

Groupware goes to school: adapting BSCW to the classroom

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Abstract: Groupware for cooperative work (CSCW) and for collaborative learning (CSCL) have many important commonalities as well as different requirements. By transforming a generic CSCW platform into an environment to support a particular vision of education as collaborative knowledge building, we discovered how functionality had to be adopted, transformed and refined to meet the specific educational social setting. By 'taking groupware to school', we learned how to extend the original system into a CSCL application that could facilitate collaborative learning, knowledge building, perspective intertwining, knowledge negotiation, portfolio sharing and knowledge artifact production in active, structured virtual learning places. In this paper, we describe the resulting system and reflect on issues of design and implementation that differentiate our CSCL approach from its closely related CSCW basis.

Keywords: collaborative knowledge building, CSCL, educational groupware, knowledge negotiation.

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1 INTRODUCTION: FROM CSCW TO CSCL

With widespread use of the Internet, groupware promises to provide the kind of support to networked groups that individual productivity software like word processors and spreadsheets grant individuals. The potential of computer support for groups is perhaps even higher than that for individuals because communication within groups has, until now, suffered from severe constraints that may be eased by computer support. The question must still be addressed as to what groupware should aim at beyond the reproduction of pre-computer forms of group interaction.

We need a vision of how networked computers can facilitate the discussion of all with all that does not require the coordination of a manager or teacher and can support the collaborative building of knowledge that is not restricted to the skills, memories and efforts of individuals. Perhaps when we take groupware into the schools in a principled and explorative way we may see how computer support can be designed to transform teacher-centric learning into collaborative learning and

transcend knowledge management with knowledge building. In this way, what we learn about computer support for collaborative learning (CSCL) could provide an informative model for design of computer support for cooperative work (CSCW).

Academically, the exploration of groupware has historically been split into two separate domains: CSCW and CSCL, which address issues of work and learning, respectively. Each domain has its own conferences, journals and adherents. The CRIWG international workshop on groupware (where an earlier version of this paper was presented in September 2002) is one of the few places that these two fields come together. This distinction has not been based on a conceptual analysis that might motivate and justify such a division. Certainly, the two domains have at least sufficient commonalities that they can borrow extensively from one another.

Why should CSCW and CSCL be distinguished? There is at least a superficial rationale for this. CSCW is concerned with the world of work, where people must accomplish commercially productive tasks, while CSCL is concerned with the world of schooling, where students

must learn basic skills that will in the end allow them to function effectively in the world of work and in adult society generally. These are very different social contexts. Perhaps the clearest lesson of CSCW research to date has been the importance of taking into account the social context—the motivations, prevailing practices, political constraints—in which software is to be used [1, 2]. By this criterion, the two domains are indeed distinct and should be treated so.

However, it is also true that in today's 'knowledge society' work is often knowledge work that requires constant learning [3, 4]. In the interesting cases, work—whether individual or cooperative—is not the repetitive carrying out of well-known tasks that were learned once and for all in school, but work itself centrally involves various learning tasks. Work may require just-in-time learning, where existing information must be found to solve a current problem. Or it may involve inquiry learning, where solving a wicked, ill-structured or non-routine problem requires the building of new knowledge. Similarly, the learning that is needed to prepare students for an effective role in tomorrow's knowledge society cannot consist merely in the transfer of existing knowledge into passively receptive minds, but must guide the students to develop personal and social skills that will allow them to find information relevant to unanticipated problems and to engage in inquiry processes. In this sense, the application domains of CSCW and CSCL are closely related; it is not just a matter of both having to support activities of groups.

This paper reports on the results of trying to extend a basic CSCW system for a typical CSCL application. We started with BSCW, a well-known and widely used groupware system [5–7]. Used by over 200,000 people since 1995 when it was developed at the Institute for Applied Information Technology—FIT (previously a GMD Institute, now a Fraunhofer Institute near Bonn, Germany), BSCW provides a system of autonomously managed Web-based workspaces that can be used by members of a workgroup to organize and coordinate their work. These workspaces are central access points for shared documents, including folders for organizing them and a wealth of functionality for knowledge management.

Although BSCW has been used in many classrooms, especially at universities in Europe, it is clearly a CSCW application: It provides generic support for work groups to share documents in an organized and accessible way. We wanted to adapt it specifically for the social setting of schools to see what it would mean to transform it into a CSCL application. We undertook this within a European Union project named ITCOLE (Innovative Technology for Collaborative Learning and Knowledge Building) [8]. With its emphasis on collaborative knowledge building, this project aims primarily at supporting group discourse. It differs from many other online educational approaches, that strive to convey information in the form of curriculum content or videotaped lectures, which can perhaps be done with a CSCW

system. In ITCOLE, we assume that students can find information on the Internet or in documents uploaded into the system, and that what need CSCL support are such activities as:

- the collaborative reflection on this information (sharing and annotating),
- the building of group knowledge (discussion from perspectives) and
- the determination of what is to count as produced knowledge artifacts (knowledge negotiation).

The focus of the ITCOLE Project differs from that of BSCW, which is on the archiving and sharing of existing knowledge artifacts. Thus, while we wanted to take advantage of important forms of CSCW support like knowledge sharing and social awareness, we also wanted to go beyond the management of established knowledge to the creation of knowledge that is innovative within a learning community that develops, defines, sanctions and shares its knowledge.

This paper reports on how we designed a CSCL system by transforming a CSCW system. It begins with a scenario (Section 2), illustrating the vision of how our new system, called 'Synergeia', might be used to facilitate collaborative knowledge building in a typical collaborative classroom. The system is named 'Synergeia' in recognition that the whole can be much more than the sum of its parts. Thus, the system strives to support the synergistic construction of knowledge at the group level that is quite distinct from what any of the students could produce on their own. The scenario anticipates the pedagogical concepts that are then presented in the next section (Section 3). For instance, the 'folders' of BSCW are referred to as 'virtual learning places' because the metaphor is no longer one of passive storage containers, but of locations within which active knowledge building takes place. The functionality associated with the pedagogical concepts is described with the respective concepts. Other Synergeia functionality for students, teachers, administrators and researchers is then summarized (Section 4). Following a brief discussion of the system infrastructure (Section 5), reflections on the attempt to adapt CSCW to CSCL are presented (Section 6).

The Synergeia groupware is already going to school. Teachers and students in Italy, Greece, the Netherlands and Finland began in early 2002 to use an initial version within the ITCOLE Project. An additional 50 classrooms in these countries will use the revised version described in this paper during Fall 2002. The revisions are based on early feedback from pedagogic researchers, teachers and students to the initial version, which was itself based on extensive experience with related systems in both CSCW and CSCL contexts.

Synergeia is designed to support collaborative knowledge building. However, it must also be flexible enough that teachers in various countries can use it for a broad spectrum of educational approaches. The following

scenario illustrates what might be called the ‘default usage’ of Synergeia. This means that Synergeia was designed to make it especially easy for teachers to set Synergeia up for structuring knowledge building this way, although other ways of using it are also supported.

2 SCENARIO OF CSCL SUPPORT

Meet Carla, a student in a course on The Human Brain. Her teacher has enrolled her in the course and assigned

her to a workgroup on the role of Vision. When Carla first logs in, she can see a folder for her course on ‘The Human Brain’. In addition, there is a ‘personal knowledge building perspective’ for her to jot down her own ideas (Figure 1).

Carla clicks on her course to view its contents. She sees a folder for her project group within that course called ‘The Vision Team’. She notices in the size column that there are already some items in the group learning place, so she clicks on ‘Group: The Vision Team’ and goes there (see Figure 2). Carla works with the other

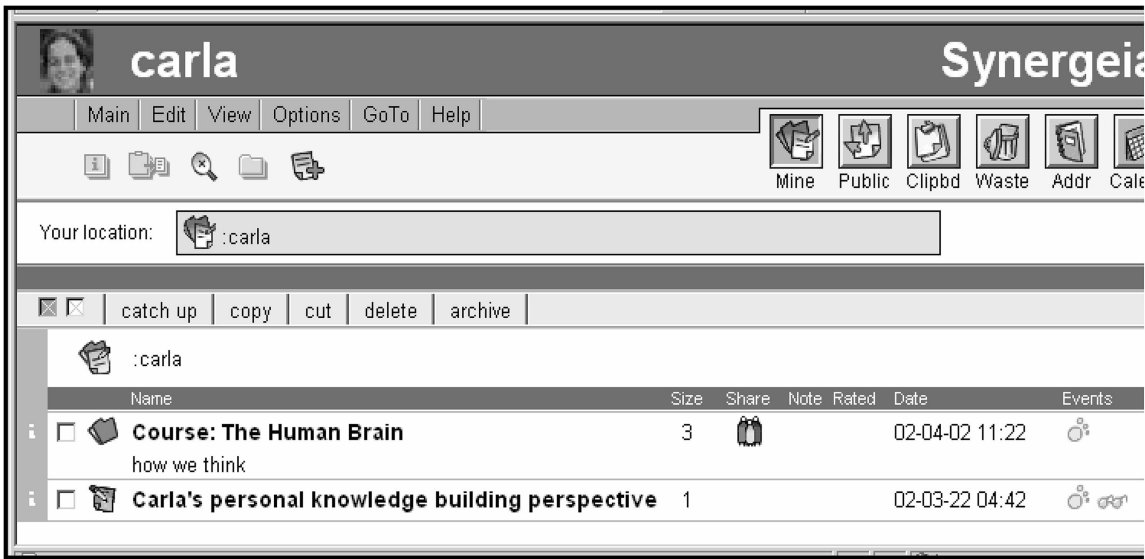


Figure 1 Carla’s computer screen after she logs in. Her personal learning place includes access to the learning places associated with her courses and to her private knowledge building area.

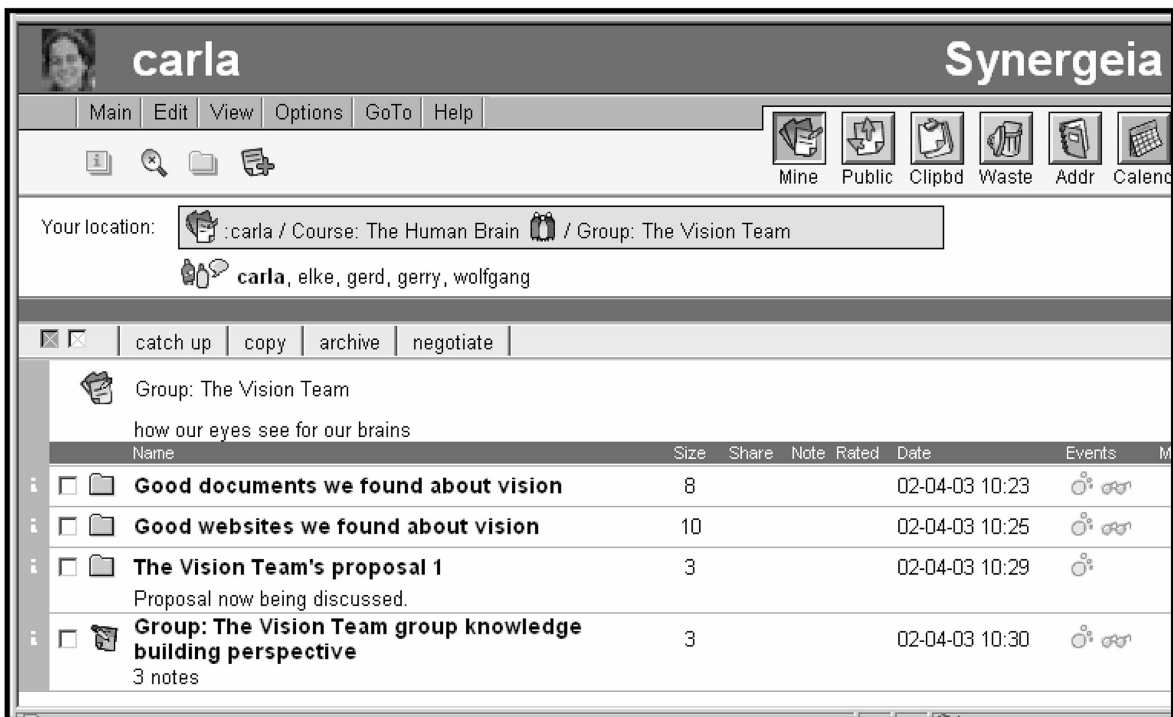


Figure 2 The Group learning place. Here is where collaboration takes place. Documents, websites and other forms of information are collected, shared, organized, analyzed and critiqued.

students in her project team to collect websites and other documents about how vision works as part of the human brain.

As they collect new information, the team members discuss what they have found and begin to build theories about vision in the group knowledge building perspective (see Figure 3). This discussion motivates them to do more Web searches and to try to answer questions that they pose to each other. Gradually, they converge on an understanding of their topic and put together a portfolio of what they have learned, to share with the other members of the course.

As they begin to explore the physiology of vision, different students come upon different explanations. Some find discussions of vision in terms of light dynamics, lenses and the stimulation of the retinal sensors; others read about chemical reactions in the sensors and nerve connections; while others discover presentations involving electrical charges in neurons. As these different findings come together in the group knowledge building perspective, the concepts and claims in the notes interact. Efforts to question one another and to synthesize multiple notes raise new questions, hypotheses and insights.

Carla is a shy girl who does not normally participate much in face-to-face class discussions. She is afraid that her ideas are not very good and she hesitates to share them until she has had time to think about them and to compare them with other ideas or to check them out by collecting more information. So when she sees an interesting idea in the group learning place, she often

copies it into her personal perspective and works on it there, where no one else will see it right away. During the week, her personal area fills with the results of new web searches, documents she has collected or edited, notes that she has copied from the group area, and ideas she has jotted down in her own knowledge building area. When she is happy with some of her ideas, she copies them and related documents into the group area to see what her team mates will say about it. Now she has some confidence that her ideas are thought through and can stand up to inspection by others. Even if her suggestions are not adopted unchanged in the end, they will be taken into the group discourse as serious contributions.

At some point in the collaborative knowledge building process, Carla thinks that the group members have something almost ready to present to the course as a 'knowledge artifact' or part of their team 'knowledge portfolio'. So she puts this information together in folders named 'Good documents/websites we found about vision' and makes a proposal to share this with the course (Figure 4). Now the group area contains a proposal folder named 'The Vision Team's proposal 1' (see Figure 3).

In addition to the folders with proposed content, the proposal folder contains a voting interface and a knowledge building area for discussing what changes are needed before the group members are ready to agree to send this folder to the course learning place as their 'knowledge portfolio'.

Once the team has decided to send their portfolio to

The screenshot shows a web-based interface for a group knowledge building area. At the top, there is a user profile for 'rudolf' with a small icon and the text '[reflection] How do you know this? | rudolf | 2002-04-03 17:44'. Below this is the content of the note: 'What makes you think that we need to talk about electrical signals rather than the chemical reactions that take place in the nerve connections?'. Underneath the note are three buttons: 'Reply to this Note', 'Edit this Note', and 'Thinking Type Descriptions'. Below the buttons is a navigation bar with the text 'Show:' followed by five tabs: 'As a Thread', 'By Thinking Type', 'By Author', and 'By Date'. The main content area displays a list of notes in a threaded format, each with a small icon and text: '[starting] From the eyes to the brain | by gerry | 2002-04-03 17:37 |', '[problem] our problem | by elke | 2002-04-03 17:38 |', '[working] how neurons work | by carla | 2002-04-03 17:40 |', '[deepening] some good websites on neurons | by carla | 2002-04-03 17:40 |', '[reflection] How do you know this? | by rudolf | 2002-04-03 17:44 |', '[problem] passing info | by elke | 2002-04-03 17:38 |', '[working] electrical signals | by elke | 2002-04-03 17:39 |', and '[help] Does anyone know where we can find out more? | by carla | 2002-04-03 17:41 |'. A small arrow icon is positioned to the left of the 'How do you know this?' note.

Figure 3 The group knowledge building area. This area provides an overview of the discussion within a group and offers an interface for engaging in the knowledge building process.

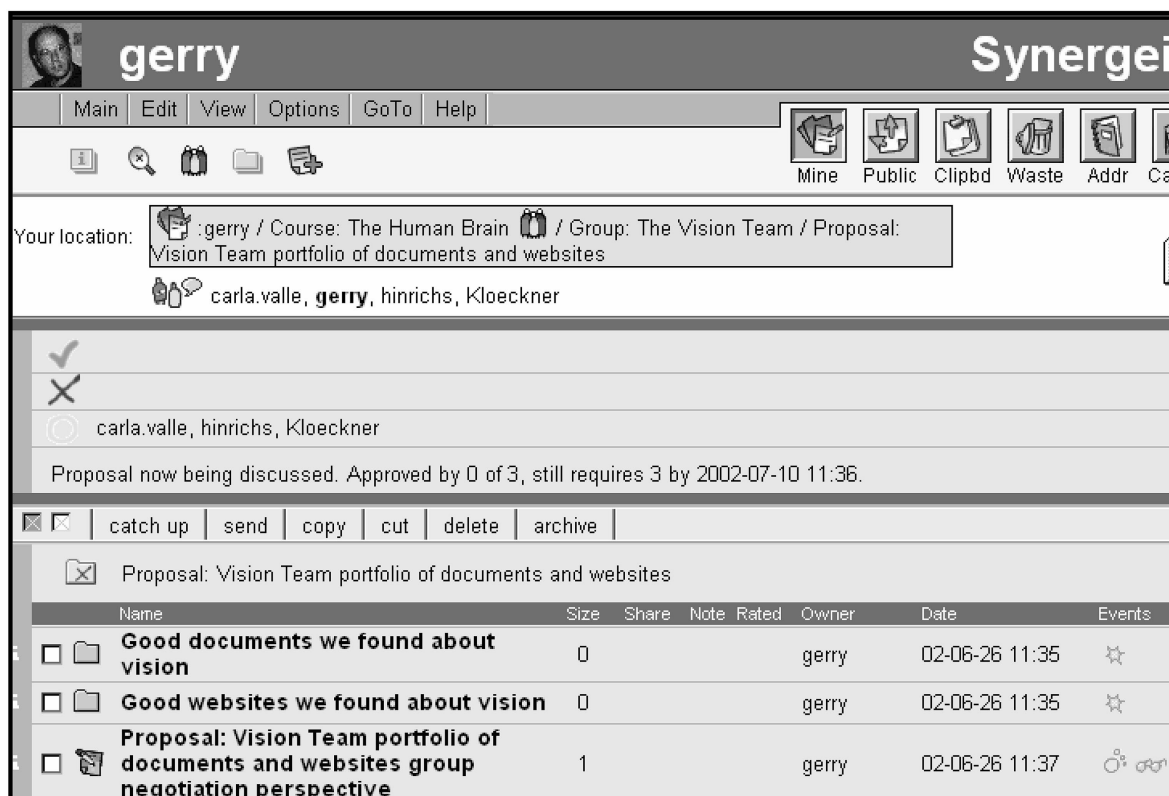


Figure 4 The proposal folder. This collects a number of documents or subfolders that are the content of the proposal, as well as a group negotiation perspective for discussing the proposal and debating possible changes to it. It also includes a voting interface displaying the present status of the proposal (who has voted for it, voted against it, or not yet voted).

the course learning area, it can be discussed by everyone in the course and evaluated by the teacher as a product of the group's knowledge building effort. This might be the end of a curriculum unit, or it might lead to further inquiry and knowledge building. The same groups might continue to work together or the teacher and students might create new groups in new learning places. Our scenario ends here, but the learning continues.

3 PEDAGOGICAL REQUIREMENTS FOR SYNERGIEIA

The adaptation of BSCW for school classrooms involves responding to a particular pedagogical vision, and providing support for the particulars of that vision. To understand the difference that the CSCL setting makes to system design, one must understand the pedagogical concepts that drive the adaptation. The central concepts of collaborative knowledge building are presented in the current section, along with a description of the support implemented for them in Synergieia.

Note that although Synergieia is most useful and powerful if used to support what is here called 'collaborative knowledge building', the system has been designed to be flexible so that teachers with different curricular goals and pedagogical approaches can adjust it to their needs. The design process tried to incorporate the following influences:

- Adoption of pedagogical principles of collaborative knowledge building and progressive inquiry.
- Incorporation of effective functionality from related CSCL and CSCW systems, both commercial and research.
- Adaptation to the social settings of constructivist European classrooms.
- Support for social practices involved in collaborative learning such as that described in the preceding scenario.
- Flexibility for teachers in different countries and pedagogical cultures to adapt the system to their varying approaches.

3.1 Collaborative knowledge building

The design of Synergieia is guided by an educational approach that stresses the construction of knowledge within a learning community, typically including students and more experienced teachers. The idea is that new knowledge will be created through the investigations and discourse of the group. While there are important roles for individual student thinking as well as for teacher guidance, there is also emphasis on sharing, critiquing and building upon each others' ideas to arrive at deeper knowledge of a topic within the community [9, 10]. 'Group learning' is to be understood here in an emphatic sense. It is the group that learns.

Knowledge is constructed by the group itself. Whereas CSCW supports the sharing and archiving of knowledge that is contributed by cooperating individuals, CSCL supports the functioning of a collaborative group so as to build knowledge that is the shared creation and property of the group. Primarily, group knowledge arises in discourse and is preserved in linguistic artifacts, whose meaning is interpreted within group processes [11, 12].

Because knowledge building proceeds largely through discussion, each personal, group and course perspective automatically contains its own *knowledge building area* in Synergeia. These knowledge building areas have extended the basic threaded discussion facility of BSCW. While threaded discussion support is derived from CSCW, it requires more nuanced and specialized support in CSCL. Notes from one perspective can now be copied to other virtual learning places in other perspectives, and notes from elsewhere can be pasted here. Notes in these areas are now included in system searches, because they form an important part of the knowledge in the system.

The user interface of the threaded discussion areas in Synergeia has been carefully designed to encourage thoughtful, focused, deep knowledge building. Below the current note is a display of all other notes entered in the same knowledge building area. The notes can be displayed as indented threads, indicating which notes reply to which other notes. Alternatively, the notes can be sorted by author, date or thinking type. Sorting by author shows quickly who is contributing the most; by date shows the order in which ideas were written; by thinking type indicates which parts of the knowledge building process have or have not been emphasized so far. In each of the sorted displays, the display of the content of the notes can be toggled on and off so that one can see either just the list of the notes or the full content of the whole discussion. This is useful so that one can quickly get an overview of the structure of complex discussions or see (or print) the full content of brief discussions.

As seen in Figure 3, the note that is currently being read is at the top of the screen. With it are a number of buttons for building further knowledge, such as adding a 'Reply to this Note'. The background color of this part of the display corresponds to the note's thinking type. The different thinking types are described on a help page reached with the 'Thinking Type Descriptions' button; the corresponding background colors can be seen there.

3.2 Thinking types

Thinking types take on a much more important role in Synergeia than in BSCW, where they were limited and rarely used. It is important for students to reflect upon the role that a note they are entering will play in the knowledge building process. Both note titles and categories should be chosen carefully [13].

Discussion within the knowledge building areas is scaffolded with a set of *thinking type* categories for the notes. Before someone can enter a note, they have to decide what category of note they want to add to the existing discussion. For instance, do they want to state the problem that is to be pursued, propose a working theory, deepen the knowledge that is already there, or make a meta-comment about the knowledge building process that is taking place? It is possible to have different sets of thinking types for different approaches to knowledge building. For instance, the preceding examples illustrate categories of inquiry learning notes. Other categories are appropriate for brainstorming, debate, design rationale, etc.

A teacher or other user may select a thinking type set for a given knowledge building area when that area is defined or when the first note is written in that area. The following thinking type sets were defined for version 2 of Synergeia:

<i>Knowledge Building</i>	<i>Debate</i>	<i>Discussion</i>
Starting Note	Starting Note	Starting Note
Problem Statement	Position	Greeting
Working Theory	Argument	Comment
Deepening Knowledge	Pro	Opinion
General Comment	Con	Like
Reflection on Process	Evidence	Dislike
Summary Statement	Question	Story
Request	Clarify	Question
<i>Brainstorming</i>	<i>Negotiation</i>	<i>Scientific theory</i>
Starting Theme	Topic	Phenomenon
Suggestion	Proposal	Hypothesis
Clarification	Counter	Experiment
Process Guidance	Agree	Proposal
Distinction	Disagree	Analysis
Generalization	Ask	Argument
Example	Question	Evidence
Summary	Summary	Theory

3.3 Virtual learning places

The most basic function that Synergeia offers is a set of workspaces on the Internet where people can share ideas, documents, web links and other objects. Whether people using Synergeia are in the same room during the same class period or they are in different countries working at different times, they can share their work and collaborate within these *virtual learning places*. Teachers and students can create new places whenever they want for any special needs they have. Places can be created to store new collections of documents. Synergeia offers several special kinds of learning places, such as Courses, Groups, Proposals and Knowledge Building areas that have special features. Although these virtual learning places are based upon BSCW folders for storing documents where they can be accessed by other group members, these places are structured to support specific collaborative knowledge building activities like negotiation of group knowledge. The CSCW workspaces are

appropriated and specialized to support a variety of specific CSCL activities.

A major advantage of Synergeia over threaded discussion systems in commercial groupware systems is that the discussions in Synergeia are separated into personal, group and course perspectives in different virtual learning places, so that different topics are not mixed together and it is easier to keep up with relevant discussions without being overwhelmed by contributions of many other people who are investigating other issues. The same is true of the documents, web links, etc., that are collected in the various learning places.

It is important that the network of learning places be structured in a way that seems natural to the students using them. The basic structure of learning places follows the normal structure of schools, with students in projects within courses. It should be easy to see what is available and relevant, and to navigate to it easily. Therefore, when a student logs in, that student's personal learning place is displayed; the personal place includes a list of the student's courses and the course learning place includes the student's groups. It should also be easy to copy documents and ideas from one place to another. At the same time, because these places are generally shared, it is also important to protect the contents so that one person cannot change or delete someone else's work arbitrarily—as can occur in BSCW.

By default, Synergeia defines appropriate connections between places and reasonable access rights to them when people are registered for courses and groups. Each user, group and course automatically has its own knowledge building area—additional areas can be added or the automatic ones can be deleted. Also, plain places that do not have the special characteristics of groups and courses can easily be added. Thus, the structures, navigation paths, access rights and facilities within Synergeia are designed for usage within the social practices prevailing in school settings, with adequate flexibility to allow for broad variations within these settings.

3.4 Perspectives

The approach to building knowledge in Synergeia is based on the idea of intertwining personal and group perspectives [14]. All knowledge involves interpretation from specific perspectives [15, 16]. In collaboration, personal interpretations of what is said in group discourse interact to form shared understandings [11].

The default structure of Synergeia provides a network of virtual learning places that are set up for personal, group and course uses. These perspectives support a range of pedagogical models that are favored in the different countries participating in the ITCOLE Project:

- **Community of learners** (Italy). The areas in which work, communication and learning take place are structured to reflect the structure of the community,

with its sub-groups and members.

- **Progressive inquiry** (Finland). The inquiry process progresses through collaborative discourse within groups as well as through reflection by individuals.
- **Conceptual change** (Greece). Learning is treated as a social process in which the understanding of individuals is affected by and grounded in the discourse of the community.
- **Shared and individual regulation process** (Netherlands). The intertwining of shared group and personal individual ideas leads to new understandings at all levels.

Thus, there are private *personal learning places* where only one person can add notes, documents or sub-folders and can come back and look at these, modify them, or copy them to a group place. These are places to develop your personal perspective on a topic without worrying what other people will think about what you are doing. Because your personal ideas and documents are in Synergeia, they can be easily related to ideas in other learning places. Allowing the system for group work to be used for personal reflection as well has two major advantages. First, it encourages system use and familiarity. A major problem with groupware systems can be that they require users to log in every day to see what is new there; if people do not use the system for their normal activities then they tend not to log in frequently enough. Also, if people have to use too many different systems for their work then it is difficult to become proficient in them all. Second, by conducting both personal and group work in the same system, people can easily move ideas and documents back and forth between the two. In particular, Synergeia is designed to allow quick cut and paste of items and sets of items from any visible learning place to any other.

Then there are the *group learning places* where most of the collaboration and knowledge building gets done. Here everything is shared with the other members of the team or work group. Students who are not in the group cannot modify or comment on work in the group until the group decides to share something with the whole course. Knowledge usually emerges from a group perspective [12].

And there are also *course learning places*, where all the smaller work groups or project teams within the course contribute the knowledge they have built up. For instance, a teacher who has a course with 30 students might divide them into six or seven teams. Perhaps each team would develop a portfolio to present their ideas to the course. Each team might have the same task or they might divide up different aspects of the larger course topic. After they develop their group portfolios, they can share and debate within the whole course perspective. While CSCW systems provide support within a generic group, a CSCL system should support various levels from individual to large group, with fluid navigation and transfer of contents among the levels.

3.5 Negotiating knowledge artifact portfolios

Sometimes it is pedagogically important for groups to negotiate the promotion of knowledge from one perspective to another, such as the decision to make products of a group available to the larger course. A teacher can set up course learning places so that the only way that new documents, maps and folders can be added is by a group developing a *knowledge portfolio* or *knowledge artifact* in their group learning place and then deciding to move this into the course place. Making this kind of group decision is called *knowledge negotiation* in Synergeia. There is a negotiation mechanism to help a group reach this decision and move the knowledge they have created into the course learning place, where it can be shared and discussed by all members of the course. By specifying the negotiation option for a course, the teacher in effect declares that the only knowledge allowed in this learning place is knowledge created by groups.

In CSCW negotiation, such as Herrmann's or Wulf's model [11, 14, 17], commenting on one's voting serves the purpose of expressing one's supposedly pre-existing opinion. By contrast, within Synergeia, engaging in negotiation of knowledge building is participating in a group reflection on shared knowledge. This can be seen in the thinking types of the notes contributed. In CSCW the note format stresses who the author is and may characterize the notes as a 'pro' or 'con' opinion (e.g., in BSCW); in Synergeia the note must first of all be determined to be a particular aspect of the knowledge building process, such as a problem statement, a working theory or a summary statement. Knowledge negotiation is thereby explicitly structured as a collaborative group effort, where notes written by individuals must fit into the group process and are categorized by their function in the group thinking, not in individual opinions.

Negotiation in a knowledge building context is essentially different from that in a knowledge management or group decision situation [18]. In other groupware settings, negotiation is conceived of as a straw vote to determine how people's pre-existing opinions are distributed on alternative options that have been proposed [17, 19, 20]. In a collaborative knowledge building setting, however, it is a matter of further refining the proposed knowledge artifact. Voting serves just to signify that the participants are generally satisfied that the artifact represents their group knowledge, and it can be shared at the course level as a knowledge portfolio contributed by their group. The important part of the negotiation process is the evolution of the knowledge itself in parallel with the group discourse about it.

When members of a group learning place have built a knowledge artifact—such as a collection of websites, a PowerPoint slide presentation, a concept map, or a portfolio of texts and pictures—they can decide to copy

it to their course learning place to share with members of other groups in their course. This result of their collaborative work as a group may be a final product that the teacher will evaluate or it may be an intermediate product that they want to share and get feedback on from other people.

If a course has been defined to require negotiation, then students in that course must go through the formal negotiation procedure to copy a proposed knowledge artifact portfolio to the course learning place. The purpose of this is to ensure that all or most people in the group agree to have the proposed portfolio represent the knowledge that the group has built together. (If negotiation is not required in the course, anyone can simply copy an item from the group place into the course learning place.) To use the negotiation procedure, a student must select items for their portfolio and execute the 'Negotiate' command. This will create a portfolio proposal in the group place.

The portfolio proposal interface includes a voting area that allows group members to vote on submitting the portfolio when they are happy with it. Within the portfolio are:

- the selected portfolio knowledge artifacts, and
- a negotiation knowledge building area for discussing changes that should be made to the proposed portfolio.

Students use the negotiation knowledge building area to negotiate changes that they think should be made within the portfolio. They make changes in the portfolio that they think will make it acceptable to all or most people in their group. When they like the way the portfolio looks, they vote to approve it. Each person who submits an approval or disapproval vote must enter a statement justifying their vote; this statement is automatically incorporated into the negotiation knowledge building area where it is included in the negotiation discourse and can be discussed. When all or most of the people in the group have voted for the portfolio, it is automatically copied to the course learning place. The negotiation knowledge building area is copied with the portfolio folder so that members of the whole course can see what the group said about the portfolio. Group members may want to make summary comments in this area to say what they think is important in the portfolio. If they still have criticisms of the portfolio or if they would like course members to discuss certain ideas about it, they can put that in the area as well.

3.6 Concept maps, multi-modality and social awareness

In building knowledge, it is often useful for a group to discuss how the concepts they are using are related to each other. One method for doing that is for the group to construct a *concept map* which diagrams these relationships. Synergeia provides a whiteboard called MapTool for people to work together simultaneously to

sketch a concept map. The whiteboard is accompanied by a chat window to support coordination of this task and interpretation of the symbols in the map.

Students and teachers can open the MapTool in course and group learning places and in proposal portfolios. To work with other members of a proposed portfolio, work group or course, they go to the learning place for that portfolio, group or course. At the top of the screen is a list of all members of the place. Those who are currently logged in to Synergeia have their names shown in bold; if they are active in MapTool, their name is in red. This is a form of social awareness which has been added to BSCW; it lets people know who is involved in MapTool in this learning place.

Each proposed portfolio, group and course learning place has its own version of MapTool. When a MapTool session is first started, the last map for that place is automatically opened so that work on it can be continued if desired. One can also reset the MapTool to start with a blank whiteboard. When other members join an active MapTool session, they see the current state of the whiteboard and the chat window, so they can catch up on what has already been done in there.

At any time, the current state of the work in MapTool can be saved. Then a student can go into the learning place and make a copy of this map. The saved map can be opened as a JPEG graphics file. The student can save this file in a Word document, a PowerPoint slide show, a larger graphic file or simply as a JPEG file in a sub-folder. This way, collaborative work in MapTool can be documented as part of a report or knowledge portfolio.

The MapTool module was included in Synergeia as an experiment in combining synchronous communication (the whiteboard and the chat) with asynchronous (the knowledge building threaded discussion). BSCW did not include any synchronous communication and many learning support systems like CSILE are also exclusively asynchronous. While asynchronous is considered a more thoughtful, reflective mode for knowledge building [21], synchronous communication can be much more time-efficient for intense interaction, such as brainstorming or working out details of a drawing—assuming that the participants can get together online at the same time. Threaded discussion has its problems [22], and sometimes chat can overcome them. Working out the interplay between MapTool and the BSCW database was complicated (sending information between the modules and storing MapTool sessions in the database and in the asynchronous interface). However, it provides a good demonstration of how this can be done successfully.

The social awareness implemented with MapTool is just a first step in what is possible. The need to meet synchronously in MapTool made it important to know who else was currently online in one's group. A further function requested by early users but not yet implemented is the ability to invite specific people to

participate in a current or future MapTool session—e.g., through an announcement highlighted in the Synergeia interface or with email.

In general, as the CSCL medium becomes richer, it becomes more important to provide awareness about who is doing what, what has been done in the system and how to find existing information. As users become more sophisticated, it is useful to provide different modes of interaction that are appropriate and that are tuned to different undertakings. Synergeia takes just a first exploratory step in this direction.

3.7 Roles and personalization

Synergeia defines *roles* for students, teachers, guests, mentors, etc. This gives people in these roles the power to execute certain menu functions, such as to read, edit or delete objects in a learning place. When someone is invited into or registered for a particular learning place (such as a course or group) they are invited or registered as a member with a specific role (such as student). It is possible to change a user's role, to define new roles and to add new sub-folders where the user has a different role. Whereas roles in BSCW were generic and rarely used, in Synergeia they capture important distinctions between people based on power and knowledge in school settings. These roles must be adapted to different kinds of learning places.

For youthful users, it is important to make software more fun to use. Personalization and customization facilities allow users to adapt the system to their own preferences and to feel that the systems is 'theirs'. Synergeia users can personalize the user interface by including a picture of themselves in the upper left-hand corner of the screen next to their username. This picture will represent them at other places in the Synergeia interface as well, such as when knowledge building notes are sorted by author.

There are many functions for customizing the Synergeia interface. A student can:

- specify which columns to display for details related to sub-folders and documents.
- change the size of the displayed text.
- sort the listed sub-folders and documents in different orders.
- toggle on and off the display of menu shortcut icons below the main menu.
- toggle the descriptions below the names of sub-folders and documents.
- toggle the contents below the titles of knowledge building notes.

Students can set a variety of details about how the Synergeia system will work for them. They can:

- change their password.
- set the location for their picture.

- enter their email address or home page.
- set their system preferences.

Students are automatically initially considered ‘beginners’ as users of Synergeia. This means that the menus they see are not full of options that are intended for more experienced users. They can change to ‘Advanced’ or ‘Expert’ status when they feel ready to access more menu items. For younger students in primary school, a new ‘primary’ profile has been defined; it makes the interface simpler by removing many menu items and shortcuts to make student usage simpler.

4 ADDITIONAL FUNCTIONALITY IN SYNERGEIA

Section 3 described the pedagogical requirements for Synergeia that distinguish it from related work. Synergeia is focused on the needs of small collaborative groups of students, guided by teachers who structure and facilitate their interactions. By contrast, most commercial systems are oriented to administrative concerns such as delivering pre-defined content, tracking attendance and test results, handling homework assignments and conducting student evaluation. At best, systems like LearningSpace and WebCT provide basic CSCW functionality for sharing documents and communicating. Because systems like Lotus Notes cater to corporate and professional training applications, they provide generic discussion forums, without specialized thinking types or workgroup perspectives structured in response to classroom cultures. Alternative approaches like Swiki [23] systems also lack the tailoring to classroom needs due to the generality of their functionality. At the other extreme are CSCL systems that are more specialized for particular pedagogies, like the STEP system to support problem-based learning [24]. CISLE/KnowledgeForum [10] is very similar to Synergeia—because its developers began the tradition in which the ITCOLE Project is firmly planted. Synergeia also incorporated features from FLE [25] and Web-Guide [14], research prototypes that led to its conception and prototyped much of the functionality incorporated in it. Synergeia is unique in combining the features of perspectives, multiple thinking type sets and negotiation with threaded discussion to support collaborative knowledge building. It also features a rare integration of synchronous and asynchronous support.

In addition to the pedagogically motivated features, Synergeia provides a wealth of functions from BSCW. Some of these have been modified or extended to allow students, teachers, administrators and researchers to take advantage of the core Synergeia functionality.

Student actions have been modified to simplify the uploading of the user’s picture; uploading, archiving and versioning of documents, images and websites is already well supported by the inherited BSCW commands. Likewise, the ability to search the Web, review hits, rate

URLs and store shared bookmarks was already available. Students can set up new virtual learning places and invite friends to them, as well as starting new knowledge building areas and initiating MapTool sessions. Social awareness is well supported with BSCW’s info, events and history systems. In addition, Synergeia added displays of the names of course and group members, with indications of who is currently active in Synergeia or MapTool.

Considerable support for *teachers* has been added. Teachers can register lists of students in the system and assign them to courses and workgroups easily. Students no longer have to have their own email addresses in order to be registered. Teachers can define course and group learning places, with a number of options for negotiation and access; this gives teachers considerable control in structuring the use of Synergeia. They can, of course, seed a learning place with documents and a knowledge building area with starting questions for discussion. When a new knowledge building area is created, the teacher can select which set of thinking type categories will be used: ‘knowledge building’, ‘scientific theory’, ‘negotiation’, ‘debate’, ‘discussion’ or ‘brainstorming’. Teachers can revise the parameters for negotiation, such as the percentage needed for a majority vote. They can also over-ride the voting process to move proposals from group to course places—or even in the opposite direction.

Although Synergeia is currently run on a central server in Germany, it can be downloaded to local sites to overcome Internet delays in schools with slow connections. The system *administrator* registers an initial set of teachers and researchers to use Synergeia. The administrator can also translate all terminology in the interface, including the sets of thinking type categories, as well as re-define the actions associated with various user roles. The entire Synergeia interface has been translated into Italian, Greek, Dutch and Finnish from the English original. Administrators can modify the translation files. Users select the language they want—by default it corresponds to their browser language setting.

In addition, functionality has been added to assist *researchers* who want to analyze the usage of Synergeia. There are now log files that track all actions in BSCL, the contents of all knowledge building areas and all actions in MapTool. The log files can be analyzed with special tools or copied into a spreadsheet. Knowledge building areas can be printed out in various formats.

5 THE SYNERGEIA ARCHITECTURE

The present section briefly indicates how the technological infrastructure of BSCW was extended in response to the needs of the classroom setting. Technically, Synergeia consists of the following three components:

- **BSCW** This is the Basic Support for Cooperative

Work system. It is a Web-based system designed to support teams of adult professionals working together and sharing documents. It provides mechanisms for uploading, downloading, versioning and archiving of many kinds of documents. It also supports Web searches, annotations and ranking. BSCW is written in Python as an object-oriented set of cgi scripts. It includes a persistent store for objects. The server runs in Windows or Unix and the client can be displayed in any Web browser. Interestingly, the BSCW technology is literally a technology of extensibility; the cgi scripts extend the functionality of a core webserver like Apache or IIS by means of standard HTTP calls. This makes BSCW an attractive basis for further, open-ended extensions.

- **BSCL** This is the set of functions and interfaces that adapts the BSCW software to collaborative knowledge building in K-12 classrooms. It includes the functions to create personal, group and course learning places and to register users in these with specific roles. It also includes the knowledge building interface, sets of thinking types and support for negotiation. BSCL is implemented as a Python Package that extends BSCW and that interfaces with MapTool. Packages are a flexible technology for modular extensibility in object-oriented languages like Python. BSCL is one of several packages that extend BSCW and it is possible to create new packages that extend BSCL itself.
- **MapTool** This is a collaborative whiteboard that students in a group or course can work on simultaneously (synchronously) to construct concept maps and other simple diagrams. It includes a chat window for coordinating and discussing the drawing. The maps are stored in BSCL learning places. Synchronous support for the MapTool Java applet client is provided by the Ants system, using the Elvin server. The inclusion of MapTool in the Synergeia system is an experiment in extending BSCW with synchronous components, where user information, drawings and chat data must be stored in and retrieved from BSCL's database by MapTool.

6 WHAT GROUPWARE CAN LEARN BY GOING TO SCHOOL

Much has already been learned about the differences and similarities of CSCW and CSCL groupware support through the process of designing and implementing Synergeia. The school setting has special characteristics that make certain functionality particularly important and that require specific transformations of other functions. Many such adaptations and extensions have been illustrated in the preceding sections of this paper.

One unanticipated technical finding was the importance of mechanisms for setting specific access rights for various kinds of folders. A new version of BSCW (4.0)

that was released during the beginning of the ITCOLE Project included mechanisms for defining roles. These mechanisms—which to date have only been explored in the development of Synergeia—proved particularly helpful. From an implementation standpoint, many extensions to BSCW for Synergeia are largely accomplished through the definition of special domain-specific roles, with specific access rights within various kinds of learning places.

A straightforward application of the role mechanism was to define roles for teachers, mentors, students, administrators and guests. New users are registered in Synergeia with one of these roles. The role determines what actions the user can undertake within his or her personal learning place. For instance, a user who is registered as a teacher may create courses and groups or redefine negotiation parameters; a student user may upload documents; and a guest may only view contents in Synergeia. A teacher has special powers to delete offensive materials, and so on. A mentor also has many of these powers that students do not have, but does not have the ability to create courses and groups. Users have more control over objects that they created than over other objects, such as the ability to edit or delete them. A user can invite other users to folders and can reset or modify roles, but can never assign abilities that exceed that user's own existing abilities.

In addition to the standard roles, special roles were defined for 'course mates' and 'restricted students'. These are used for special circumstances. For instance, course mates can see in their course learning places what groups exist that they do not belong to. Depending on the option set by the teacher when the group was defined, users who had student roles are re-assigned 'course mate' roles, where they are able to see the name of the group listed, or else they are re-assigned the 'restricted student' role, where they may enter the group learning place and view or copy—but not add to or modify—the content there.

Similarly, in a course where the negotiation option was selected, all student users are re-assigned the role of 'restricted student'. This means that they can see and copy all content, but cannot add or modify anything (except indirectly through the group negotiation procedure). This re-assigned role is inherited down into all sub-folders and sub-sub-folders, etc. (as is usual for roles). This automatically prevents students in a course from changing the contents of negotiated portfolios from groups, although they can view these contents and copy them elsewhere to work further on them. In a course knowledge building area, the 'restricted student' roles are changed back to normal student roles, so that students can participate in knowledge building discussions within the course perspective.

The school setting requires much more complex control over access rights than is instituted in the normal BSCW system. The role mechanism provides a convenient, flexible and elegant means for defining and

instituting the needed sets of access controls.

This paper reflects the design of version 2 of Synergeia, which will be released to European elementary and secondary schools within the ITCOLE Project in Fall 2002. It has already benefited substantially from informal feedback from the review of version 1 by pedagogic partners in the Project and from the use of version 1 by teachers and students in the Winter and Spring 2002. The use of version 1 is currently being subjected to extensive evaluation in each of the participating countries. It is expected that this will reveal additional groupware requirements of the school setting.

Version 2 of Synergeia will 'go to school' in 50 courses in Italy, Greece, the Netherlands and Finland during the Fall of 2002. This will again be subjected to formal evaluation using a variety of survey instruments. Data from the log files and classroom observations will be analyzed with a mix of quantitative and qualitative methods. Results of these evaluations should provide important insight into the effectiveness of the Synergeia adaptations and extensions to groupware mechanisms presented in this paper.

There are many fundamental commonalities between CSCW and CSCL groupware requirements and the two can build upon each other's accomplishments. However, the school setting, seen from a specific pedagogical perspective, brings with it considerations that call for particular treatments. In the case of the development of Synergeia within the ITCOLE Project, we have seen that it was necessary to develop a suite of functionality that adapted generic CSCW forms of support to define a unique educational environment. It is likely that as the CSCL extensions mature through testing and usage they will feed back into suggestions for CSCW itself.

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