Support for Group Awareness in Educational Groupware

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Abstract

Real-time educational groupware systems are multi-user computer applications that allow physically separated learners to work together in a shared virtual space at the same time. These systems do not yet provide the rich communication and awareness that are possible in a face-to-face learning situation. One of the elements lacking in these systems is *group awareness* - the up-to-the-minute knowledge that is needed to work or learn with another person. This paper describes our initial investigations into computer support for group awareness. We present a framework for thinking about the awareness requirements of collaborative learning situations, and then we organize group learning situations in terms of group awareness. From the framework, we have designed and built several *awareness widgets* for educational groupware that can be used in the networked classroom and in distance learning. These widgets help learners maintain awareness of other learners' locations when their views are separated, of other learners' activities in shared and separate view situations, and of other learners' past activities in out-and-back collaboration.

1. Introduction

The field of computer-supported collaborative learning (CSCL) attempts to understand and provide technological support for cooperative and collaborative learning (e.g. Koschman 1994; Roschelle and Clancey 1992; Pea and Gomez 1992; Koschman, Newman, Woodruff et al. 1993). Within the wide range of CSCL, one area of interest is synchronous, distributed educational groupware. These systems are networked computer environments that allow geographically separate learners to collaborate at the same time in a shared virtual workspace; the system may provide audio and video links as well. Educational groupware is becoming more common as local and wide area networks are put into place, and is used both in networked classrooms and in distance learning.

Educational groupware systems do not yet provide the richness that is possible in a face-to-face interaction. If these systems are to foster learning within a context of interaction, as has been advocated by educational theorists (e.g. Bruner 1985; Brown, Collins, and Duguid 1989; Lave and Wenger 1991), they must support the existing practices and processes of group learning. One practice that is not well supported in current groupware systems is the maintenance of *group awareness* (Gutwin and Greenberg 1995). Group awareness is the up-to-the-minute knowledge about others in the activity that people need in order to work or learn together. Group awareness is maintained by keeping track of information such as other learners' locations in the shared workspace (where are they working?), their actions (what are they doing?), the interaction history (what have they already done?), and their intentions (what are they going to do next?). Group awareness is necessary for effective collaborative work, but also plays an integral part in how well an environment creates opportunities for collaborative learning.

This paper describes our investigation into the awareness requirements of collaborative learning, and specifically, how group awareness can be supported in groupware interfaces. Section 2 presents a framework for organizing and categorizing the awareness requirements of a collaborative learning situation. Section 3 describes group awareness in more detail, and Section 4 describes our initial work in supporting group awareness through innovative interface components.

2. A Framework of Awareness in Collaborative Learning

We have created a framework of awareness in collaborative learning in order to discuss the types of awareness that are used in a collaborative experience. We briefly explore the involvement and awareness requirements for the curriculum designer, teacher, evaluator and student in a successful collaborative activity. We then focus on types of student awareness which include: social awareness, task awareness, concept awareness and group awareness in a collaborative activity. The support of group awareness in CSCL then becomes the focus of sections 3 and 4. The framework, shown in Figure 1, creates a context for our later discussion of group awareness.

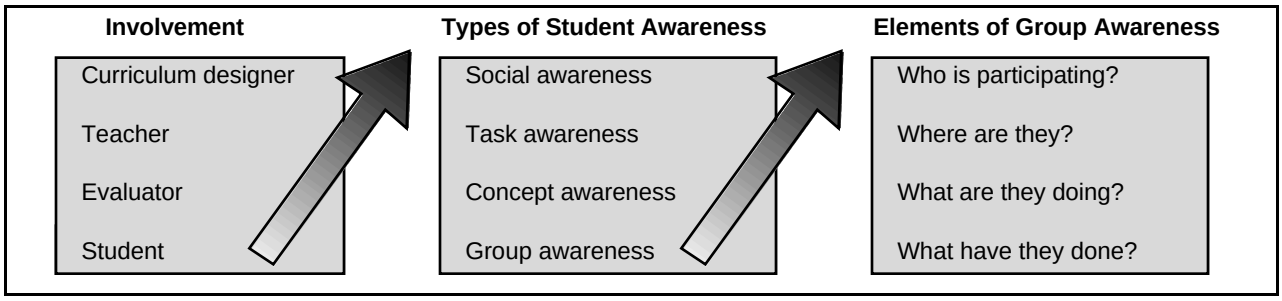

Figure 1. Framework of Awareness in Collaborative Learning

The success of a collaborative learning experience depends on the informed involvement of curriculum designer, teacher, evaluator, and students. The curriculum designer is responsible for the development of the activity and must be aware of the pedagogy of collaborative learning.(e.g. Brufee 1983; Slavin 1983) In addition, the curriculum designer must be aware of the objectives of the activity and must create the collaborative experience to support these objectives. The teacher is responsible for facilitating the activity and must be aware of the constraints of the group they are working with. The teacher must be aware of what the students are doing in the activity in order to help the students work towards the successful completion of the task. The evaluator is responsible for the evaluation of the process and must be aware of the interactions that take place during the activity and must be aware of the outcome of the task. Although every role and type of awareness in the process is important, the role of the student and the types of awareness they must have in order to work successfully in a collaborative environment are the focus of the following discussion.

The students are responsible for working together to complete the collaborative task. Goldman (1992) identifies three types of student interaction: social, task, and conceptual. For each kind of interaction there is a corresponding type of awareness; in addition we add another type of awareness called group awareness

In order to complete a collaborative task , students must be aware of what is going on around them. This awareness can be categorized as social awareness, task awareness, concept awareness and group awareness. 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. Finally group awareness is the up-to-the-minute knowledge of where other students are working, what they are doing, and what they have already done. The questions in Table 1 are examples of what students consider during the collaborative activity in order to be aware of what is happening in the group and to move towards the completion of the task:

Social awareness	-What should I expect from other members of this group? -How will I interact with this group? -What role will I take in this group? -What roles will the other members of the group assume?
Task awareness	-What do I know about this topic and the structure of the task? -What do others know about this topic and task? -What steps must we take to complete the task? -How will the outcome be evaluated? -What tools/materials are needed to complete the task? -How much time is required? How much time is available?
Concept awareness	-How does this task fit into what I already know about the concept? -What else to I need to find out about this topic? -Do I need to revise any of my current ideas in light of this new information? -Can I create a hypothesis from my existing knowledge to predict the outcome of this task?
Group awareness	- What are the other members of the group doing to complete the task? Where are they ? What are they doing? What have they already done? What are they going to do next? -How can I help other students?

Table 1. Types of Student Awareness

As suggested by the questions in Table 1, social awareness is a type that is difficult to support in a groupware system, although videoconferencing and media spaces (e.g. Buxton 1992; Harrison and Minneman 1990) can provide some of the information that people need in this area. Support for task and concept awareness has been considered in cooperative learning (e.g. Johnson and Johnson 1985) and CSCL research; this support often provides explicit structures that students can use as scaffolds to assist them with organization or to help them stay focused on the learning tasks (Slavin 1983). For example, cooperative learning assigns explicit roles to students and provides a clear outline of how the task is to be completed. In CSCL, knowledge-building environments such as CSILE (Scardamalia,

Bereiter, Brett, et al. 1992) and CoVis' collaboratory notebook (O'Neill and Gomez 1994) provide structured message capabilities that guide students through the steps of a learning dialogue. Although social, task, and concept awareness are important to the success of a collaborative learning experience, we now consider group awareness in more detail.

3. Group Awareness

Our research deals specifically with group awareness, the up-to-the-minute knowledge that is required to work effectively with another learner. This section describes group awareness in more detail, and presents a third part of the framework that organizes group learning situations in terms of task and view separation.

Group awareness is important in collaborative learning for two reasons: first, it reduces the overhead of working together, allowing learners to interact more naturally and more effectively; and second, it enables learners to engage in the practices that allow collaborative learning to occur.

As an example of how group awareness allows groups to be more effective, consider two learners engaged in an activity where they must reconstruct a poem that is given to them as individual, mixed-up lines. Each person maintains an awareness of where in the text the other is working, what they are doing, and what their intentions may be. Learner A may begin by picking out two lines that end with a certain rhyme. Learner B can ascertain A's activity by watching her work, even though she has not explicitly stated her chosen task. If B during the course of his own tasks comes across another line with the same rhyme, he can pick it out and give it to A, thereby assisting with her part of the task. This moment of collaborative effort is made possible because of group awareness, and though small, will be joined by many other similar moments of opportunistic collaboration. Taken together, these actions allow a group to be significantly more effective than an individual.

Group awareness also allows students to take advantage of the opportunities for interaction that make collaboration a valuable way to learn. In a collaborative learning situation, people may learn in a number of ways, such as:

- modelling the practices and skills of a more knowledgeable peer (e.g. Forman and Cazden 1985; Collins, Brown, and Newman 1989)
- identifying and resolving differences between conflicting ideas and theories (e.g. Doise and Mugny 1984; Messer and Light 1991)
- peer teaching, where one student assists or instructs another when appropriate (e.g. Smith and MacGregor 1992)
- constructing new shared meanings practices (e.g. Roschelle 1992; Scardamalia and Bereiter 1992)

Each of these mechanisms depend upon learners having a clear understanding of others' states of affairs. For one learner to model another, they must be able to perceive the details of what the other is doing. For one learner to propose a competing hypothesis at a point when it will be immediately relevant, they must know what the other person's activities and intentions are. Peer teaching is similarly dependent upon knowing what another learner is working on and what they have already attempted, and building shared knowledge demands that a group understand what each other are doing and have done. Although the actual learning in a collaborative situation often happens through verbal interaction (Repman 1993) and not through group awareness, it is the awareness of others allows learners to initiate meaningful interaction at appropriate and opportune times.

Another mechanism of collaborative learning that group awareness makes possible is the use of conversational props (Brinck and Gomez 1992) to support learning dialogues. When the objects being discussed are visible to both learners, they can point and gesture to make clear the referents of their comments, something that is difficult using language alone (Brown, Collins, and Duguid 1989). In addition, visible objects can act as a notational system (Singer, Behrend, and Roschelle 1988) that extends the range and sophistication of concepts that the learners can discuss.

Although group awareness is often taken for granted in face-to-face collaborative learning situations, current groupware systems provide only a small amount of the information that students need to maintain it. We have been investigating how group awareness works in face-to-face situations, and how it can be supported in groupware applications. Our goal is to create real-time educational groupware that allows much of the same kinds of interaction, opportunities for collaboration, and opportunities for learning that are possible in a face-to-face situation.

The next part of our framework is a step towards this goal; it organizes group situations in a way that allows us to examine the specific mechanisms and information sources that people use to maintain group awareness. This organization considers two dimensions of group activity that involve the distance between learners: *view separation* and *task separation*. View separation is the distance between the objects that group members are looking at; task

separation relates to the level of detail at which people share a task (although we assume that they share a global goal). In collaborative learning situations, learners will either be looking at the same set of objects or different sets of objects, and they will either be working on the same low-level task or will have different low-level tasks. Figure 2 shows these two dimensions of group activity and, for each major area within the space, lists some of the group awareness questions that learners may need to answer.

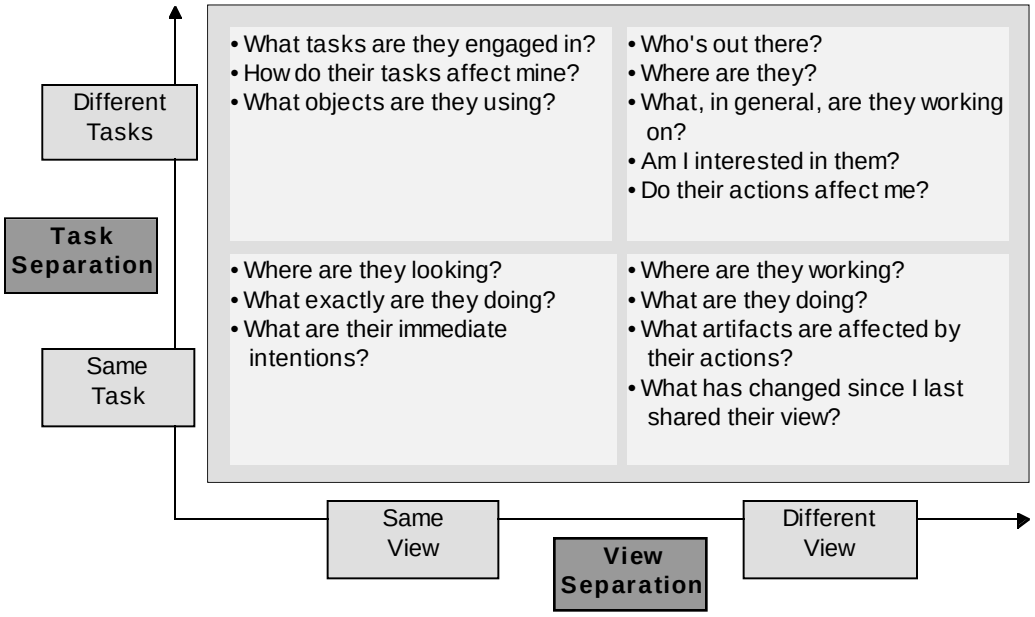

Figure 2. View and task proximity in collaborative situations

Some of the collaborative learning situations defined in Figure 2 are outlined in the following section; we also describe our early investigations into supporting group awareness through groupware interfaces.

4. Interface support for group awareness

We are building general, reusable groupware components for GroupKit (Roseman and Greenberg 1992; Roseman and Greenberg 1995), a groupware toolkit that streamlines the construction of multi-user applications. Educational groupware systems built with GroupKit are designed for multiple students in different locations, each with their own computer that is connected to a common network.

The following sections describe three types of collaborative learning situation contained in Figure 2, and introduce interface tools in GroupKit for each type that support the maintenance of group awareness. The types are: same task and same view situations; same task and different view situations; and situations where learners have the same task and have views that are sometimes the same and sometimes different.

4.1 Same task, same view situations

In some collaborative learning situations, students work on the same low-level tasks, and focus on a small set of common objects. These situations involve close interaction and require awareness of the precise location and exact actions of other learners. For example, group creative writing often involves partners who discuss and collaborate on each word and phrase of a poem; they need to know the exact context in which to interpret the other's comments and contributions. Peer editing is similar, where two students carry on a detailed discussion about a piece of writing. This activity illustrates the importance of supporting gestural communication, since the two learners will use their text as a conversational prop, indicating pieces of text and possible changes by pointing and gesturing. Another example involves problem-solving in a microworld for exploring physics concepts, where students work at the same task level and take part in each decision and action.

Same-view groupware systems (called 'what you see is what I see' (Stefik, Foster, Bobrow, et al. 1987)) must provide precise cues as to another learner's location and activity. There are two ways to provide these cues with GroupKit. First, a designer is given control over how closely the screens are linked: for example, a shared drawing program might transmit the intermediate motion of an object as it is moved, or perhaps only transmit its new position after the move. In a same-task same-view groupware application, fine-grained screen linking can be implemented to give learners greater awareness of immediate changes to the environment.

Multiple cursors (Hayne, Pendergast, and Greenberg 1993) are a second means for supporting fine-grained awareness of location and activity in GroupKit. These show each person's mouse cursor and their movements displayed on every learner's screen. Multiple cursors allow gestural communication and give visual cues to a person's activity and intentions. GroupKit's telepointers are shown in Figure 3 as cross-hatched circles.

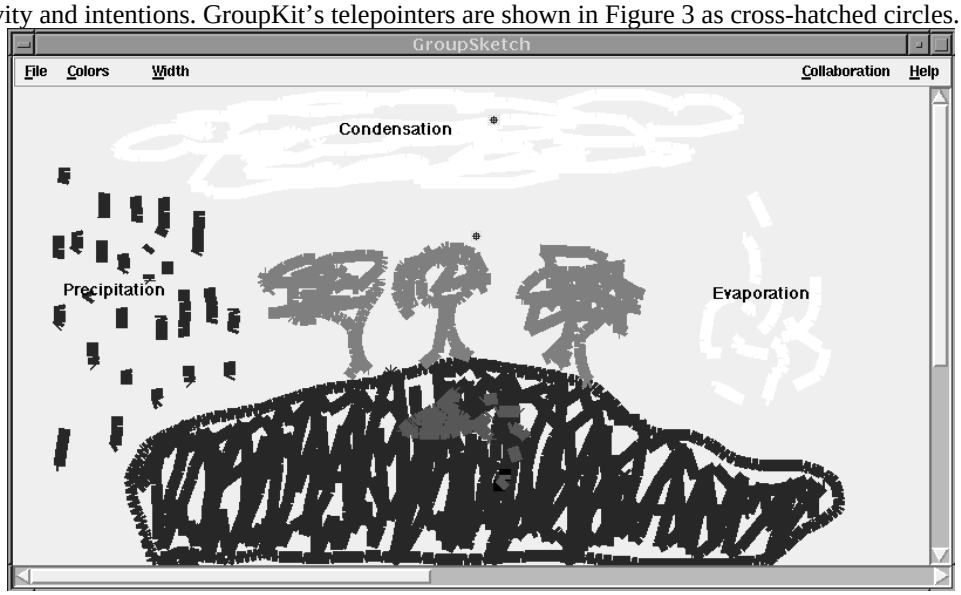

Figure 3. Telepointers in a group drawing program

We have extended the idea of multiple cursors for situations where people see the same objects but with different presentations. For example, if two people view the same text but display it in different font sizes, then reproducing the literal movements of each person's cursor will not show their actual position in the text. To address this problem, we have prototyped a *semantic telepointer* that indicates the logical location of a person's cursor rather than its screen position. For example, the semantic telepointer shown in Figure 4 highlights the letter that is currently underneath the remote learner's cursor (the 'd' in 'climbed'), rather than tracking the cursor's screen location.

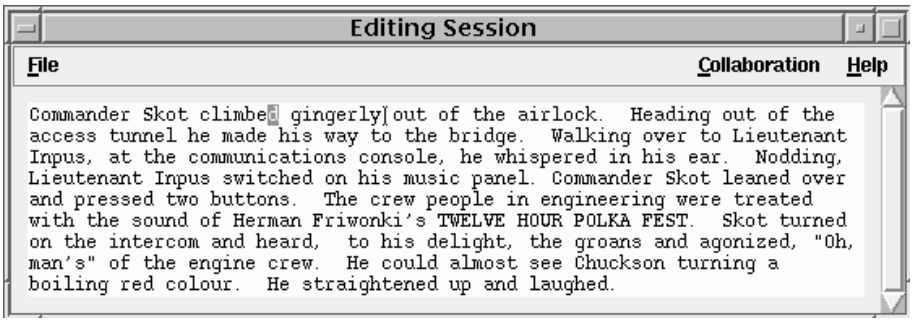

Figure 4. Semantic cursor used in a peer editing application

4.2 Same task, different view situations

Some learning situations involve coordinated action that occurs in different areas of the workspace. This kind of interaction can be seen when learners create a poster or collage: the learners are no longer making group decisions about each word or figure in the poster, and they may be working on different parts of the page. However, a sense of awareness about the others' activities is needed for coordination of effort and for making overall decisions. Another situation involves literature students who have the task of finding imagery of evil in Macbeth; each student looks for images of a different theme (blood, darkness, reversal, or decay). The students are working toward the same goal, and will need to keep track of each others' activities and progress, but they will all be looking at different parts of the play at any one time. A third example from our experience is that of social-studies students constructing a timeline to represent events in the history of a country. Since the timeline will be long, students will often have different views onto the document. Again, they will still need information about where others are working, perhaps to offer additional information or to see what remains to be completed in the task.

Different views of the worksurface often imply that the requirements for group awareness will be more coarse than in a WYSIWIS situation. Awareness of low-level actions like the movement of someone's pointer may be less

important, but awareness of location with respect to the entire document, and awareness of activities at a higher level, are more important. However, there are also cases where learners may need some kinds of detailed information about others' activities, such as the kind of information that is gathered through peripheral vision or hearing in a face-to-face situation. Groupware systems that allow learners to view different parts of the shared workspace use relaxed-WYSIWIS screen linking (Stefik, Foster, Bobrow, et al. 1987). We have designed widgets in GroupKit to provide information about both location and activity in these kinds of systems.

Location can be shown with a multi-user scrollbar or a global-view display. The multi-user scrollbar is illustrated in Figure 5. The scrollbar supports group awareness by pinpointing other learners' relative locations within the document. The right-most control acts like a standard scrollbar, and lets each student manipulate their own view. To its left is a vertical bar showing the relative viewport of all other learners, each identified by a unique colour. The position and size of each bar is continuously updated as learners scroll through the document or change their window size. If a learner wishes to match their view with someone else's, they need only drag their scroller until it is level with the other's indicator bar.

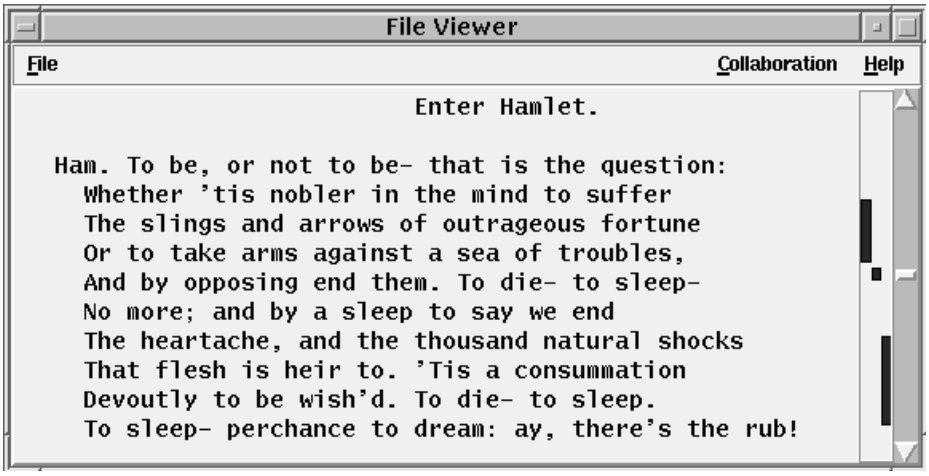

Figure 5. The multi-user scrollbar showing three learners' locations in *Hamlet*

The global view display is similar to the multi-user scrollbar but is much richer in function. It shows a miniature of the entire document, overlaid with colored boxes that show the actual viewport of each student in the session (Figure 6). These boxes are active interface objects: a student can scroll to a new location by dragging their box with the mouse. The miniature provides structural cues about the document that help someone understand where their collaborators are working and what they are doing. As in the multi-user scrollbar, a learner can make their view congruent with another by dragging their view outline over top another.

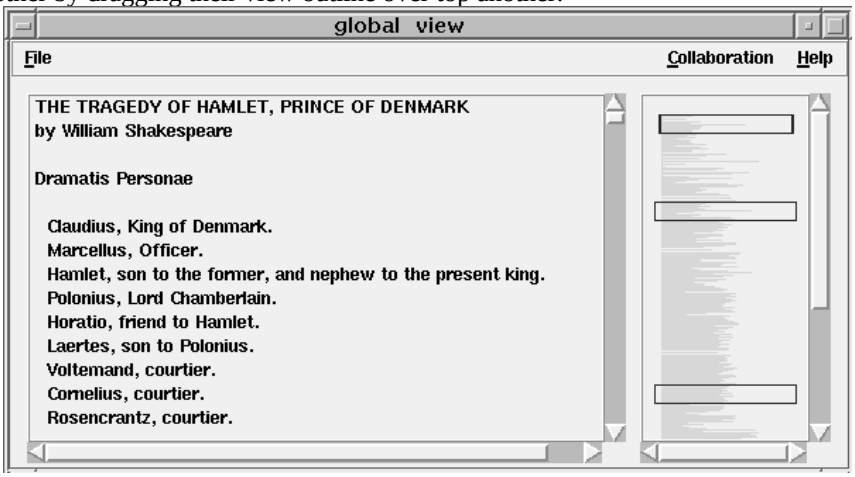

Figure 6. Global view of three locations in the text of *Hamlet*

Supporting awareness of activity in different-view situations is more difficult than when learners can see the same objects, since they can no longer see the other person's cursor or how the objects are being changed. Limitations on screen space discourage the simple solution of showing complete duplicates of every student's view. Instead, we have prototyped a What You See Is What I Do (WYSIWID) display. This widget shows only the immediate context around another learner's cursor, which is a subset of their view. This is illustrated in Figure 7, where a person sees

not only their main view, but also part of Saul's view (top right corner). The remote view is always centred around their cursor; rather than showing cursor movement, the background is panned instead. Since most actions in graphical applications involve the mouse cursor, the local-view display can show what others are doing in a limited space.

Figure 7. A 'what you see is what I do' widget

4.3 Same task, out-and-back interaction

A third kind of collaboration falls between same-view and different-view situations. We call this kind of interaction *out-and-back collaboration*: individual and shared activities are interleaved, and learners shift their focus back and forth between separate and shared views of the workspace. Many of the collaborative learning situations described so far also have elements of out-and-back collaboration. For example, the poem reconstruction, the collaborative poster, and the group effort in finding imagery in *Macbeth* all involve periods of individual and shared activity.

The individual and shared activities of out-and-back collaboration can be supported by the techniques discussed in the previous two sections. However, out-and-back situations present an additional requirement for group awareness. Learners may need to bring themselves up to date on what has happened with another person before rejoining their view and engaging in a period of shared work. Learners must consider what the other person has been doing, what changes they have made, and where they have been.

Existing techniques such as adding change bars to a document or calculating the difference between two versions ('diffing') can only provide some of this information, and usually only for text documents. We have designed a few widgets to investigate awareness of a group's recent actions. For example, to support awareness of where other learners have been working, we have added a history mechanism to the global view display. The new tool is shown in Figure 8 below.

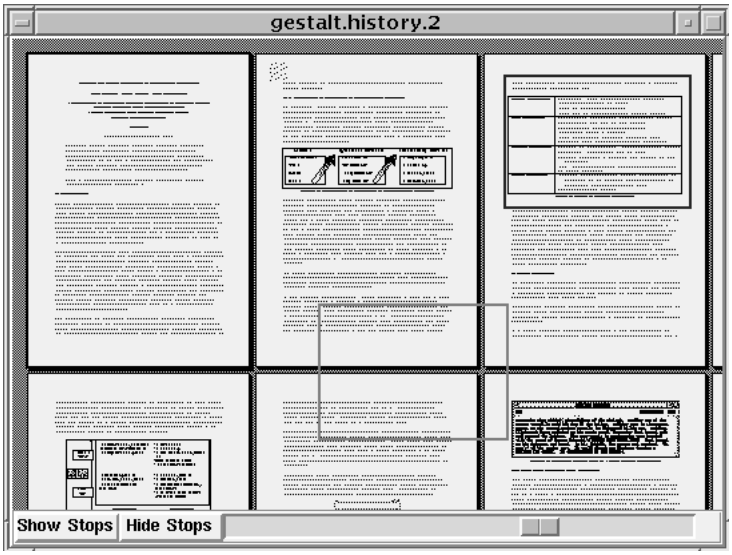

Figure 8. A global view with history.

In addition to showing another learner's current viewport, the widget tracks their location over time. Moving the slider at the bottom of the window plays back the movement of another person's viewport (displayed as a moving outline rectangle), and also indicates where they stopped for a while (shown as a filled rectangle).

5. Related Work and Plans for Further Research

Educational groupware draws on work done in the field of computer-supported cooperative work (e.g. Baecker 1993); several CSCW projects have considered the issues involved in creating real-time distributed systems, and some have touched on the concept of group awareness. For example, the multi-user scrollbar and a 'gestalt-view' were first seen in SASSE (Baecker, Nastos, Posner, et al. 1993); other systems have used tools like activity indicators (e.g. Stefik, Bobrow, Foster et al. 1987; Ellis, Gibbs, and Rein 1991) to keep people informed. One branch of CSCW research that has promise for supporting both social and group awareness looks at mixing video signals of learner's hands or faces together with a computational representation of the shared workspace (e.g. Ishii & Kobayashi 1992; Tang and Minneman 1991).

Our investigations into support for group awareness will continue in several directions. We plan to conduct observational experiments to gather data about what mechanisms people use to maintain group awareness in particular situations like out-and-back collaboration. This knowledge will be used to form design principles for the creation of new groupware components. The process of translating the knowledge for use in the radically different setting of groupware presents many challenges: for example, we are exploring how to represent peripheral awareness when the visual field is reduced to the size of a computer screen. As well, we are identifying overall issues that affect the design and implementation of these techniques, including:

- the trade-off between being well informed about other learners' activities but being distracted by that information from their individual tasks;
- allowing learners to exert some control over the awareness information that others receive about them;
- whether we can go beyond existing face to face practises, and create new awareness mechanisms augment, rather than just replace, what people normally expect.

6. Conclusion

This paper has outlined a framework that sets group awareness in a context of awareness requirements for collaborative learning. We presented a way to organize collaborative situations in terms of task and view separation, and introduced several interface components that can support the maintenance of group awareness in educational groupware. The components are useful for same view situations, for different view situations, and also for out-and-back interaction.

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