Knowledge Negotiation in Asynchronous Learning Networks

ABSTRACT

The negotiation of what is to count as mutually acceptable collaborative knowledge is difficult to conduct when participants cannot interact face-to-face. We review certain related work on negotiation support and develop a concept of "knowledge negotiation" that is appropriate for collaborative learning in ALNs used in school classrooms. This concept is situated within the framework of collaborative knowledge building viewed at the group unit of analysis; it contrasts with negotiation as the reconciliation of multiple personal opinions through voting. We then describe an implementation of support for knowledge negotiation in an ALN that is currently being tested in European schools.

1. INTRODUCTION

Negotiation is a central phenomenon in cooperative work and collaborative learning – specifically the negotiation of what is to count as new shared knowledge. While there has been considerable research on asynchronous learning networks (ALN) and computer-supported collaborative learning (CSCL) lately, this has not been accompanied by discussion of computer software mechanisms to support negotiation within learning contexts.

ALN or CSCL systems are designed to support the building of shared knowledge, but rarely provide adequate support for establishing and identifying agreement on achieved knowledge artifacts. Such negotiation is conceptually different from the forms of negotiation

supported in CSCW, GDSS and other business-oriented systems because in classroom collaborative learning it is a matter of groups constructing new knowledge interactively, rather than making decisions based upon pre-defined options and existing opinions of individuals.

Consideration of computer support for negotiation has arisen in the past primarily in relation to group decision-support systems (GDSS) for use in industry. (Connolly, 1997; Kraemer & Pinsonneault, 1990; Vogel *et al.*, 1987) GDSS is a sub-area of computer-supported cooperative work (CSCW). Although CSCW is a sister field to CSCL, its decision support, knowledge management and social awareness mechanisms have not yet been adapted for CSCL applications. This paper provides an example of how one can adapt a CSCW approach to a CSCL context by re-thinking the nature of the interactions within these differing contexts. Specifically, we focus on adapting the role of negotiation and arguing for a concept of "knowledge negotiation." For a more general discussion of how we converted a CSCW system to a CSCL system, see (Stahl, 2002b).

Starting in May 2001, the European Union ITCOLE Project (Information Technology for COllaborative LEarning and knowledge building) (Leinonen *et al.*, 2001) began to develop and test a new software system for K-12 classroom support named BSCL (Basic Support for Collaborative Learning). Developers in Finland, Germany and Spain are working together to design and implement BSCL.

BSCL is an adaptation and extension of the well-known and widely used BSCW system. (Appelt & Klöckner, 1999) 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.

In BSCL, new components have been added to BSCW to offer improved support for knowledge building (usually created in threaded discussions), social awareness (knowing who else is active in the system) and synchronous interaction (multi-user diagramming with chat). An initial version of BSCL was successfully field-tested by pedagogic researchers, teachers and students in Greece, Italy, the

Netherlands and Finland. The system is fully multi-lingual so that students in different countries view the user interface in their native language. Development and dissemination of a revised version is currently underway; a major new feature is the support for negotiation described in this paper. A future round of field tests will include cross-cultural courses in which students from more than one country collaborate together at a geographic and cultural distance by means of BSCL.

The approach to knowledge negotiation support is integrated within a set of software components designed for collaborative learning, including virtual learning spaces, perspectives, community roles, knowledge building, thinking types and concept maps. Specifically, knowledge negotiation is implemented to control the publication and transfer of ideas, documents, drawings and other artifacts or sets of items from a small project group perspective into the perspective of a larger community of learners in a course.

Knowledge negotiation focuses on evolving a group knowledge artifact to a mutually acceptable status for publication, rather than reaching consensus on a pre-existing choice of personal opinions. Asynchronous support for such negotiation must allow for:

- the proposal of a set of items for consideration as a shared knowledge artifact,
- the discussion of desired modifications to this artifact,
- carrying out the actual changes to the items,
- discussion of remaining misgivings,
- signaling readiness to accept and publish the artifact for access by a larger community.

The recognition of a need for support of knowledge negotiation and the design of BSCL generally is based on classroom experience with previous ALN systems. Classroom testing of the BSCL base system began in January 2002. During the summer, the implementation of knowledge negotiation described here will be released for studies in 50 European classrooms in the Fall. Preliminary empirical results will be reported at HICSS.

The question we faced as designers of BSCL was how to support negotiation among students. Collaborative learning in classrooms has different requirements for sharing knowledge than what is supported by BSCW for professional teams. For instance, BSCW is used primarily for knowledge management – the sharing and manipulation of

knowledge that already exists somewhere within the workgroup – while BSCL is intended to support knowledge building – the collaborative construction of knowledge that is new within the community.

This paper follows the historical sequence of our approach. We began by considering relevant explorations of *negotiation in CSCW* (see section 2), particularly those of Herrmann and Wulf that had been used in systems related to BSCW. Then we reflected on *the role of negotiation in collaborative learning* (sec. 3), based on the major theoretical frameworks for CSCL. From this, we identified various *concepts of negotiation* associated with alternative possible support mechanisms (sec. 4). We developed a concept of "knowledge negotiation" that seemed most suited for *BSCL as an adaptation of BSCW* to learning scenarios (sec. 5). This notion may be relevant for many CSCW contexts as well. We implemented *support for knowledge negotiation* among students in small workgroups (sec. 6), and are now *studying negotiation in classrooms* using BSCL (sec. 7).

2. NEGOTIATION IN CSCW

Negotiation is a process by which a group of people who are working together arrive at a group decision. The usual approach to conceptualizing and supporting this process within CSCW was not quite what we wanted for our concept of collaborative knowledge building. We will here review some of the approaches that we critiqued and built from.

2.1. Negotiation as voting

Within traditions of computer science (or informatics), it is common to model negotiation as a voting process. This is not only a result of the implicit acceptance of rationalist philosophy and of modeling human communication as information processing, but arises also for pragmatic implementation reasons:

Rationalism assumes that people have ideas already existing in their heads (Winograd & Flores, 1986) – in the form of expressible propositions, mental representations or brain states – that they can then express verbally as opinions on the basis of which they may vote on various issues posed to them.

Communication theory derived from the information processing tradition (Shannon & Weaver, 1949) implicitly builds on the rationalist model and construes communication as the transfer of such pre-existing opinions (as data) through (error-prone) media.

Implementation of computer support tends to accept these models because computers necessarily represent explicit information, such as propositional representations of explicit opinions. (Stahl, 1993) They can easily respond to small numbers of clearly pre-defined options, such as yes/no votes.

Thus, when we look for examples of support for negotiation in CSCW, we find that they often reduce negotiation processes to voting processes, assuming that the goal is to collect and respond appropriately to a set of opinions that already exist in the minds of the individual system users. In particular, this is true of GDSS systems that frequently include a component for conducting straw votes. (Connolly, 1997; Kraemer & Pinsonneault, 1990) Straw votes, by definition, are a means of measuring pre-existing personal opinions, with little attempt to influence them or to build group consensus. The goal here is typically to provide support for collecting the opinions of participants about some fixed issue, with the assumption that differences of opinion are based in personal structures of preferences, in differing interests or in limitations of information about the opinions of other participants. (Lim & Benbasat, 1993; McGrath, 1993; Nunamaker Jr. *et al.*, 1991) Thus, GDSS support usually focuses on expressing, collecting and possibly influencing participant opinions, rather than on altering the subject matter under consideration.

2.2. Negotiation as approval of decisions

Herrmann (Stahl & Herrmann, 1998) proposed a notion of negotiation that goes significantly beyond the simple voting model. He and his students developed an approach to computer-supported negotiation over the years, and have designed and/or prototyped it in a number of software systems, (Herrmann, 1995; Herrmann, Wulf, & Hartmann, 1996; Herrmann & Kienle, 2002) including a simulation of negotiation. (Lepperhoff, 2001) He has reviewed related CSCW and GDSS research, and has developed a socio-technical model for his approach to negotiation. His examples involve group decisions for knowledge

management, such as what categories should be used to organize a shared bibliography.

In Herrmann's approach, someone makes a proposal and the other group members can vote on the proposal. They always have an opportunity to comment on their vote. In addition, they can make a counter-proposal or call for discussion outside of the computer support system. Although this approach goes beyond a simple yes/no voting system with options for counter-proposals and for switching communication media, it is still based on a model of negotiation as voting. This approach serves well to conduct a quick poll to see where agreement does or does not already exist, but cannot well support re-framing or co-construction of knowledge. It recognizes the frequent need for people to engage in more complex processes of interaction to settle a negotiation issue and allows for people to leave the computer support system to do this, but provides little automated support for their consequent decisions to affect the knowledge in the system.

2.3. Negotiation as access permission

Wulf (Stiemerling & Wulf, 2000; Wulf, 2001; Wulf, Pipek, & Pfeifer, 2001) proposed further extensions of the voting model, now applied to function activation rather than decisions. His examples include the right of an individual to access a specific document created by another member of the group. The empirical cases he cites from governmental bureaucracies might best be considered examples of moderated, rather than negotiated, activation. The primary actors do not engage in negotiation with one another, but agree to have their interactions mediated by trusted third parties or public procedures, including automated procedures in a computer support system.

Applied to CSCW systems, the issue is whether a particular user should have access to a specific system function, such as editing a document. Wulf has developed a formal Petri net model of negotiation approaches, but oriented to the question of activation. This paradigm may work for situations with fixed options, such as access to a defined system function, but not in the general situation in which a group is collaborating to produce group knowledge through exploration and inquiry.

2.4. Negotiation as intertwining of perspectives

Individual learning, as a process of constructing personal knowledge, takes place within a learner's personal perspective. (Boland & Tenkasi, 1995; Nygaard & Sørgaard, 1987; Stahl, 1993) Collaborative learning involves an interaction among personal perspectives contributed by the participants and a merging of these into a group perspective definitive of the group discourse. There have been scattered attempts to formulate a conceptualization of perspectives that would lend itself to computer support. The Phidias system was an early attempt to display a database of design rationale notes according to different "contexts"; (McCall *et al.*, 1990) this was subsequently re-implemented in Hermes, (Stahl, 1993) where shared contents were displayed within different professional or personal perspectives.

Stahl & Herrmann (Stahl & Herrmann, 1998, 1999) proposed an approach to integrating Herrmann's negotiation and Stahl's perspective mechanisms within a single software system, WebGuide, that they designed specifically to explore these mechanisms. The motivation for this was the following: On the one hand, negotiation takes time, and group members may want to continue working on a topic while it is under negotiation – perspectives allows them to continue to work in their own perspective while contents of a group perspective are being negotiated. On the other hand, within individual perspectives there is a strong tendency for ideas to diverge (Hewitt & Teplovs, 1999) – negotiation is required to bring ideas back into consensus and to promote individual ideas to the status of group knowledge. So it seemed that integrating perspective and negotiation mechanisms – and conceptualizing negotiation as the intertwining of multiple personal perspectives to arrive at a shared perspective – would mutually solve the central problems of these two mechanisms.

While the perspectives mechanism has by now been extensively implemented in WebGuide, (Stahl, 2001) the corresponding negotiation mechanism is still missing in that system. The lack of an appropriate negotiation mechanism was already reported as a serious limitation of WebGuide at the 1999 CSCL, Group and WebNet conferences (Stahl & Herrmann, 1999). The delay in implementing negotiation support in WebGuide was largely a result of the feeling that the voting model of negotiation did not seem appropriate for CSCL uses of groupware. Recent reflections on the relation of perspectives to knowledge building

(Stahl, 2002a) suggest that a different, more dialogical, concept of negotiation is called for.

3. THE ROLE OF NEGOTIATION IN COLLABORATIVE LEARNING

To appreciate the role of negotiation in CSCL, consider the centrality of negotiation within each of the different theoretical frameworks that have historically dominated this field:

Small group process. This approach maintains a view of learning as transfer of information from teacher to students, and conducts experiments to demonstrate the increase in individual learning outcomes through group work in classrooms. A typical approach would be to divide up topics within a course and assign the topics to small groups; the small groups would *negotiate* agreed upon solutions to their topic; the different groups would then share their solutions with the larger group, for instance using procedures like "jig-sawing". (Brown & Campione, 1994)

Social constructivism. Knowledge is socially co-constructed (Vygotsky, 1930/1978) before it may be internalized by children based on what they are capable of understanding. This social co-construction is a *negotiation* process by which shared understanding is reached about a "knowledge object" or knowledge "artifact". (Bereiter, 2002; Stahl, 2002a)

Distance education. Even when peer interaction is possible in distance education, for instance with threaded discussion in asynchronous learning networks, it is hard to encourage sustained, in-depth knowledge building; discussions tend to diverge without some form of *negotiation* to bring different people's ideas back together. (Hewitt & Teplovs, 1999)

Distributed problem-based learning. Originally developed for medical education, PBL is built around problem cases, like patients presenting illness symptoms that a group of about five students and a tutor attempt to diagnose. The group *negotiates* lists of problem statements, key evidence, working hypotheses and learning issues. Then the individual students research relevant medical theories and come back to the group to *renegotiate* the group understanding. The tutor plays a key role in guiding the negotiation. (Barrows, 1994)

Distributed cognition. Knowledge is not simply a matter of an individual's mental representations, but is frequently distributed among the abilities of group members and the artifacts that they use. (Hutchins, 1996) Accordingly, knowledge is co-constructed by interactions among people and their shared artifacts, including prominently by means of *negotiation* practices that result in establishing a common ground for understanding.

Situated learning. This approach views learning in terms of changing relations within the community of practice. (Lave & Wenger, 1991) Like situated action theory (Suchman, 1987) and ethnomethodology, (Garfinkel, 1967) the situated learning approach looks at how people skillfully interact socially to co-construct and interactively *negotiate* knowledge, rather than at individuals as possessors of explicit propositional knowledge.

Cultural-historical activity theory. Learning is viewed as it takes place over extended periods of time and within its broad cultural and historical contexts. It is even possible to track "expansive learning" in which multiple groups *negotiate* changes to the existing social arrangements. [36] Here, again, socially shared artifacts play a significant role in providing a focus to negotiations.

It is possible to conceptualize collaborative learning in different ways, focusing on various units of analysis as seen above. However, in each approach some form of negotiation plays a central role in the learning process. In order to design computer support for negotiation in collaborative learning, it is necessary to specify an appropriate concept of such negotiation.

4. CONCEPTS OF NEGOTIATION

4.1. Negotiation as voting

The concept of negotiation as voting seems inadequate for CSCL. In particular, the negotiation of what is to count as new shared knowledge for a group engaged in collaborative knowledge building has different characteristics from other forms of group decision making. Such negotiation might be called "knowledge negotiation" because it is not just a matter of selecting among alternative existing states (propositions, proposals, activation functions), but of constructing new

knowledge through collaborative interaction and discourse. The new knowledge is typically represented by or embodied in a shared "knowledge artifact," such as a concept, theory, text or folder of structured information.

There is an important theoretical difference concerning the unit of analysis. We conceptualize knowledge negotiation as a *group* knowledge building process, rather than as a process involving *individuals* and their personal opinions. In CSCW negotiation, such as Herrmann's model, commenting on one's voting serves the purpose of expressing one's supposedly pre-existing opinion. In BSCL, engaging in negotiational knowledge building is participating in a group reflection on shared knowledge. This difference can be seen in the thinking types of the notes contributed. In CSCW systems like BSCW, the note format stresses who the author is and may characterize the note as a "pro" or "con" opinion; in BSCL the note must first of all be determined to be a particular aspect of the group's knowledge building process, such as a problem statement, a working theory or a summary statement before a student can begin to construct a note. Knowledge negotiation is thereby explicitly structured as part of a collaborative group effort.

4.2. Negotiation as discourse

Knowledge negotiation is at heart quite different from voting. It is, in its paradigmatic forms, a nuanced give-and-take, whose aim is to reach a solution that did not already exist in any participant's opinion, but that is ultimately made acceptable to all. It often involves compromises, whereby one participant gives way in part to another's wish in order to get the other to give in partially to one's own position. Negotiation is a way people respond to non-routinized, "wicked" or ill-defined problems – where reaching agreement often involves re-framing the issues. (Rittel & Webber, 1984)

The negotiation process as bargaining is not well modeled as a series of pre-existing positions, among which the group must vote. Nor is it well modeled as a series of positions and counter-positions among which the group must choose. In a negotiation process, typically multiple starting positions interact and evolve through a series of changing alternatives until a single consensus position is reached

through discourse. The discussion is a subtle political interaction that brings many aspects of power, motivation and persuasion into play; it is a sophisticated linguistic process that cannot be algorithmically interpreted. In the end, when a consensus is reached (or not), there is often little need for a vote because agreement (or agreement to disagree) has already been established. The purpose of a vote would be to signal within a support system that everyone agreed that a consensus had been reached.

4.3. Negotiation as knowledge building

Negotiation may be conceptualized as a much broader phenomenon than the process of making a joint decision about pre-specified actions (or explicit access permissions). Collaborative knowledge building, itself, can be viewed as fundamentally a knowledge negotiation process. Proposed statements of knowledge by individuals are subjected to collaborative interactions, whereby meanings of terms are clarified, alternative related statements are compared, linguistic expressions are refined, warrants are scrutinized, etc.. (Stahl, 2000)

Through these activities, the original suggestion is transformed; through broadening consensus, the resultant expression increasingly takes on the status of socially established knowledge. (Stahl, 2002a) Simultaneously, this process establishes a "common ground" of understanding concerning the meaning of the accepted expression and its constituent terms. (Baker *et al.*, 1999) This does not necessarily mean that every individual involved fully understands and accepts this common ground in his or her own mind, but rather that a group understanding has been established in the discourse of the community in which this knowledge is thereby accepted. The co-constructed knowledge is often embodied in some form of cultural artifact, such as a text or slogan; the common ground provides a basis for the meaning that the artifact encapsulates to be understood in a shared way by the collaborative community.

The shift to understanding group interactions in more dialogical terms as co-construction within a discourse community has implications for the design of groupware: away from automated selection among alternatives, toward greater emphasis on supporting communication among system users. Accordingly, it is necessary to

design an appropriate mechanism for the support of knowledge negotiation in situations of collaborative learning along these lines.

5. BSCL AS AN ADAPTATION OF BSCW

BSCL is an adaptation and extension of the BSCW system for collaborative learning applications in schools. It assigns roles of teacher and student, that define the available functionality and access rights of the users. Courses are usually split into smaller workgroups (typically comprising about 3 to 7 students) that pursue specific learning goals and produce group products or portfolios.

Each student, workgroup and course has an associated "virtual learning place," i.e., a folder in which information and ideas are collected, typically in the form of documents, notes, links to Web pages and discussion threads. Learning places may be hierarchically structured in sub-folders. The default structure of learning places supports the concept of perspectives: There are personal, workgroup and course perspectives for students collaborating in workgroups within larger academic courses. Teachers and students can use BSCW operations to create other kinds of folder structures, but the structure to support typical workgroup collaborative activities is generated automatically by BSCL as the default.

5.1. Knowledge building within BSCL

For the knowledge building process, students typically collect information and ideas for a learning project in their personal or group learning places. They share and discuss these in the group learning place. The essential task of a workgroup is to produce a group report or "knowledge building portfolio" from collected materials and the associated discussions, and place the report and related materials in the course learning place for students from other groups to view and discuss.

Within an academic setting, such a contribution to the course learning place may count as the group's final product or work portfolio, displayed as the group's knowledge, shared with the other course members so they can learn from it and comment on it. It may also be evaluated by the teacher or others once it has reached this stage.

In BSCW, any user would be able to copy objects from a group to a course learning place. Because of the requirements of the school setting, it is important that a workgroup has reached a consensus on what may count as (and be evaluated as) their group product. This requires a negotiation function.

In a CSCW system, access rights and access functions may be specified to an arbitrary degree of precision. This determines whether a given user can execute a given operation under various conditions – or in BSCW it determines whether the operation appears on that user's menus. The rules governing access may even be adaptable so that a group or manager can adjust these rules. However, once set, the rules arbitrate group conflicts silently and invisibly. For instance, if one member of a group workspace wants to delete or edit a document and another member does not want this to happen, then the rules determine whether it can be done or not – but the conflict between the members who do and do not want the operation to be executed is never made apparent. In a given case, no one knows who favors what or if and when there is a conflict of desires, let alone people's reasons. The systems of Herrmann and Wulf have the advantage of making such conflicts visible and providing means for resolving them interactively.

We were primarily concerned with transitions of knowledge from the group perspective to the course perspective. Here we wanted to bring to light any conflict within the group about promoting a knowledge artifact to the class perspective as a product of the group.

5.2. Approach to knowledge negotiation in BSCL

The discussion process within a workgroup may already be considered as an implicit knowledge negotiation process. However, in the BSCL system we make this process fully explicit to the users by commencing a formal negotiation when a member of a workgroup proposes to promote a group knowledge artifact to the corresponding course perspective.

Operationally, the difference between the CSCL knowledge negotiation that is proposed here and a voting approach is that *the real negotiation action is in the evolution of the knowledge artifact proposed for agreement, and not in the voting process itself.* What is needed is to allow a proposed knowledge artifact to be successively

changed by the negotiating parties until all (or a substantial majority) of them agree that the object is now an acceptable representation of the group knowledge. This knowledge negotiation process may proceed as follows:

A member of the group proposes that a specific knowledge artifact (a set of folders, documents, ideas, or threaded discussion) be promoted to the course perspective. Criteria for the acceptance of the proposal (e.g., agreement by 74% of the group within two weeks) has already been set by the teacher for the whole class.

The knowledge artifact is made available for all group members to modify – i.e., the object proposed for negotiation has group access rights – within a negotiation interface at the group perspective level.

A threaded discussion area is made available for the group members to negotiate changes to the artifact, including the statement of reasons and suggestions for acceptable modifications.

At any point, a member can vote to accept or reject the artifact in its current state. These votes can be withdrawn at any time, e.g., when a group member has made a counter-proposal which is considered more appropriate or as the knowledge artifact is modified.

When the preset criteria for acceptance are met, the artifact is automatically published in the class learning place. There is a time limit for group approval; however, this is often moot since the group is usually strongly motivated to agree on final knowledge products in order to produce their portfolio and complete their work assignment.

In this approach, the voting interface can be extremely simple – for instance a button for the current user to signify agreement with the current version of the proposed artifact. The important point for the knowledge negotiation process is the possibility for a participant to state his or her reasons for withholding agreement in terms of dissatisfaction with the current state of the knowledge artifact. Thus, an adequate interface for the negotiation dialog is needed, in which students can formulate, exchange and react to disagreements so that the knowledge artifact can be modified in a direction that is likely to promote consensus. The knowledge negotiation interface therefore includes its own threaded discussion. When students vote, they must provide statements explaining their vote; these statements are automatically incorporated in the discussion forum where they can be further discussed. At the conclusion of negotiation, this threaded discussion represents the history of negotiation and implicitly reflects

changes that have been made to the knowledge artifact as part of the knowledge negotiation, including the rationale. It can also include summary statements or a minority opinion, for instance.

6. SUPPORT FOR KNOWLEDGE NEGOTIATION

The implementation of negotiation in BSCL is intended to allow teachers to define course learning spaces that contain only shared knowledge. The knowledge in this area is contributed by groups as such, not by individuals. It comes from group learning spaces and represents a consensus of the thinking of the members of that group. In the course area there is a threaded discussion area where all course members can reflect upon the group portfolios and build further shared knowledge on that basis at the level of the course as a whole.

In many cases, such a strict regulation of contributions will prove impractical and cumbersome. Therefore, we have given teachers certain powers to short-cut or over-ride the negotiation procedures. Most importantly, a teacher can cause a proposal folder to be published to the course without waiting for the voting threshold to be reached. For instance, the teacher might conduct a face-to-face negotiation with the group and then publish the folder on that basis. Going in the other direction, a teacher might feel that an already published portfolio has not been carefully enough discussed and refined, and send it back for more work and renegotiation. The teacher can also change the voting threshold for contributions to a course.

Within BSCL, teachers generally have the right to copy items between folders, including student work from group folders into course folders. However, when they do this using the new negotiation functions, the copied items are clearly marked as having been moved by the teacher from the specific group, incorporating the CSCW principle of visibility recommended by Herrmann and Wulf.

7. STUDYING NEGOTIATION IN CLASSROOMS

Knowledge negotiation is a central process within collaborative learning. However, most software systems for learning do not support it explicitly and adequately. There is a need for empirical exploration of negotiation support functionality. BSCL will be tested in 50 schools in

Greece, Italy, the Netherlands and Finland this Fall as part of the ITCOLE project, and we hope that many of the teachers will use curriculum that requires negotiation by student project groups, testing the support mechanisms we have implemented.

The current design of support is based on our experience with the use of BSCW under many conditions during the past seven years, (Appelt & Klöckner, 1999) with studies of prototype systems by Herrmann and his students, (Herrmann, 1995; Herrmann *et al.*, 1996; Herrmann & Kienle, 2002; Lepperhoff, 2001) and with systems created by Stahl and his associates, (Stahl, 1993; Stahl, 2001) including the joint exploration of perspectives by Herrmann and Stahl. (Stahl & Herrmann, 1998, 1999) We also have experience from an earlier version of BSCL without negotiation support that has been used in 20 European schools.

The BSCL system has been instrumented to log all knowledge building and knowledge negotiation activities so that the mechanisms described here can be evaluated in detail. In particular, every time a menu item is executed, the specifics of the action are saved to a server log that can be analyzed in a spreadsheet or with special analysis tools. All threaded knowledge building areas, including those within negotiation folders, are saved to an electronic file for quantitative analysis; interesting sessions will be printed out for manual qualitative analysis. Quantitative analyses of timing and depth (e.g., thread lengths) of negotiation discussions will indicate the importance of the knowledge negotiation within the larger knowledge building processes. Qualitative analysis of the discourse in key discussions may provide further insight into the nature of the negotiations conducted.

Clearly, such negotiation processes are extremely sensitive to social settings and age groupings. We will be able to compare student groups across several age levels in K-12 and across contrasting school cultures in northern and southern Europe. We will also run trials at college and workplace settings to broaden the basis of comparison. However, we suspect that detailed analysis of individual case studies – if they are sufficiently rich and if they yield to a combination of quantitative and qualitative analysis – will provide significant insight into the phenomenon of computer-mediated knowledge negotiation.

8. CONCLUSIONS

The negotiation of what is to count as shared knowledge is an essential aspect of cooperative knowledge work and collaborative learning. When the interaction that creates this knowledge does not take place face-to-face, computer support in asynchronous learning networks can play an important role. We have tried to develop an appropriate concept of knowledge negotiation based on a survey of theoretical frameworks for CSCL and a critical review of related concepts of negotiation in CSCW, particularly the concept of negotiation in the systems of Herrmann and Wulf.

The shared knowledge typically aimed at by knowledge building efforts in CSCL is not taken to be objectively given; it is socially sanctioned within a community. The support we have implemented in BSCL is designed to scaffold the social process of constituting shared knowledge in a group. By requiring all knowledge in a course workspace to originate in a smaller project group, we attempt to have the shared knowledge building of the course community mediated by the smaller, more tractable working groups. These groups mediate between the individual and the community in a series of manageable steps. The proposal folders that get negotiated by the groups form another layer of organization for ideas and documents, and the proposals themselves function as knowledge artifacts-in-the-making.

In transforming a CSCW infrastructure into a CSCL environment, we have had to give considerable thought to the definition of appropriate roles and activation rights for the different kinds of actors (e.g., students of different ages, teachers, mentors, guests) within educational social settings. The work spaces or learning places had to be designed to correspond with these roles and to appropriately house the knowledge building and knowledge negotiation processes.

In adapting the concept of negotiation to collaborative learning, we have defined "knowledge negotiation" as a phase of collaborative knowledge building, taken as an activity at the group unit of analysis. This form of negotiation does not simply reconcile multiple personal opinions, but helps to construct and confirm new shared group knowledge – and makes it public for the larger community.

The mechanisms for negotiating shared knowledge in face-to-face situations are part of what it means to be human; we need to evolve similar mechanisms that will seem natural and effective in ALNs.

ACKNOWLEDGMENTS

REFERENCES

Appelt, W., & Klöckner, K. (1999). *Flexible workgroup cooperation based on shared workspaces.* Paper presented at the World Multiconference on Systems, Cybernetics and Informatics: SCI '99 and ISAS '99 (5th International Conference on Information Systems Analysis and Synthesis), Orlando, FL.

Baker, M., Hansen, T., Joiner, R., & Traum, D. (1999). The role of grounding in collaborative learning tasks. In P. Dillenbourg (Ed.), *Collaborative learning: Cognitive and computational approaches.* Oxford, UK: Pergamon.

Barrows, H. (1994). *Practice-based learning: Problem-based learning applied to medical education.* Springfield, IL: SIU School of Medicine.

Bereiter, C. (2002). *Education and mind in the knowledge age.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Boland, R. J., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, A., & Campione, J. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press.

Connolly, T. (1997). Electronic brainstorming: Science meets technology in the group meeting room. In S. Kiesler (Ed.), *Culture of the internet* (pp. 263-276). Hillsdale, NJ: Lawrence Erlbaum Associates.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.

Herrmann, T. (1995). *Workflow management systems: Ensuring organizational flexibility by possibilities of adaption and negotiation.* Paper presented at the COOCS´95. Conference on Organizational Computing Systems, Milpitas, CA.

Herrmann, T., Wulf, V., & Hartmann, A. (1996). Requirements for a human-centered design of groupware. In D. Shapiro, M. Tauber & R. Traunmüller (Eds.), *Design of computer supported cooperative work and groupware systems*. Amsterdam, NL: Elsevier.

Herrmann, T., & Kienle, A. (2002). *Kolumbus: Context-oriented communication support in a collaborative learning environment.* Paper presented at the World Conference on Social, Ethical and Cognitive Issues of Informatics and Information and Communication Technology. Retrieved from http://iugsun.cs.uni-dortmund.de:2048/pub/bscw.cgi/d219854/30206.PDF.

Hewitt, J., & Teplovs, C. (1999). *An analysis of growth patterns in computer conferencing threads.* Paper presented at the Computer Supported Collaborative Learning (CSCL '99), Palo Alto, CA.

Hutchins, E. (1996). *Cognition in the wild*. Cambridge, MA: MIT Press.

Kraemer, K., & Pinsonneault, A. (1990). Technology and groups: Assessment of the empirical research. In J. Galegher, R. Kraut & C. Egido (Eds.), *Intellectual teamwork: Social and technological foundations of cooperative work* (pp. 375-405). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leinonen, T., Hakkarainen, K., Appelt, W., Dean, P., Gómez-Skarmetav, A., Ligorio, B., et al. (2001). *Itcole project: Designing innovative technology for collaborative learning and knowledge*

building. Paper presented at the Ed-Media 2001: World Conference on Educational Multimedia, Hypermedia and Telecommunications, Tampere, Finland.

Lepperhoff, N. (2001). *Sam: Untersuchung von aushandlungen in gruppen mittels agentensimulation (analysis of negotiation in groups: An agent-based simulation).* Unpublished Ph.D. Dissertation, University of Dortmund, Dortmund, Germany.

Lim, L.-H., & Benbasat, I. (1993). A theoretical perspective on negotiation support systems. *Journal of Management Information Systems, 9*(3), 27-44.

McCall, R., Bennett, P., d'Oronzio, P., Ostwald, J., Shipman, F., & Wallace, N. (1990). Phidias: Integrating cad graphics into dynamic hypertext. In A. Rizk, N. Streitz & J. Andre (Eds.), *Hypertext: Concepts, systems and applications. Proceedings of the european conference on hypertext (echt '90)* (pp. 152-165). Cambridge, UK: Cambridge University Press.

McGrath, J. (1993). A typology of tasks. In R. Baecker (Ed.), *Readings in groupware and computer-supported cooperative work: Assisting human-human collaboration*. San Francisco, CA: Morgan Kaufmann.

Nunamaker Jr., J., Dennis, A., Valacich, J., & Vogel, D. (1991). Information technology for negotiating groups: Generating options for mutual gain. *Management Science, 37*(10), 1325-1346.

Nygaard, K., & Sørgaard, P. (1987). The perspective concept in informatics. In G. Bjerknes, P. Ehn & M. Kyng (Eds.), *Computers and democracy: A scandinavian challenge* (pp. 371-393). Aldershot, UK: Avebury.

Rittel, H., & Webber, M. M. (1984). Planning problems are wicked problems. In N. Cross (Ed.), *Developments in design methodology* (pp. 135-144). New York, NY: John Wiley & Sons.

Shannon, C., & Weaver, W. (1949). *The mathematical theory of communication*. Chicago, Il: University of Illinois Press.

Stahl, G. (1993). *Supporting situated interpretation.* Paper presented at the Annual Meeting of the Cognitive Science Society (CogSci '93), Boulder, CO. Retrieved from

http://www.cis.drexel.edu/faculty/gerry/publications/conferences/1990-1997/cogsci93/CogSci.html.

Stahl, G., & Herrmann, T. (1998). *Verschrankung von perspectiven durch aushandlung (in german; translated by g. Stahl as: The sharing of perspectives by means of negotiation).* Paper presented at the Interaktion in Web: Innovative Kommunikationsformen, Marburg, Germany. Retrieved from http://www.cis.drexel.edu/faculty/gerry/publications/conferences/1998/verschrankung/index.html and http://www.cis.drexel.edu/faculty/gerry/publications/conferences/1998/sharing/sharing.html.

Stahl, G., & Herrmann, T. (1999). *Intertwining perspectives and negotiation.* Paper presented at the International Conference on Supporting Group Work (Group '99), Phoenix, AZ. Retrieved from http://www.cis.drexel.edu/faculty/gerry/publications/conferences/1999/group99/group99.pdf.

Stahl, G. (2000). *A model of collaborative knowledge-building.* Paper presented at the Fourth International Conference of the Learning Sciences (ICLS 2000), Ann Arbor, MI. Retrieved from http://www.cis.drexel.edu/faculty/gerry/publications/conferences/2000/icls/icls.pdf.

Stahl, G. (2001). WebGuide: Guiding collaborative learning on the web with perspectives. *Journal of Interactive Media in Education, 2001*(1). Retrieved from http://www-jime.open.ac.uk/2001/1 and http://www.cis.drexel.edu/faculty/gerry/publications/journals/jime2001/webguide.pdf.

Stahl, G. (2002a). *Contributions to a theoretical framework for CSCL.* Paper presented at the Computer Supported Collaborative Learning (CSCL 2002), Boulder, CO. Retrieved from http://www.cis.drexel.edu/faculty/gerry/publications/conferences/2002/cscl2002/cscl2002.pdf.

Stahl, G. (2002b). *Groupware goes to school.* Paper presented at the Groupware: Design, Implementation and Use -- CRIWG 2002, 8th International Workshop on Groupware, La Serena, Chile. Retrieved from http://www.cis.drexel.edu/faculty/gerry/publications/conferences/2002/criwg/Stahl_CRIWG_Paper.pdf.

Stiemerling, O., & Wulf, V. (2000). Beyond "yes and no" -- extending access control in groupware with awareness and negotiation. *Group Decision and Negotiation, 9*, 221-235.

Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge, UK: Cambridge University Press.

Vogel, D., Nunamaker, J., Applegate, L., & Konsynski, B. (1987). *Group decision support systems: Determinants of success.* Paper presented at the Decision Support Systems (DSS '87).

Vygotsky, L. (1930/1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation of design*. Reading, MA: Addison-Wesley.

Wulf, V. (2001). *Zur anpassbaren gestaltung von groupware (tailorable design of groupware)* (Vol. No. 10). Sankt Augustin, Germany: GMD Research Series.

Wulf, V., Pipek, V., & Pfeifer, A. (2001). Resolving function-based conflicts in groupware systems. *AI & Society, 15*, 233-262.