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The nature of the discourse in web-based Collaborative Learning Environments: Case studies from four different countries

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Abstract

The present paper describes a series of case studies of collaborative learning supported by two web-based learning environments: Synergeia2 and FLE3. The case studies were conducted in Finland, Greece, Italy, and the Netherlands as a part of international project called Innovative Technologies for Collaborative Learning. The general aim of this investigation was to examine the cases in a detailed way, and to find possible indications that might explain success and difficulties related to implementation of web-based Collaborative Learning Environments. The specific aims of the present study were to investigate the nature of the students' and teachers' computer-mediated discourse, whether and to what extent the students and teachers actually used the knowledge types in Synergeia2 and FLE3-environments (resembling CSILE's thinking types); and finally, to what extent the use of knowledge types was connected to the content of knowledge produced by the students and the teachers. The results showed considerable differences in the nature of the discourse and difficulties in students' labelling of their own notes. It is suggested that the adoption and development of collaborative practices takes time: collaborative learning in web-based environments is best organized around long-lasting learning activities; instead of weeks, whole academic terms. Further, it is underlined that the selection of good sets of knowledge types is important. Software must allow teachers to construct appropriate sets of knowledge types.

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1. Introduction

During the years 2001–2003, an EU-funded Innovative Technologies for Collaborative Learning (ITCOLE) project was carried out. The project aimed to develop and test modular web-based Collaborative Learning Environments (CLEs) with close collaboration between technical and pedagogical partners. Further, a strong emphasis was given to teacher training and support for making collaborative learning practices a part of the everyday classroom activities. The fieldwork focused on four European countries, Finland, Greece, Italy, and the Netherlands. From these countries, teachers and students from primary and secondary schools conducted learning projects in their classroom using the developed environments, Synergeia2 and FLE3 (Future Learning Environment). A special feature in the both environments is built-in knowledge types, with cues that ask the students to think what kind of contribution they are posting in the virtual environment. This type of help is assumed to be linked with the metalevel of students' deepening discourse.

At the beginning of the ITCOLE project, a review on the state of the art of information and communication technology (ICT) in education in the participating countries was conducted (Lakkala, Rahikainen, & Hakkarainen, 2001). The review showed that there were huge differences in how ICT has been implemented by the authorities in the four countries; the emphasis from the government and other organizations varied a great deal between the countries. The differences in the schooling systems and cultures may partly explain these differences. The countries had started to build an information society at different times, that is, to equip schools with computers and networks; it appears that secondary level students had quite good access to computers in all the countries reviewed. Further, it was found that there are plans, in the next few years, for substantial investment in each country, on governmental or private levels, to equip all the schools with computers and networks. What also seems to be common are the constraints on use of ICT in education: a lack of trained personnel to give adequate support for teachers, and a lack of guidance to use ICT in a pedagogically meaningful way. A few computer labs are still used by too many students and teachers, and, therefore, are not providing possibilities to use ICT in a versatile way, or to create meaningful learning environments. Teachers are mostly using basic applications, such as word processing, and students are using educational programs or multimedia products designed for individual learning.

Despite the constraints, there are considerable attempts to guide schools in these countries to adopt more meaningful ways to use ICT in education. New learning technology is said to be promising in that it can be designed and used to support students' learning in various ways. One such an attempt was the ITCOLE project. This article describes how students and teachers from four European countries carried out classroom and cross-classroom projects aimed to build knowledge in two web-based Collaborative Learning Environments, Synergeia2 and FLE3.

2. Web-based Collaborative Learning Environments

2.1. Socio-constructivist approach

The socio-constructivist approach to learning and instruction emphasizes learners' self-regulative and intentional activities. Collaborative Learning Environments (CLEs) designed to implement socio-constructivist ideas usually rely on principles of distributed cognition (e.g., Salomon, 1993). Instead of assuming that cognition resides in the individual's mind, the concept of distributed cognition makes cognition a shared construct among people and/or the environment. In a group, all individual participants have the possibility to extend their individual cognitive resources by relying on the distributed cognition of the group.

In general, CLEs emphasize active learning, encouraging students to ask questions, formulate hypotheses, and experiment to test them. This learning contrasts with that arising from a more teacher-centred way of teaching. Evidence for the benefits of students' active role in learning has been reported: supporting active engagement in the learning process, fostering curiosity and motivation, and enabling the development of life-long learning skills (e.g., Goldman, Mayfield-Stewart, Bateman, Pellegrino, & The Cognition and Technology Group at Vanderbilt (CTGV), 1998; Järvelä et al., 2001; Krajcik et al., 2000; Minstrell, 2000). However, a challenging issue is the degree and kind of support needed by learners; because self-regulative learning is difficult, there is a clear need to fully and comprehensively support learners (e.g., Krajcik et al., 2000).

All four countries participating in ITCOLE employed the same basic theoretical framework (constructivism, sociocultural/situative view) to create learning practices and to conduct research within this area. However, in each country, the pedagogical designs of the actual learning projects were concentrated on some special domains, or theoretical approaches. In Finland, special focus was on developing and implementing the pedagogical model of Progressive Inquiry (Hakkarainen, 2003; Hakkarainen & Sintonen, 2002). In Greece, the researchers emphasized the importance of research on conceptual change, especially in mathematics and science education (Vosniadou & Kollias, 2003). The Italian researchers were interested especially in the features of community development, and various forms of collaboration (Brown & Campione, 1994). In the Netherlands, the emphasis was on authentic learner-centred learning contexts, and on how students learn to learn within these new conditions. The training of the participating teachers followed the same main principles drawn from the socio-constructivist frame, but also had some nation-specific features.

2.2. Support in the web-based CLEs

Facilitation of learning in CLEs appears to require changing the traditional division of cognitive labor between the teacher and the students in order to encourage students themselves to take on the responsibility for cognitive (e.g., questioning) and metacognitive (e.g., monitoring) aspects of inquiry (Bereiter & Scardamalia, 1987). Students cannot be expected to make this kind of transformation immediately; it requires gradual increase in and facilitation of a student-centred aspect of learning.

One way to support learners is to provide them with tools, technology. The technology designed to support the principles of Collaborative Learning Environments has grown rapidly over past decade (e.g., Lehtinen, 2003). Many recent studies have reported evidence that technology can help to structure the process of learning, and it provides specific tools for supporting the learning process (Davis & Linn, 2000; Fretz et al., 2002; White, 1993). Technological solutions can help, for instance, the process of guidance by providing tutoring tools, built-in support and scaffolds, or even entire learning environments (e.g., Ainsworth, Wood, & O'Malley, 1998; Goldman, Zech, Biswas, & Noser, 1999; Muukkonen, Lakkala, & Hakkarainen, 2001; Scardamalia & Bereiter, 1994). Learners can store and exchange information and knowledge in a flexible and meaningful way. The information and knowledge can be also presented in many formats, and the representations can be manipulated, for instance, in a simulated learning environment with several representations of the same phenomenon and the possibility for the learner to change the variables in the simulation (e.g., De Jong & Van Joolingen, 1998; Veermans, 2002).

Computer Supported Intentional Learning Environments (CSILE), and its next-generation version Knowledge Forum (KF) (see Scardamalia & Bereiter, 1991), are among the first collaborative systems used in education, which are designed according to specific pedagogical ideas. For instance, one idea was to provide support for students by implementing, in the environment, a set of knowledge types (known also as 'thinking types') that represent essential aspects of inquiry. The basis of such scaffolding, which guides the participants to label their computer entries during inquiry, is based on the concept of writing as not just a tool of thinking, but also a means of controlling one's process of writing (Bereiter & Scardamalia, 1987). Therefore, it is possible to help weaker learners to engage in expert-like processes of inquiry by guiding them to write notes and label them according to the essential aspects of inquiry.

Implementation of the CLEs into an authentic classroom has not proven to be easy. There exist many studies reporting these challenges and ways to overcome the implementation problems (e.g., Edelson, Gordin, & Pea, 1999; Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998; Lipponen, 1999). The studies have focused on various aspects related to the implementations: student cognition and cognitive demands of the environments (e.g., Brown & Campione, 1994; Land, 2000), supportive classroom structures (e.g., Lehrer, Carpenter, Schauble, & Putz, 2000), and teachers' contributions in the learning environments at various levels of schooling (e.g., Lakkala, Muukkonen, & Hakkarainen, 2003; Lakkala et al., 2001; Ligorio, Talamo, & Simons, 2002). These studies have been conducted in several cultural contexts; school systems have reported evidence that CLE is not easy for students; their participation in the discussion is uneven; quality of discourse is varied, and the students need considerable support.

The ITCOLE project aimed to give more attention to the pedagogical principles to be implemented in the learning environment, to the pedagogical support of the teachers, and the use of the learning environments; in other words, to support more versatile and meaningful use of CLEs. Focusing on case studies in four countries, the aim was to examine teachers' and students' projects in a detailed way, and to find possible indications that might explain success and difficulties related to implementation. The specific aims of this study were: (1) to characterize the nature of students' and teachers' computer-mediated discourse; (2) to assess the usefulness of the knowledge types (labels), in particular, to find out whether and to what extent the students and teachers actually used the knowledge types in Synergeia2 and FLE3-environments, and finally; (3) to determine to what extent the use of knowledge types was connected to the content of knowledge in the postings produced by the students and the teachers.

3. Methods

In the third phase of the ITCOLE-project, teachers from Finland, Greece, Italy and the Netherlands carried out several classroom projects, to further test the pedagogical models and Synergeia version2 and FLE3 with their students.[1] In all, 84 teachers and 1413 students participated in the test projects in phase 3. For more details, and reviews for some of the projects, see the Idea Bank on www.euro-cscl.org.

The projects in the four counties were generally different in the emphasis given to a particular pedagogical design described in Section 2.1. In Finland, all the projects were strictly related to the pedagogical model of Progressive Inquiry; in Greece a great emphasis was given to conceptual change in scientific education. The Italian projects were mainly characterized by distance collaboration by students of various schools and also of differing age levels, building something together, such as, hypermedia and stories. The Dutch teachers emphasized distribution of activities in smaller units, clear goals of each unit, and quantifiable final assessment.

This article focuses on four case studies from the respective participating countries; each case represents one school project per each country. The decision to use a case study approach made it possible to gather detailed information about content of students' and teachers' discourse.

The analyses proceeded by categorizing students' and teachers' postings in virtual environments, a qualitative judgment by the researchers; the intent was to better examine the content of students' and teachers' work in each project. This categorization was done according to four main categories: *Social*, *Progress of the process*, *Content of inquiry*, and *Other* (see Table 1). The *Content of inquiry*-category had four sub-categories: *problems*, *low-level explanations*, *high-level explanations*, *and scientific information.*

The unit of analysis was agreed to be one note because, according to the preliminary analysis, the notes written by the students were rather short, and mainly consisted of only one type of knowledge. The researchers all agreed upon the categorization of the content, in a common meeting. The categorization was based on the following elements:

- the theoretical approaches applied in the ITCOLE project (see Lakkala et al., 2001): Progressive Inquiry model (Hakkarainen, 2003) community of learners (Brown & Campione, 1994) and conceptual change (Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001);
- the previous studies of the participating researchers', in which the content of knowledge produced by the students was investigated in similar educational settings (Lakkala, Ilomäki, Lallimo, & Hakkarainen, 2002; Muukkonen et al., 2001);
- the preliminary analysis of the content of the databases.

Further, the log files of FLE3 and Synergeia2 were examined to calculate the frequencies of the knowledge types used. There were four types of knowledge type sets (message categorization) avail-

[1] Synergeia2 was used in Greece, Italy, and the Netherlands; FLE3 was used in Finland.

Table 1
The main categories for analyzing students' and teachers' postings in the databases

Name of the category	Description
Social	Messages in this category represented general discussion relating to the common purpose of the learning community (collaborative work), communication about the ways of using the virtual tools (organizing the forums, using sensible titles), and social aspects of the community (arranging a common meeting room, invitations to participate actively to virtual work)
Progress of the process	Messages in this category included communication that was needed for organizing the (arranging meetings, asking help or comments, telling about information sources, making agreements of task completion)
Content of the inquiry	These messages represented students' problems, thoughts and explanations of the topics and subject domain concepts, descriptions of the content of their learning, and teachers' content-specific guidance
Other	Messages put into this category included conversation about other topics or school activity unrelated to the project tasks, and nonsense test messages written by students in the practicing phase

able in the Knowledge Building Areas: *Progressive Inquiry*, *Design*, *Informal Discussion and Collaborative Knowledge Building*. Each one has its own set of knowledge types (for details, see in this issue, Rubens et al.). In the four countries teachers (or in some countries, researchers) decided which set of knowledge types to use. Finally, in two of the case studies, Finland and Italy, the categorizations chosen by the students and teachers were compared with the content of the notes categorized, in order to see whether the students and the teachers used knowledge types appropriately.

4. The settings of the case studies: pedagogical design

In the following section, a presentation of the four case studies is given, emphasizing some differences in pedagogical design among the different countries.

4.1. Finland: studying sea coast organisms

The project studying seacoast organisms was carried out in a third grade classroom with 18 students (aged 9), and one teacher. There was also an outside expert, a biologist, participating in the project. Natural science and Finnish language lessons were used for the project. The project lasted 11 weeks, approximately 2 h per week in a computer lab. The project started by visiting the nature-education centre in Harakka Island, which was very inspiring for the students. After the visit, the principles and procedures of inquiry learning were discussed in the classroom. The teacher facilitated students' awareness of the phases of inquiry during the project by hanging, in the classroom wall, pictures describing different phases, depending on what phase was being carried out, at the moment.

The students were divided into three groups (Seaside group, Bird group, and Plankton group) when visiting the nature-education centre. After the visit, a knowledge-building (KB) context was created in FLE3, in which the whole classroom shared the experiences and findings of the visit. Later on, the KB tool was used twice for creating initial and specified working theories, and for evaluating them critically in the three groups. The students also worked face-to-face in the classroom and searched for information in the school library. The shared course folder in WebTop was used for students' individual folders (for collecting a portfolio of each student's work during the project, and for feedback from the teacher), and for providing instructions and links. The KB tool was also used at the end of the project for students' self-evaluation.

4.2. Greece: the throwing of a coin

The goal of the project was to implement a design that would lead to a better understanding in a difficult subject of Physics: explaining, by using Newtonian Forces, the motion of a coin (the coin toss problem) and to provide opportunities for the students to get a deeper understanding of what learning Physics is about.

The participants of the project were 26 students of the 10th grade (aged 15). The project lasted 3 weeks, 1 h per week in a computer science classroom. The students worked in groups of three, and each group had one PC to use. Before the project, all the students had some contact with formal mechanics taught in the traditional way. The didactic sequence that was conducted during the project combined a series of traditional lessons with a series of web-based CLE using Synergeia2. The Synergeia2 investigation was part of the computer science course, and was presented to the students as a new way to learn through collaboration.

During the first lesson with Synergeia2, the students read a note in the database that presented the coin toss problem, and they were asked to write down their opinions on some questions, justify them, and read and comment on the opinions of other groups.

A week later, during the traditional lesson, the students were introduced to the 2nd law of Newton and studied free fall, a topic strongly related to the problem posed. During the second lesson with Synergeia2, the students were encouraged to continue their thinking about the problem, by stating their current opinion about the coin toss problem. They were asked to state explicitly, whether their opinion had changed or not, and to justify the possible change. At the end the students argued in the classroom (face-to-face), and each group defended the opinion it had endorsed. A week later, in their classroom (traditional lesson), students worked more on free fall problems. Two weeks after that, the third lesson with Synergeia2 took place. In the third lesson, a fully justified exposition of the coin toss problem of another group was presented to them through the discussion space of Synergeia2 for criticism. This piece, in reality, was manufactured by the teacher himself and expressed the scientifically correct explanation; it was presented as part of the same research going on in another school. During the Synergeia2 lessons, the teacher encouraged the students to collaborate, to express freely their opinions, to see the answers of the other groups through Synergeia2, and to comment on them. In no case was the teacher assessing the answers given by the students, although he sometimes pointed out inconsistencies of argumentation.

4.3. Italy: myths

In all, 65 students of four classes participated in this project on European mythology. The classes involved in this project were two 4th grade and one 5th grade classes from a primary school in Rome; and one 6th grade class from a junior secondary school in Milan (aged 9–11). Six teachers (two with experience of CLE, and four with no experience) supported the students in the collaborative work within Synergeia2. The project lasted 20 weeks, approximately 2 h per week, both in classroom and in computer lab.

Interaction between the students at a distance started with the students' individual introduction of themselves. Primary school students chose to use nicknames in Synergeia2, and junior secondary school students to use their own names. They worked on mythology in small groups (2–3 students) and, after a period of brainstorming and discussion, they chose Atlantis from all the myths because it seemed to be the most intriguing and mysterious one. The teachers asked students to search for any information about Atlantis, and invited them to search documents and pictures from Internet. Through class discussion, they analyzed the information collected and decided what to post in Synergeia2. Each small group uploaded a number of documents (58 files all together both documents and pictures) in Synergeia2, to share them with the other students.

In the second work phase of the project, the teachers proposed to divide documents in four different folders: Atlantis in our drawings (students' imaginings of Atlantis and prepared drawings), Contemporary events that send back to Atlantis (students collected hypotheses about Atlantis disappearance), Work hypotheses and interviews on Atlantis (students arranged a questionnaire on Atlantis to propose it to every student at a distance), Evidences and verifications on Atlantis (students gathered information pro and versus Atlantis' existence). Every folder was managed by a small group that organized information and documents. The final goal of the group was to prepare a book (textual or hyper-textual), using all the information collected in all folders.

4.4. The Netherlands: 400 years United Dutch East Asia Company

The participants of the Dutch project were 41 students in the 7th and 8th grade (10–13 years). The students varied in their cultural background. In this project, groups of four students were formed. The groups were mixed from grades 7 and 8. Four PCs were available for all the students. The teachers arranged a scheme so that every student could work on a computer. Synergeia2 was used for 6 weeks, mostly three times a week for 2 h time.

A museum in Amsterdam asked the schools in the Netherlands to produce a brochure about the foundation of the Dutch East Asia Company (Verenigde Oost-Indische Compagnie, VOC) that was founded 400 years ago. This brochure was meant for children. History lessons were used to produce this brochure in a collaborative way. The teachers divided the brochure preparation in subtasks. In the classroom, the students had the opportunity to study books and watch videos about the VOC, and the groups discussed the subject. The tasks were divided within groups. In the first lesson, the subject was introduced. The teachers told about the foundation of the VOC, and about the request of the museum. They had formulated the request as an assignment for students. The assignment contained some questions that focused on facts, but several questions were intended to stimulate deeper understanding.

In the first lesson, the teachers also made clear the procedure of the project. The students became familiar with Synergeia2. During the other lessons, the students came together in the classroom. They decided together, who had to do what task; who had to do what chapter of the brochure. They used Synergeia2 to post questions, to answer questions of others, to add websites, to search for information (e.g., via selected websites), and to add documents with concept-texts. The students also answered questions of other groups. In the beginning of the project, they were not willing to do this. The teachers stimulated such activities by giving rewards. The teachers guided the process; they did not give class instructions, but they gave individual help to those students who had problems (e.g., with grammar), and groups of students.

5. Results

5.1. Content of the discourse

5.1.1. Finland

Because of the nature of the project, many notes in KB included discussion of the features of the findings (Are the bones, birds' bones? How did the blue alga look?), or wonderment about the animals that the students saw (What does a seashell eat?). The notes in the first KB context, especially, included also many social and process organization notes (see Table 2) because the students were interested in each other's experiences during the visit to the nature-education centre. The whole epistemological nature of the discourse in FLE3 was rather fact-oriented because it was based on students' effort to conceptualize their observations of the seacoast. High-level explanations were all the notes that included students' guesses and suggestion that were something more than observable surface features of the issues under study. Yet such students were not necessarily producing very high-level theoretical explanations of mechanisms or principles. The notes were also rather short, but it is understandable because the students were very young, and they carrying out this kind of inquiry for the first time.

In the last KB discourse, students produced many notes categorized as metalevel knowledge, because they answered to the self-evaluation questions formulated by the teacher.

Table 2
Content of the notes based on the categorization of each note: Finland

Knowledge category	Students ($N = 18$)		Teachers ($N = 2$)	
	f	%	*f*	%
Social	*48*	*17*	*0*	*0*
Progress of the process	*80*	*27*	*14*	*37*
Content of inquiry	*155*	*53*	*24*	*63*
Wonderment, problems	48		10	
Low-level explanation	55		0	
High-level explanation	46		11	
Scientific information	6		3	
Other	*10*	*3*	*0*	*0*
Total	293	100	38	100

In addition to face-to-face guidance in classroom, the teacher contributed to the KB discourse by starting new KB contexts with structured guidance notes, and by commenting on the students' inquiry with notes that usually included both social support and guidance to continue the inquiry. The notes written by the outside biology expert from the nature-education centre included content-related expert comments to students' explanations. He wrote only five notes, but they were very ingeniously formulated to the young student's level of understanding.

5.1.2. Greece

In the Greek case, the teacher had limited participation through Synergeia2. However, the teacher interventions were at a very high level, addressing evaluation and metalevel issues, problems and high-level explanations.

In students' notes about 80% were high-level explanations (see Table 3). At the same time, there were very few social comments and no *Progress of the Process* comments. These data reflect the nature of the intervention: although the teacher did not force students to some particular position, students had a heavy schedule of activities to deal with, and a plan of activities already set out for them. Under these conditions, the students did not take upon themselves the responsibility to organize the work, or build a sense of community of learning.

5.1.3. Italy

The database of Italian case study is characterized by many files introduced by students themselves. In all, students introduced 58 documents and 93 notes. There were 11 notes that could not be coded in the proposed categories. Four of them were stories about the myths and thus a new subcategory was added for the *Content of Inquiry*: Telling stories about myths. Seven notes were about asking or giving clarifications about technical difficulties with Synergeia, and they were all collected in the *Other* category. The results of the database analysis are in Table 4.

Altogether half of the students' notes fall into *Social* category, suggesting that in the Italian culture, creating social relationships among users is the first step to build shared knowledge. In addition, this course involved four classes in different schools, and distance communication certainly requires social relationships between students who do not know each other.

Table 3
Content of the notes based on the categorization of each note: Greece

Knowledge category	Students ($N = 18$)		Teachers ($N = 2$)	
	f	%	*f*	%
Social	*2*	*4*	*0*	*0*
Progress of the process	*0*	*0*	*2*	*50*
Content of inquiry	*52*	*96*	*2*	*50*
Wonderment, problems	0		1	
Low-level explanation	9		0	
High-level explanation	42		1	
Scientific information	1		0	
Other	*0*	*0*	*0*	*0*
Total	54	100	4	100

Table 4
Content of the notes based on the categorization of each note: Italy

Knowledge category	Students ($N = 65$)		Teachers ($N = 6$)	
	f	%	*f*	%
Social	*46*	*49*	*5*	*31*
Progress of the process	*12*	*13*	*6*	*38*
Content of inquiry	*15*	*16*	*3*	*19*
Wonderment, problems	1		2	
Low-level explanation	6		0	
High-level explanation	3		0	
Scientific information	2		0	
Telling stories about myths	3		1	
Other	*20*	*22*	*2*	*12*
Total	93	100	16	100

In this course, the Knowledge Building tool was used more for students' introduction and for organizational issues than for discussion on topic. The goal of the activity was to collect information in order to build a hypermedia together (58 files uploaded), instead to discuss topics in Knowledge Building Areas (109 notes, with the 49% of social notes).

5.1.4. The Netherlands

As Table 5 shows in the Dutch case, the teachers did not very actively participate through Synergeia2. Three of four notes, posted by teachers, were progress-of-the-process notes. The students used knowledge building especially to ask content-related questions and to give their own opinion about the question. They used knowledge-building spaces especially for questions and answers about facts.

It should be taken into account that the individual students did not often have the opportunity to use Synergeia2. Much discussion between the groups of students took place in the classroom. The results of the discussions were reported in chapters of the final brochure (as set in the assignment).

Table 5
Content of the notes based on the categorization of each note: The Netherlands

Knowledge category	Students ($N = 41$)		Teachers ($N = 2$)	
	f	%	*f*	%
Social	*0*	*0*	*0*	*0*
Progress of the process	*7*	*22*	*3*	*75*
Content of inquiry	*19*	*59*	*1*	*25*
Wonderment, problems	8		1	
Low-level explanation	11		0	
High-level explanation	0		0	
Scientific information	3		0	
Other	*6*	*19*	*0*	*0*
Total	32	100	4	100

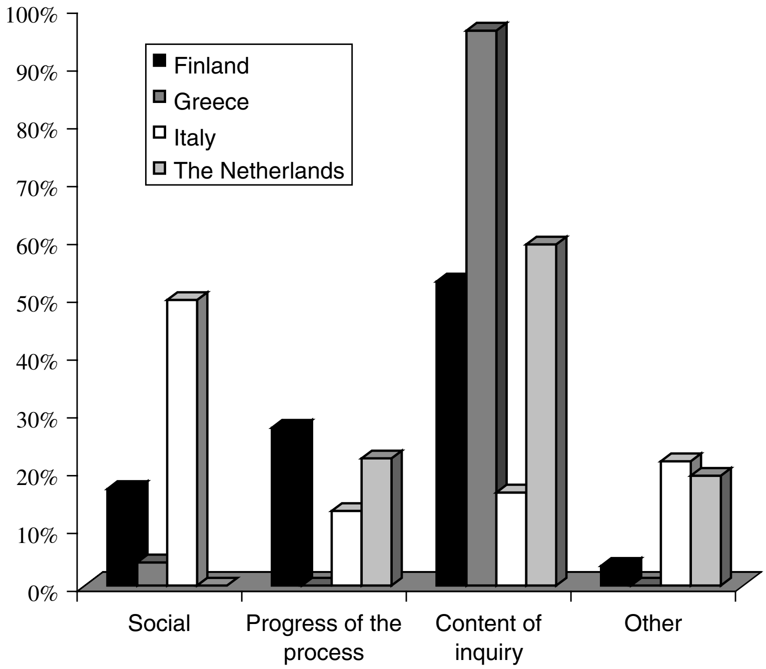

Fig. 1. Categorization of the students' notes in the four different databases.

5.1.5. Comparing the content of the discourse

In Fig. 1, the percentages of the three knowledge types (social, progress of the process, content of inquiry) in the four case studies in the different countries are compared. It is evident that the notes of the Greek students were mostly focused on the *Content of the inquiry*, mainly due to the particular task proposed: to solve a problem in the physics domain. The Italian students posted a relevant number of notes categorized as *Social*, quite plausibly, due to the necessity to collaborate at a distance, and at the beginning to know one another. Moreover, the main collaboration between the students was in exchanging files with information on myths, and notes were used mainly to monitor and organize the common work. Almost all the total notes categorized as *Progress on the process* were about organizational issues; 25% of notes *Other* were questions or suggestions on how to solve technical problems.

The Finnish and Dutch students' postings were concentrated in the two categories *Content of inquiry* and *Progress on the process*; with a reasonable percentage of *Social* notes in Finland and notes *Other* in The Netherlands.

We may hypothesize that the differences in the content of the databases in the four case studies were caused by many factors: class level, topic, hardware equipment, and time per project available, but also pedagogical principles held by the teachers of collaborative learning.

We examined the teachers' notes in the four databases (see Fig. 2). There is a difference in teacher participation in the four case studies; the reason for this may be both differences in the duration of the projects (in Italy and Finland the projects were longer), in ages of participants students (elder students requires less guidance), and in pedagogical choices made by the teachers themselves.

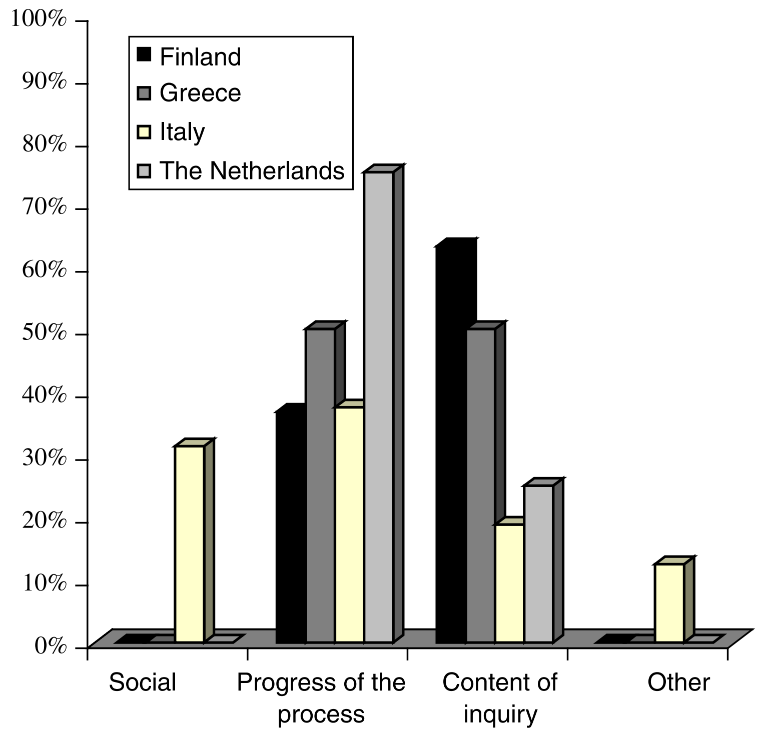

Fig. 2. Categorization of the teachers' notes in the four different databases.

In examining the percentage of teachers' notes in the total of posted notes, it can be seen that the Greek teachers posted the fewest notes. They choose to let students discuss and try to solve the problem proposed, giving their own solutions only at the end. The Italian teachers had the highest percentage of the posted notes. Most likely, this is due to the necessity to collaborate also with teachers at a distance and to virtually organize students' work, which in non-distance settings can be done face-to-face, as happened in Finland and in the Netherlands.

In fact, looking in Fig. 2, one can see that the Italian teachers' notes are mainly categorized into *Social* and *Progress of the process* categories, having to collaborate with distance colleagues and students. The two notes *Other* are focused on technical problems. The notes of the Finnish, Greek and Dutch teachers split only in the two categories *Progress of the process* and *Content of inquiry.* It means that their notes were both dedicated in supporting students' work and giving them comments, social support and feedback on their progresses in the inquiry. In the Dutch case study, most of the files posted by the teachers were about the organization of the project (e.g., description of the aim of the project and the procedures).

5.2. Use of knowledge types

In Finland, Greece, and The Netherlands, only the Progressive Inquiry knowledge types – set were used; the students had to label their notes by choosing among the following categories: *Problem*, *My own explanation*, *Progress of the process*, *Scientific information*, *and Summary.* In Finland

Table 6
Frequencies of the knowledge types used in the Italian database

Knowledge types'	Students	Teachers
Progressive inquiry		
Process organization	0	1
Problem	7	2
My explanation	2	0
Summary	0	0
Scientific explanation	3	0
Informal discussion		
Starting	3	0
Greetings	49	4
Comment	14	3
Idea	3	2
Agree	5	1
Disagree	0	0
Clarify	3	2
Story	4	1

and Greece, students used only *Problem* and *My own explanation* knowledge types. In Finland, 57 notes were categorized as *Problem* and 236 as *My explanation*. In Greece 2 notes were categorized as *Problem* and 52 as *My own explanation.* The use of knowledge types by students in The Netherlands was as follows: *Problem* 9, *My Explanation* 12, *Scientific Information* 10, *Progress of the Process* 1, *Summary* 0. In Italy, both Progressive Inquiry and Informal discussion sets were used. The frequencies of knowledge types used are reported in Table 6. The Progressive Inquiry set was used for two Knowledge Building Areas, with a total of only 15 notes, 12 of which were written by students. Students labelled their notes with these frequencies: *Problem* 7, *My explanation* 2, *Scientific explanation* 3. The Informal discussion set was used for a big Knowledge Building Area, with a total of 94 notes, 81 written by students, 13 by teachers. The label most used by students was *Greetings* (49 notes) and *Comment* (14 notes).

5.3. The use of knowledge types compared to the content of knowledge produced

We compared the knowledge types chosen by the students with the categorizations described in Section 5.1. Two cases out of four were used: Finland and Italy.

In order to assess the appropriate use of labeling of the Finnish students and teachers, a combined table was constructed, to compare the label and the content of the notes (Table 7). In this table the same note is counted more than once if it included many knowledge types.

As mentioned earlier, the Finnish students used only the knowledge types *Problem* and *Own explanation*, based on the teacher's advice, whereas their notes included also other kinds of knowledge as seen in Table 7. For example, 77 notes categorized by students as *Own explanation* were categorized as progress of the process, indicating that students were engaged in metalevel process also, though they did not label the metalevel notes as such. In addition, notes labeled by students as *Problem* were in six cases *Scientific information*, in 34 *Own explanation* and in three cases *Process on the progress.* At the end of the project, the teacher could probably have guided the students

Table 7
Comparison of knowledge types and the content of the notes in the Finnish database

Knowledge type	# Notes	Content of the notes							Total
		Social	Process	Problems	Own explanation		Scientific	Other	
					Low	High			
Problem									
Teachers	*9*	0	9	0	0	0	0	0	*9*
Students	*57*	6	3	29	11	23	6	2	*80*
Own explanation									
Teachers	*19*	4	6	9	0	5	0	0	*24*
Students	*236*	44	77	34	48	31	2	8	*244*
Progress of the process									
Teachers	*0*	0	0	0	0	0	0	0	*0*
Students	*0*	0	0	0	0	0	0	0	*0*
Scientific information									
Teachers	*10*	3	2	1	0	6	3	0	*15*
Students	*0*	0	0	0	0	0	0	0	*0*
Summary									
Teachers	*0*	0	0	0	0	0	0	0	*0*
Students	*0*	0	0	0	0	0	0	0	*0*
Total	331	57	97	73	59	65	11	10	372

to use the *Process organization* label in their evaluation notes, to teach them gradually to learn to structure their work in more advanced way. Also, the knowledge type *Summary* was not used. Students may have had difficulties with the idea of summarizing KB discourse. On the other hand, students did summarize their findings and knowledge when writing their final papers about their topics. Thus, perhaps writing a more traditional paper was a more convenient way of putting things together in this case.

In the Italian database, the set of Progressive Inquiry knowledge types was also not used in a very appropriate way. The students used this set in two Knowledge Building Areas that were used only to introduce themselves, and to begin a first discussion about the myth of Atlantis; therefore, there were only two notes that were really *Problem*, only one *Scientific explanation* and only one *Own explanation* (instead of 8 *Problems*, 3 *Scientific explanations* and 2 *Own explanation* used by students). The other notes were all classified by the researchers as *Social* (10 notes) and *My own explanation* (1 note).

It may be explained that it was a teacher's misunderstanding of not choosing the most appropriate set of knowledge types; instead of choosing the Progressive Inquiry they should have chosen the Informal discussion set for the Knowledge Building Area aimed to introduce themselves.

Indeed, in the third Knowledge Building Area (94 notes), the students used the Informal discussion set in a quite appropriate way. According to a similar categorization done by the researchers, in 51% of the notes, the students and the teachers used the appropriate knowledge type, compared to the content of the note. Nevertheless, it is concluded that *Greetings* is the knowledge type most used, and used most correctly in the Italian database. As seen in Table 8, 29 notes labelled as *Greeting* were assigned by the researchers to the *Social* content, 17 to *Other*.

The Informal discussion set do not contain knowledge types aimed to label the knowledge building process, but only knowledge types created to let students know each other and begin to discuss the topic through an initial brainstorming. There are a relevant percentage of notes classified by the researchers as *Progress of the process* (19%, 18 notes) that could not be so labelled by students and teachers, because there was not an appropriate knowledge type. These notes were mostly aimed to organize the knowledge exchange at a distance, and students and teachers looked for a correct labelling, choosing the *Comment* knowledge type (7 notes), or the *Agree* (2) or *Clarify* (2) when they agreed with others' proposals on how to organize the work or gave clarification to others about how to proceed. There were few *Own explanation* (7 in all), labelled by students as *Idea* in 3 cases, *Comment* in 1, *Agree* in 2, and *Greetings* in 1. Also in this case, students' searched for a knowledge type

Table 8
Comparison of knowledge types and the content of the notes in the Italian database: Informal discussion set

Knowledge type	# Notes	Social	Process	Problems	Own explanation		Scientific	Other	Total
					Low	high			
Starting									
Teachers	0	0	0	0	0	0	0	0	0
Students	3	2	1	0	0	0	0	0	3
Greetings									
Teachers	4	0	2	1	0	0	0	1	4
Students	49	29	2	0	1	0	0	17	49
Comment									
Teachers	3	0	2	0	0	0	0	1	3
Students	14	4	5	1	1	0	0	3	14
Idea									
Teachers	2	1	0	0	0	0	0	1	2
Students	3	0	0	0	2	1	0	0	3
Agree									
Teachers	1	0	1	0	0	0	0	0	1
Students	5	2	1	0	1	1	0	0	5
Disagree									
Teachers	0	0	0	0	0	0	0	0	0
Students	0	0	0	0	0	0	0	0	0
Clarify									
Teachers	2	1	1	0	0	0	0	0	2
Students	3	1	1	0	0	0	0	1	3
Story									
Teachers	1	1	0	0	0	0	0	0	1
Students	4	0	2	0	0	0	0	2	4
Total	94	41	18	2	5	2	0	26	94

that could better explain the content of their notes. *Idea* and *Comment* in this set are the knowledge types that can better define a note trying to explain the participant's point of view (*Own explanation*).

6. Discussion

In this investigation, the nature of students' and teachers' discourse in CLEs was analyzed in case studies representing four European countries. The results showed that the cases differed a great deal. The durations of the collaborative projects varied from a couple of hours to months; the number of notes posted in databases varied as well. Based on the descriptions of the cases, some reasons for the differences can be traced, such as technical and organizational constraints that the teachers faced, and differences in the pedagogical designs (e.g., possibilities for open design vs. curricular demands; teachers' personal choices). The prevailing school culture as a background factor may also explain these differences.

The teacher in the Finnish case could use weeks for his project, and plan the activities freely. He also had sufficient technical infrastructure to work with. In this project, the visit to the seacoast, face-to-face activity in the classroom, and the use of FLE3 were connected together in a sensible way. The students used the collaborative tool to list their observations and own explanations. In addition, face-to-face activity served well in situations where students needed instant feedback and interaction with the teacher and peers. In Finland, elementary schools and teachers are very autonomous even at the level of developing school curriculum and in implementing new learning methods. ICT in education is promoted and supported strongly. The teacher could link the purpose of his project to that of the school curriculum to create ongoing practices and enhance cultural change in his school.

In the Greek case study, the Greek researchers were responsible for the project. They were allocated only a certain number of lessons for this purpose. Rather tight curricular constraints did not allow a holistic approach but a more focused project on a specific topic (as Physics law). The Greek educational system is very competitive, and the teachers were very pleased with the opportunity to support collaboration. They also saw a great deal of student interest in collaboration. However, the Greek teachers were still greatly concerned about their duties to provide technical assistance to their students, and they did not give special attention to their social role.

A special characteristic of the Italian case and the Italian school context in general is a scarcity of available Internet connections. Often, in the computer lab, there was just one computer connected with the Internet for a whole classroom. Therefore, the students usually worked in dyads at the other computers preparing materials, and afterwards uploaded them to Synergeia2 at their turn. A second special characteristic was the extensive collaboration among distant schools. This collaboration of distant classes can be very motivating, but it also creates logistic problems that can be disheartening if communication does not work smoothly. The Italians also experimented with combining classes of different grades in the same space of collaboration. It seems that, in their opinion, distant collaboration makes such interactions easier to realize.

The students and the teachers who participated in the Dutch case study, were enthusiastic about collaborative learning using Synergeia2, even though their contributions to the database remained few. It seemed to be hard for the students and the teachers to communicate with each other virtually when they were able to meet each other in real life. It should be also taken into account that this was the first time that the teachers and the students worked collaboratively, in a virtual learning environment, and that 41 students could only access four computers. It was also difficult to convince the teachers and the students of the pedagogical added value of writing notes. The curriculum of historical education in primary schools is, particularly, related to facts and deeper understanding of these facts.

The use of knowledge types was also examined in the present investigation. In most of the cases, only a few knowledge types were used; this was seen in various types of pedagogical settings, as a more holistic and long-term in Finland, and more focused and short-term in Greece. In Finland, the teacher advised the students not use other knowledge types than the two agreed; this was based on teacher's pedagogical idea to start with fewer and move, later on, to use the whole set. One may say that the use of knowledge types might have been more varied, and the content of the messages might have reached a deeper level of explaining and summarizing. However, this needs further research. One crucial issue is the students' and teachers' experience of using CLEs with embedded knowledge types; all of the students who participated were using knowledge types for the first time; it takes time to learn appropriate ways to support discussion with knowledge types. Another point concerning the use of knowledge types is that in most of the projects, scaffolds were provided by the teachers during the face-to-face activities.

Based on the experiences gained, especially from the Italian case, it becomes clear that knowledge types play an important role. It seems that the students do not use the knowledge type set in a random way, but in many cases try to give the right label to their note if the knowledge types set allows them to do so. Therefore, the selection of good sets of knowledge types is important; teachers should be able to choose a correct set of knowledge types, and the software should also allow teachers to construct a new and appropriate set of knowledge types for the various learning projects they are planning. At the moment, various sets are already available in both FLE3 and Synergeia2. FLE3 also provides the possibility of easily implementing one's own set of knowledge types.

One of the objectives of using scaffolding tools is to advance metalevel processing of inquiry, and learning in general. The results of the comparison of knowledge types and content of the notes indicate that students appear to have been engaged in metalevel processing of their inquiry, but the students did not label the metalevel notes as such. Instead, metalevel activity was entered under the knowledge type *own explanation*. This raises a question whether students were aware of their metalevel activity, or whether they simply chose to ignore the use of the explicit scaffolding-tool *Progress of process*, in favor of the more "all-round" scaffold *Own explanation*. Another question raised is whether the quality of the inquiry would have been higher if the students had been able to label their metalevel activity correctly. The both questions are difficult to answer, but it is worth bearing in mind that there is evidence that scaffolding tools, such as knowledge types tools, have a positive effect on the learning activity; possibly because students might be reminded of different aspects of the inquiry process simply through their presence in the knowledge type set.

Nevertheless, it appears that just providing scaffolds is not enough to advance CLEs; it is just as important to teach the proper use of the scaffolds as well as proper pedagogical use of the learning environment itself. Appropriate guidance and support for learners in using the scaffolds is one way to try to increase their metacognitive awareness of the inquiry process.

It is concluded that the adoption and development of virtual collaboration practices faces serious challenges, which will take time to meet; making the practice a part of normal school routines would make implementation a natural – but not problem-free process. It is suggested that CLE is best organized around long-lasting learning activities; unit durations, instead of weeks, should be whole academic terms. Furthermore, the learning environment and associated activities should be well structured, and both students and teachers need to obtain intensive and pedagogically meaningful training. Such activities have the potential to increase students' and teachers' awareness of the principles of collaborative learning, which would facilitate the adoption of the working procedures characteristic of web-based CLE. As students and teachers become familiar with these principles and the working procedures, the learning itself may become more meaningful.

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References

Ainsworth, S., Wood, D., & O'Malley, C. (1998). There is more than one way to solve a problem: evaluating a learning environment that supports the development of children's multiplication skills. *Learning and Instruction, 8*, 141–157.

Bereiter, C., & Scardamalia, M. (1987). An attainable version of high literacy: approaches to teaching higher-order skills in reading and writing. *Curriculum Inquiry, 17*, 9–30.

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

Davis, E. A., & Linn, M. C. (2000). Scaffolding students' knowledge integration: prompts for reflection in KIE. *International Journal of Science Education, 22*, 819–837.

De Jong, T., & Van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68*, 179–201.

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences, 8*, 391–450.

Fretz, E. B., Wu, H.-K., Zhang, B. H., Davis, E. A., Krajcik, J. S., & Soloway, E. (2002). An investigation of software scaffolds supporting modelling practices. *Research in Science Education, 32*, 567–589.

Goldman, S. R., Mayfield-Stewart, C., Bateman, H. V., & Pellegrino, J. W., The Cognition and Technology Group at Vanderbilt. (1998). Environments that support meaningful learning. In L. Hoffman, A. Krapp, & K. A. Renniger (Eds.), *Interest and learning: proceedings of the Seeon conference on interest and gender* (pp. 181–196). Kiel, Germany: IPN.

Goldman, S. R., Zech, L. K., Biswas, G., & Noser, T., The Cognition and Technology Group at Vanderbilt. (1999). Computer technology and complex problem solving: issues in the study of complex cognitive activity. *Instructional Science, 27*, 235–268.

Hakkarainen, K. (2003). Emergence of progressive inquiry culture in computer-supported collaborative learning. *Learning Environments Research, 6*, 199–220.

Hakkarainen, K., & Sintonen, M. (2002). Interrogative model of inquiry and computer-supported collaborative learning. *Science and Education, 11*, 24–43.

Järvelä, S., Hakkarainen, K., Lehtinen, E., & Lipponen, L. (2001). Creating computer-supported collaborative learning (CSCL) culture in Finnish schools: research perspectives on sociocognitive effects. *International Journal of Continuing Engineering Education and Life-Long Learning, 11*, 365–374.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., & Fredricks, J. (1998). Inquiry in project-based science classrooms: initial attempts by middle school students. *Journal of the Learning Sciences, 7*, 313–350.

Krajcik, J., Blumenfeld, P., Marx, R., & Soloway, E. (2000). Instructional, curricular, and technological supports for inquiry in science classrooms. In J. Minstrell & E. H. van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 283–315). Washington, DC: AAAS.

Lakkala, M., Ilomäki, L., Lallimo, J., & Hakkarainen, K. (2002). Virtual communication in middle school students' and teachers' inquiry. In G. Stahl (Ed.), *Computer support for collaborative learning: foundations for a CSCL community* (pp. 443–452). Hillsdale, NJ: Erlbaum.

Lakkala, M., Muukkonen, H., & Hakkarainen, K. (2003). *Patterns of scaffolding in computer-mediated collaborative inquiry* (submitted).

Lakkala, M., Muukkonen, H., Ilomäki, L., Lallimo, J., Niemivirta, M., & Hakkarainen, K. (2001). Approaches for analyzing tutor's role in a networked inquiry discourse. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *European perspectives on computer-supported collaborative learning. The proceedings of the first European conference on computer-supported collaborative learning* (pp. 389–396). Maastricht, The Netherlands: University of Maastricht.

Lakkala, M., Rahikainen, M., & Hakkarainen, K. (Eds.) (2001). *Perspectives of CSCL in Europe: A review*. A report for the European Commission, ITCOLE Project, IST-2000-26249.

Land, S. M. (2000). Cognitive requirements for ilearning with open-ended learning environments. *Educational Technology Research and Development, 48*, 61–78.

Lehtinen, E. (2003). Computer supported collaborative learning: an approach to powerful learning environments. In E. De Corte, L. Verschaffel, N. Entwistle, & J. v. Merriënboer (Eds.), *Unraveling basic components and dimensions of powerful learning environments* (pp. 35–53). New York: Pergamon.

Lehrer, R., Carpenter, S., Schauble, L., & Putz, A. (2000). Designing classrooms that support inquiry. In R. Minstrell & E. Van Zee (Eds.), *Inquiring into the inquiry learning and teaching in science* (pp. 80–99). Washington, DC: AAAS.

Ligorio, M. B., Talamo, A., & Simons, R.-J. (2002). Synchronic tutoring of a virtual community. *Mentoring and Tutoring, 10*, 137–152.

Lipponen, L. (1999). Challenges for computer supported collaborative learning in elementary and secondary level: Finnish perspective. In C. Hoadley & J. Roschelle (Eds.), *Proceedings of the CSCL'99: the third international conference on computer support for collaborative learning* (pp. 368–375). Mahwah, NJ: Erlbaum.

Minstrell, J. (2000). Implications for teaching and learning inquiry: a summary. In J. Minstrell & E. H. van Zee (Eds.), *Inquiring into inquiry learning and teaching in science* (pp. 471–496). Washington, DC: AAAS.

Muukkonen, H., Lakkala, M., & Hakkarainen, K. (2001). Characteristics of university students' inquiry in individual and computer-supported collaborative study process. In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *European perspectives on computer-supported collaborative learning. The proceedings of the first European conference on computer-supported collaborative learning* (pp. 462–469). Maastricht, The Netherlands: University of Maastricht.

Salomon, G. (Ed.). (1993). *Distributed cognitions: Psychological and educational considerations*. New York: Cambridge University Press.

Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: a challenge for the design of new knowledge media. *Journal of The Learning Sciences, 1*, 37–68.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *Journal of the Learning Sciences, 3*, 265–283.

Veermans, K. (2002). *Intelligent support for discovery learning*. Doctoral dissertation, University of Twente. Enschede, The Netherlands: Twente University Press.

Vosniadou, S., Ioannides, C., Dimitrakopoulou, A., & Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science. *Learning and Instruction, 11*, 421–429.

Vosniadou, S., & Kollias, V. (2003). Using collaborative, computer-supported, model building to promote conceptual change in science. In E. De Corte, L. Verschaffel, N. Entwistle, & J. v. Merriënboer (Eds.), *Unraveling basic components and dimensions of powerful learning environments* (pp. xx–xx). New York: Pergamon.

White, B. (1993). ThinkerTools: causal models, conceptual change, and science education. *Cognition and Instruction, 10*, 1–100.

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