The Challenges for Computer Supported Collaborative Learning in Elementary and Secondary Level: Finnish Perspectives

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Abstract: Computer supported collaborative learning (CSCL) offers promising innovations and tools for restructuring teaching-learning processes to prepare students for the emerging knowledge society. However, sufficient and reliable data have not been available concerning how the practices of CSCL fit in different school cultures, and how teachers with varying pedagogical and domain expertise and students with varying skills, attitudes and learning experiences are able to function with different network learning environments. This paper discusses the challenges of CSCL on the basis of intensive case studies conducted in Finnish elementary and secondary schools. The results of these studies indicate that in order to promote educational change and facilitate practices of collaboration at school with the new information and communication technology and CSCL, serious challenges have to be overcome. The analysis revealed challenges that can be categorized according to three dimensions: pedagogical, technical, and organizational. Focus of the article is on pedagogical challenges.

Keywords: best practices, computer-mediated communication, shared knowledge

Introduction

According to many reports, rapid social and economic changes are taking place as western society approaches the 21st Century. Educational institutions are forced to find new pedagogical and cognitive models and practices to cope with the challenges of an emerging knowledge society. In this development computers will play an important role. Computer supported collaborative learning (CSCL), especially, offers promising innovations and tools for restructuring teaching-learning processes to prepare students for the future. Recent research on CSCL has indicated several positive effects: enhanced individual learning outcomes; and higher group performance, especially with regard to knowledge construction (for a review see Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen,1999).

In advanced pedagogical practices, the use of CSCL becomes an integrated part of the whole learning environment and the culture of learning. As such, technology is used for building up social structures that encourage learning, for supporting reflective discourse and for helping students and teachers build knowledge and deepen their understanding of different subject domains. Building knowledge involves dealing with knowledge objects --ideas and theories, for example--in an intentional manner, constructing a deeper, coherent, expert-like discourse, or portion of it.

Despite positive results and visions of computer supported collaborative learning, we should also take into consideration the challenges of collaboration. For example, social psychological research has revealed challenges of group work such as free-rider effect (individual member or members of team off-loads cognitive responsibilities to the other members of the group, Kerr & Bruun 1983; Salomon 1993), status sensitivity (high ability members may dominate the group work, Dembo & McAuliffe, 1987) and sucker effect (to avoid the free-rider effect an active member of the group may expend less cognitive effort on team work, Kerr, 1983). Everyone who has participated in teamwork is familiar with these difficulties of collaboration. Collaboration is not always favorable and teams do not always function as best they can (Salomon, 1997; Salomon & Globerson, 1987). There is no reason to believe that collaborative learning in schools is free from these difficulties.

Although a few well-developed pedagogical models for CSCL do exist (see Koschman, 1996) little attention, thus far, has been focused on analyzing the challenges of CSCL in authentic school environments. Thus, few data are available concerning how various pedagogical and cognitive practices and networked learning environments fit in differing school cultures, and how teachers given their pedagogical and domain expertise and students' varying skills, attitudes and learning experience are able to function within network learning environments. In other words, what are lacking are investigations of the

wider application of CSCL in normal classrooms and schools. The aim of the article is to discuss some of these challenges of CSCL within a Finnish context .

The paper is based on analysis of a series of intensive case studies within a Finnish research project concerning the educational use of CSCL in elementary and secondary level (see Appendixes A and B). The case studies are part of a larger project that aims to develop and implement pedagogical practices and models of CSCL, to support students' participation in practices of progressive inquiry through CSCL, and to analyze the cognitive, social and motivational effects of CSCL in Finnish schools. The substudies have the goal of determining how new information and communication technology can best be used at the various school levels in order to facilitate students' skills of knowledge acquisition and production, and social construction of knowledge; as well, a goal is to enhance task-related motivation and encourage the metacognitive activities needed in an information society. An important part of the overall research project is to carry out intervention studies of CSCL in normal school environments and analyze data from naturalistic contexts students are engaged in CSCL.

Methods used in the case studies

The case studies were conducted in two elementary classes (9-12- year-old students) in the city of Helsinki and in one secondary (13-year-old students) class in city of Oulu during years 1995-1998. The technological infrastructure of the study was provided by the Computer Supported Intentional Learning Environments (CSILE) developed by Scardamalia and Bereiter (1991). CSILE is a networked learning environment for fostering higher-level processes of inquiry and collaboration in elementary-level education (see Scardamalia & Bereiter, 1994). CSILE provides students a shared space for working with knowledge. The system is used to organize students learning projects in such domains of knowledge as mathematics, physics, biology, and history.

The classes participating in the study worked with CSILE in their study projects. During the years 1995-1998 they performed several projects focused on topics on biology, chemistry, physics, environmental studies, and geography (see Appendix A) and produced, in all, almost 4000 CSILE notes. CSILE was used in order to facilitate a research-like process of collaborative inquiry in which generation of the students' own research questions, intuitive theories and search for explanatory scientific knowledge played an important role.

The intensive CSILE project lasted 4 to 6 weeks, so each class conducted approximately four CSILE projects during the school year. The first year (95-96) was an exception; during that year, several projects were performed simultaneously. The teachers initiated the projects, and there was only a minimal amount of direct intervention from the researchers. In the beginning of the CSILE project, students and teachers were generally without experience in intensive, pedagogical- development projects. Moreover, they were not familiar with principles of CSCL and did not appear to fully recognize the cognitive value of collaborative learning. It should also be noted that in Finland in elementary level the same teacher works with the same students for four years. For example, Teacher A presented in the Appendix A, worked with the same students during years 95-98.

Classroom situations are complex phenomena where numerous factors and processes occur in relation to the other factors (Salomon, 1996). For that reason, we used a multi-method approach in our case studies including self-report questionnaires of students' motivational orientation, videotaped lessons, teacher and student interviews, and a qualitative content analysis of students' written productions from the CSILE database (see Appendix B).

The pedagogical challenges for CSCL

In the process of identifying the pedagogical challenges of computer supported collaborative learning based on our empirical research, the following questions were within the focus of our interest: What is the role of the teacher in CSCL? Are the CSCL environments beneficial to all students? Are students able to communicate productively by writing in networked learning environments? What kind of communication patterns emerge in CSILE work? How actively do individual students participate in CSCL? How is CSCL integrated in the classroom work?

The analysis of our intensive case studies showed that in order to successfully use CSCL in natural settings several challenges have to be met, challenges which can be divided into at least three categories: technical, organizational, and pedagogical. By "technical challenges" we mean teachers and students' expertise in ICT (information and communication technology) and access to ICT. "Organizational challenges" refers to the

issue of how to obtain whole-school organization support for educational change with CSCL. The pedagogical challenges are given in detail in the following section.

Teacher's contribution to collaborative learning processes

In computer supported collaborative learning, the traditional role of the teacher as information deliverer is changed to a role of facilitator and co-learner. This means facilitating collaboration between students, encouraging them to monitor their understanding (without directly giving them information), communicating with them and carefully examining knowledge produced by the students. The last two appear to be extremely important in the case of networked learning environments such as CSILE.
The teachers of the Finnish CSILE classrooms did not participate very actively in the students' process of computer supported collaborative learning. This was evidenced especially in their contributions to the students' CSILE mediated discourse. During the projects, they provided only a few comments on students' notes and did not systematically contribute on the students' collaborative learning process or comment on the students' knowledge productions (Hakkarainen, Lipponen & Järvelä, in press; Lipponen & Hakkarainen, 1997). In interviews, they told investigators that they do not have enough time to do CSILE work because the normal schoolwork takes most of their time. It seemed that students were left, in effect, to conduct unguided discovery learning. Yet without actively participating in students' collaborative learning, the teacher can neither help the students to advance their learning process, nor recognize significant contributions, nor generalize emerging progressive practices of collaborative learning. It follows that in order to succeed the teachers may need a great deal of pedagogical and epistemological support from researchers in the form of project designs, and good examples. Besides theoretical knowledge about CSCL they need practical knowledge of good approaches.
However, there was one exception: In one project, Energy, Teacher B was very active. While students produced 127 CSILE notes during the project, she contributed to the discourse by producing 30 notes of substantial he pedagogical and cognitive value. Her comments were supportive; she requested students to do some more research; she did not produce direct answers nor direct guidance, but instead the objects of her comments were students' intuitive conceptions, as she tried to guide them in monitoring the progress of their understanding. (Example comments: What do you mean when you write that energy is power? Could you explicate this issue? Good note. But is energy really matter? If it is, what kind of matter do you mean?). Yet her comments did not appear to have any effect on students' work for students did not respond to her comments. This interesting issue is still under study (Lipponen, Hakkarainen, Muukkonen, & Rahikainen, 1999). The challenge for teachers is how they are to establish a supportive environment that allows students to gradually assume responsibility for high-level practices of collaboration and carry out productive knowledge construction processes.

Motivational aspects of CSCL

The general claim of CSCL has been that the networked learning environments provide a common, and mostly optimal, experience for all students. Our studies indicated that a detailed exploration concerning the characteristics of an individual student's ways to cope and perform in new learning environments is needed to explain and understand the cognitive advantages and challenges of computer-supported collaborative learning (Rahikainen, Hakkarainen, Lipponen, & Lehtinen, 1999).
Individual and cultural aspects of the learning process are in close interaction in the context of CSCL. One might, for example, have expected learning-oriented or high-achieving students to process and produce conceptually more sophisticated knowledge than performance-oriented and avoidance-oriented students in CSCL. However, regardless of their motivational orientation or school achievements, Finnish CSILE students tended to produce the same kind of descriptive, empirical, and factual knowledge (Järvelä, Hakkarainen, Lipponen, Niemivirta, & Lehtinen, 1997; Hakkarainen, Lipponen, Järvelä & Niemivirta, in press). "High motivation" measured in traditional terms did not seem to strongly promote the type of inquiry-based on collaborative activities under examination.

Making thinking visible

Writing can be seen as the most important tool of thinking in our present society (Bereiter & Scardamalia, 1987; Olson, 1994). It has a crucial significance in explication and articulation of one's conceptions. Thus the externalization of ideas by writing, making thinking visible, should help students to reflect on their own and others' ideas and share their expertise. Therefore, the networked environments of CSCL are designed to encourage students to use writing as the main medium of collaborative learning and between-student communication.

Yet such goals are based on certain presuppositions, and it is relevant to determine whether they are met. If one examines notes posted by Finnish students to CSILE's database, one notices that these usually consist of only a few sentences. A question arises whether these young children (aged 9 to 12) are capable of expressing their ideas or making their thinking visible by writing. Is writing cognitively too demanding for the young children in question? How does the culture of writing affect the nature of these Finnish students' writing (Lipponen et al., 1999). Students are not usually required to write extensively at school. The audience of writing is almost always the teacher, and the function of writing with which they are most familiar is to demonstrate that one has understood assigned texts and acquired desired knowledge. Students are not encouraged to use writing for articulating their ideas in an extended way: Extensive thinking is not facilitated through writing assignments; such assignments do not usually require production of more than one or two paragraphs. Presumably as a consequence of such practices regarding writing at school, students are generally not able, through writing to build knowledge creatively in CSILE notes they produce.

The nature of computer mediated discourse is different from the face-to-face communication. In written communication the referential relations should be explicated and the context created; in contrast these are usually known by participants or are easily checked in face-to-face communication. However, examination of our CSILE students' communication indicated that in many cases the students did not explicate such referential relations. In this respect, their written activity resembled oral discourse (Lipponen & Hakkarainen, 1997; Lipponen & Hakkarainen, 1998).

These considerations do not necessarily lead to a bleak outlook. It is possible that, to some degree, students noninvolvement with writing arises from their distaste of standard classroom practice and their exposure to computer environments which demand only non-writing activities. To the extent that the student attitudes and skills mentioned above are effects of the present pedagogical and technical systems, they perhaps can be changed with exposure to new teaching methods and new technological environments.

Patterns of communication

Computer supported learning environments offer a new medium for a classroom discourse that is not always controlled and guided directly by the teacher. This might facilitate peer interaction and offer participants possibilities to negotiate shared ideas in problem-solving situations. Yet the patterns observed closely reflected school children's common practices of classroom interaction: The most common pattern of communication between the CSILE students was a question-answer exchange in which a factual question (what, who, how many) was presented and a factual answer provided (Example: How much energy does a man need in a day? About three meals.) In addition, disagreement between students led to a quick interruption of interaction mediated by the network. As a consequence, the average depth of inquiry was no more than a few steps.

It appears that the purpose of the fact-oriented discourse was to pose a simple question and to find the right answer quickly. This might be related partly to the issue of taking cognitive risks. It is much easier to find an answer to a factual questions than it is to answer questions seeking understanding (Lipponen & Hakkarainen, 1997; Lipponen, Hakkarainen, & Muukkonen, 1999). On the other hand, it is possible that through the observation and imitation of fellow students' processes of knowledge construction, joint norms of inquiry and practices of communication may emerge. These joint norms of discourse might guide students to conduct a certain type of discourse and in a particular way.

These findings provide evidence for the position that, according to the context of nation and school culture, collaboration does not always lead to shared, progressive articulation of partially developed ideas. Rather the common pattern of interaction was one in which differing opinions and interpretations expressed in discussion often seemed to cause cognitive conflicts that an agent tried to solve internally before going back to the social plane. Such a pattern seems to be more closely related to the Piagetian (socio-cognitive conflict) theoretical framework and differs, at least on the surface, from that of the Vygotsky and the neo-Vygotskians (intersubjective construction) (Hakkarainen, Järvelä, Lehtinen & Lipponen, 1998; Lehtinen, Hakkarainen, Järvelä, Lipponen,& Ilomäki, 1997). Yet, in parallel with the above arguments about learning practices, the preference for non-social resolution may, at least in part be the effect of present arrangements and hence subject to influence by fundamental changes in pedagogy and educational organization.

Patterns of participation

Many studies show that boys find computers more attractive, and that they also feel more positively towards computer use than girls. Girls seem to have less motivation to work with computers. This may due to gender

differences in computer experiences, girls having such experiences less both at home and in school. In addition, boys tend to see computers as more useful (Durndell, 1991; Scott, Cole & Engel, 1992).
Our studies likewise show that computer supported collaborative learning within the CSILE network has been particularly motivating for Finnish male students who have traditionally been having a lot of difficulties in adapting to externally regulated traditional school learning (Hakkarainen et al, in press; Lipponen & Hakkarainen, 1997). In every CSILE project of ours, boys have been more active, i.e., posting more notes to the CSILE database than do the girls (this does not say anything about the quality of knowledge produced). An good illustration of this is the data collected from a four-week course on "Energy" that consisted of CSILE students' (11-12-year-old students) computer mediated discourse. During the energy-project, students (female, n = 13 and male, n =14), posted 141 notes to CSILE database from which girls posted 41 notes (relative proportion of female students notes was 29,5 %) and boys posted 100 notes (relative proportion of male students' notes was 70,5 %). Moreover, in one of our studies (Lipponen & Hakkarainen, 1998) two below-average students, both males, who represent avoidance orientation as their socio-emotional coping strategy and who were very passive in traditional classroom discussions participated very actively in CSILE work.
In every one of our CSILE projects the participation activity of students was uneven; there were several projects, for example the Energy project conducted by teacher A, where six students (N = 27) did not produce any CSILE notes. As opposed to this, in one project four male students (N = 26) tried to finish their other assignments in the beginning of the school week in order to get the rest of the week for working with CSILE. Each of these four students produced over 100 notes (N = 1159) to the database.
The uneven activity of participation is the case, of course, in traditional classroom learning and classroom discussion too. But the argument and the promise of CSCL and networked learning environments have been that they will democratize the participation and activity of students. Perhaps we should admit that CSCL only gives possibilities for equal participation. Whether these possibilities are ever realized depends on context and educators' practice. Furthermore, the gender differences and the activity of low-achievers might reflect a shift in which CSCL is motivating and "favoring" different students than does traditional schoolwork.

Conclusions

The aim of the article was to analyze the educational use of CSCL, in particular the CSILE set-up, based on several Finnish case studies at the elementary and secondary level. The case studies were conducted in two Finnish schools and in three classes. Therefore, the results do not necessarily yield directly comparative data for differing cultures of using CSCL in countries other than Finland. However, it is also possible that these challenges are, to some degree, universal and every project seriously concerned with promoting educational change through CSCL will have to find ways of meeting these challenges. The analysis indicates that in order to use CSCL in normal schools several challenges have to be met, especially pedagogical ones.
In conclusion, it may be useful to discuss the pedagogical challenges of CSCL by distinguishing between first-order and second- order effects of educational technology. Our studies would appear to indicate that the introduction of computers itself affects the nature of the whole learning environment. These effects, which we call "first-order" effects of educational technology, refer to learning of skills of using information technology, developing skills of basic knowledge acquisition, generally increased motivation, and accessing extended sources of information. First order effects also involve changes in structures of classroom activities and changed division of cognitive labor between the teacher and the students. Our evidence clearly indicates that the structure of classroom activity changed after the introduction of CSILE. Students were working in a more self-regulated way; they were doing tasks more on their own and directing their own projects instead of following detailed assignments of the teachers.
It seems that the first-order effects are normal consequences of engagement with computer supported collaborative learning. However, they do not, as such, facilitate social construction of knowledge and advancement of the students' deeper, principled and conceptual understanding, which depends critically on the appropriate supportive activities of teachers, especially their involvement in new roles. Thus a very critical aspect of facilitating pedagogically meaningful use of ICT and practices of CSCL is training of teachers. It may be that in the beginning of our research project we did not provide enough support for he teachers. Recently we have radically increased the amount of training and support given to our teachers. The first-order effects, of course, may be pedagogically very valuable achievements and represent a significant improvement over traditional practices of learning and instruction.

Even if the Finnish CSILE student in our studies to date did not achieve higher-level processes of collaboration, the practices of learning and instruction have been considerably changed. However, bringing computers into the classroom does not automatically lead to what we call second-order effects of educational technology. The second-order effects involve engaging students in a sustained question- and explanation-driven inquiry, true knowledge building, and progressive discourse analogous to scientific practice. The second-order effects may lead to a profound change in the students' conceptions of what learning and knowledge are all about, and they need strong pedagogical support from the teacher. The second-order effects appear, further, to require deep change in teachers' conceptions of knowledge and in the pedagogical practices of school generally. This appears to be very difficult to achieve. Although the scientific community has considered the principles of CSCL highly promising for the development of future learning environments, practicing teachers are either unacquainted or not convinced of their value. For example in recent large survey studies (Hakkarainen, Muukkonen, Lipponen, Ilomäki, Rahikainen, & Lehtinen, 1999) Finnish teachers didn't regard collaborative learning as an important application of computers. This result is partly due to the novelty of the CSCL ideas in schools but it also indicates that the theoretical and practical principles of CSCL are still too recently articulated to be widely recognized and applied in practical educational reforms.

Computer supported collaborative learning should be an integrated part of the whole learning environment. Yet a phenomenon we call "The problem of two curricula" appears to be very common in classes that are implementing or using new technology. The two curricula seem to co-exist side by side, often unnoticed. The first curriculum followed in our classrooms was the traditional information-transmission curriculum focused on making sure that each student "carried out the assigned tasks". The teacher assumed responsibility for the higher-level cognitive activities such as generating questions and explaining and took charge of metacognitive activities like planning, monitoring and evaluating. In the second curriculum, which we call "collaborative inquiry with computer networking and support", students were encouraged to take more responsibility for their own and their fellow students' learning. If these two curricula are not integrated or supportive of each other, it is very difficult to achieve the pedagogical goals of either of them or to bring about the second-order effects of educational technology. In addition, if we admit that curriculum very strongly guides what teachers and students are doing in the classrooms, then we might ask, what is the role of technology or collaborative work in the curriculum? How much space and time is given for students to do computer supported collaborative work and how is it organized? The time that is used to work with CSCL is closely related at least to the problem of two curricula and on the other hand to the technical challenges of CSCL such as location and access of computers.

In order to facilitate CSCL in elementary-level education, a substantial change in pedagogical practices and in the wider culture of schooling is needed. Nevertheless, the culture of school learning cannot be expected to change immediately but presupposes a long process of exploring and testing different cognitive and pedagogical practices, such process necessarily involving educational personnel. The change also demands the educational policy to seek and foster these changes. The challenges for CSCL arise from the fact that we are, simultaneously, trying to promote educational use of the new information and communication technology and implement new pedagogical and cognitive practices of learning and instruction. Although the new technology and pedagogical ideas support each other, the change demands the utmost of both teachers and students.

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Appendix A. Students' CSILE projects during years 95-98

School year	Students' grade	Students' age (years)	Topics of students projects	Teacher
95-96	3	9-10	My Home Town Helsinki, Finland and their own suburb, Dinosaurs, Solar System, Our school, Health education, Traffic, Maps and map marks, Reproduction of plants	A
96-97	4	10-11	Scandinavian countries, Natural Phenomena (exploring phenomena such as thunder or rain, Environmental studies, Biological processes connected with human survival	A
97-98	5	11-12	Energy, History, Democracy	A
98 autumn	6	12-13	Good habits	A
97-98	3	9-10	Energy, Maps and environment	B
98 autumn	4	10-11	Biological adaptation: How a mammal adapts to environment?	B
96-97	7	13-14	Water as a chemical environment	C

Appendix B. Research topics, methods and publications of CSILE case studies

Research topics	Methods	Publication
Interaction between motivational and cognitive processes	Videodata and CSILE database analysis, self report questionnaire of motivational orientation, interviews	Järvelä, Hakkarainen, Lipponen, Niemivirta, & Lehtinen, (1997). Hakkarainen, Lipponen, Järvelä, & Niemivirta, (in press).
Communication patterns	Videodata and database analysis	Lehtinen, Hakkarainen, Järvelä, Lipponen, & Ilomäki, (1997).
Comparison of Canadian and Finnish students' knowledge-seeking practices	Database analysis	Lipponen, & Hakkarainen, (1997). Lipponen, & Hakkarainen, (1998). Hakkarainen, & Lipponen, (1998). Hakkarainen, Lipponen, & Järvelä, (in press)
Communication patterns	Videodata and database analysis	Hakkarainen, Järvelä, Lipponen, & Lehtinen, (1998).
Science teaching and CSCL	Videodata and database analysis	Lipponen, Hakkarainen, Muukkonen, & Rahikainen, (1999).
Practices of knowledge building	Database analysis	Lipponen, Hakkarainen, & Muukkonen, (1999).
Motivational aspects of CSCL	Videodata and database analysis, self report questionnaire of motivational orientation, literacy tests, interviews	Rahikainen, Hakkarainen, Lipponen, & Lehtinen, (1999).
Aspects of Collaboration	Theoretical articles	Järvelä, Hakkarainen, Lehtinen, & Lipponen, (in press) Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen (1999).