments will continue in several directions. We plan to conduct experiments to establish the usability of our awareness widgets. From the result, we will further improve our widgets design. The next step is to use our collaborative learning system with larger samples of students and track their use of the collaboration tools over a longer period of time. The main objective of this phase of evaluation is to understand whether the collaborative learning tools and awareness widgets that we have designed are helping students in their study. During this stage we will engage in a process of iterative design. We also wish, in the longer term, to find out whether we can go beyond existing face to face practices and create new awareness mechanisms that augment, rather than just replace, what people normally expect.

6 References

[1] Brown, J. S., Collins, A., & Duguid, P., “Situated cognition and the culture of learning", Educational Researcher, Vol. 18, No. 1, pp. 32-42, (1989).

[2] Chee, Y. S. and Khoo, Y. B., "Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments", In Proceedings of ICCE'2000 International Conference on Computers in Education, Taipei, Taiwan, pp. 222-230, (2000).

[3] Clement, A., “Considering Privacy in the Development of Multi-media Communications", Computer Supported Cooperative Work, special issue on NetWORKing, pp. 67-88, (1994).

[4] Collins, A., Brown, J. S., and Newman, S. E. “Cognitive Appreneticeship: Teaching the crafts of reading, writing and mathematics”, Knowning, Learning and Instruction: Essays in honor of Robert Glaser, Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).

[5] Collins, E. and Green, J. L. “Learning in classroom settings: making or breaking a culture”, In H. H. Marshall (Ed.), Redefining student learning: roots of educational change, Norwood, N. J: Ablex., pp. 59-86, (1992).

[6] Dourish, P., “Culture and Control in a Media Space”, In Proceedings of the Third European Conference on Computer-Supported Cooperative Work (ECSCW'93), Milan, Italy, pp. 335-341(1993).

[7] Forsyth, I., “Teaching and Learning Materials and the Internet”, Kogan Page, (1997).

[8] Gutwin, C., Gwen, S., and Greenberg, S., “Support for Workspace Awareness in Educational Groupware”, In Proceedings of CSCL’95 Conference on Computer Support for Collaborative Learning, Bloomington, Indiana, pp 147-156, (1995).

[9] Gutwin, C. and Greenberg, S., “A Framework of Awareness for Small Groups in Shared-Workspace Groupware”, Technical Report 99-1, Department of Computer Science, University of Saskatchewan, Canada, (1999).

[10] Gutwin, C., Roseman, R., and Greenberg, S., “A Usability Study of Awareness widgets in a Shared Workspace Groupware System”, In Proceedings of the ACM CSCW’96 Conference on Computer Supported Cooperative Work, Boston, Mass., pp. 258-267 (1996).

[11] Krauss, R. and Fussell, S., "Mutual Knowledge and Communicative Effectiveness", Intellectual Teamwork: Social and Technological Foundations of Cooperative Work, Hillsdale, NJ: Lawrence Erlbaum Associates, pp. 111-145, (1990).

[12] NCSA Habanero, http://www.ncsa.uiuc.edu/SDG/Software/Habanero (accessed on April 15, 2001).

[13] NetMeeting, http://www.microsoft.com/windows/netmeeting (accessed on April 15, 2001).

[14] Roseman, M. and Greenberg, S., “Building Real Time Groupware with GroupKit, A Groupware Toolkit”, ACM Transactions on Computer Human Interaction, Vol.3, No. 1, p66-106, (1996).

[15] Rysavy, S. D. M., and Sales, G. C., “Cooperative Learning in Computer-based Instruction”, Educational Technology Research and Development, Vol. 39, No. 2, pp. 70-80, (1991).

[16] Segal, L., "Effects of Checklist interface on Non-Verbal Crew communications", NASA Ames Research Center, Contractor Report 177639, (1989).

[17] Tang, J., "Findings from Observational Studies of Collaborative Work", International Journal of Man-Machine Studies, Vol. 34, No. 2, pp. 143-160, (1991).

[18] Wegerif, R., “The Social Dimension of Asynchronous Learning Networks”, Journal of Asynchronous Learning Networks, Vol. 2, No. 1, pp. 34-49, (1998).