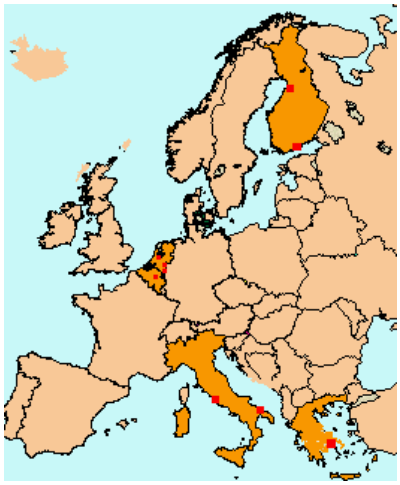
Computer Supported Collaborative Learning

Metacognition and Motivation



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Paper presented in a structured poster session entitled

'Toward practices of knowledge building in education'

8th European Conference for Research on Learning and Instruction

August24-28 ,1999, Goteborg, Sweden.

Introduction

New developments in information and communication technology (ICT) make it possible to support new ways of teaching. One of these new developments in education is Computer Supported Collaborative Learning (CSCL), a powerful learning environment where students collaborate, supported by computers. Learning can be more effective and more productive if students work together to exchange ideas, compare, solve problems, and debate with each other (De Corte, et al. (1996). These kinds of interactions stimulate reflections on the process of learning. The learning process is an active process; knowledge building implies activities such as searching, elaborating and transferring information in interaction with others. Both teachers and students serve as information sources and frames of reference (Erkens, 1997). Students are encouraged to take responsibility for their own learning. Boekaerts and Simons (1993) point out that students develop metacognitive knowledge and metacognitive skills by reflecting their own learning process and the learning process of others. De Jong (1992) defines metacognition as the "concrete, observable cognitive activities in which students explore their learning tasks and monitor and regulate their learning process during task construction". The construction of knowledge is emphasised in the latest psychological and educational theories. Constructionist theories suggest that learning occur through dialogue with others rather than primarily through individual learning. Students become active learners, engaging in a knowledge building process both inside and outside the classroom. All Daily life experiences are considered elements of the knowledge building process, not only direct teacher instruction and reading. By making knowledge construction a goal in itself, students may learn to identify their personal knowledge deficits, and take a more active role in their own education (Bereiter and Scardamalia, 1989). The way in which Computer Supported Collaborative Learning enhances knowledge acquisition and especially collaborative knowledge building is the major aim of the European project called CL-NET: "Computer Supported Collaborative Learning Networks in Primary and Secondary Education". Within this project, the research is characterised as action research. Action research is an approach to research in which teachers and students, in their everyday context, play an important role. Researchers act as participants in the schools while collecting data. Thus, while introducing collaborative networks in the schools and developing learning materials, manuals, guidelines and support-structures, they collect data at the same time. This approach guarantees professionalism of teachers concerning the implementation and use of CSCL (Verschaffel, L. et al., 1998).

The key objectives of the project are:

- to develop didactic models and design principles and learning scenarios for the use of Collaborative Learning Networks in primary and secondary education
- to experiment with different kinds of CLN-tools which support the learning process and the acquisition of knowledge building skills
- to evaluate the (meta)cognitive, motivational and social effects of collaborative learning, supported by computer networks

The Department of Educatinal Sciences of the University of Nijmegen is partner in this project, in the field of metacognition and motivation. This paper describes the present results of introducing Computer Supported Collaborative Learning in a Dutch secondary school. The inquiry focuses on three main questions:

1. Does CSCL effect student's metacognition and motivation?
2. Does the role of the teacher effect number and/or quality of the contributions in the database?
3. What opinions do both students and teachers have on CSCL?

Method

The study is carried out in a secondary school in the Netherlands, The Raayland College in Venray. The Raayland is a school that includes all types of secondary education: Gymnasium, pre-university education (VWO), senior secondary education (HAVO), junior secondary education (MAVO) and preparatory vocational education (VBO). It is a school with 2.300 students and 158 teachers. The Raayland College is a so-called pioneering school. About 120 of 700 high schools in the Netherlands receive extra money from the Department of Education of the government to introduce computers in their curriculum. The aim of this initiative is that partner schools share their experiences with other schools, which do not receive extra funding. The Raayland College is present on the World Wide Web. Participating in this project fits well in this context of a computer supported collaborative learning environment. Collaborative Learning, with or without computers, is not a common experience of students at Raayland College. Six classes of the Raayland College have applied collaborative learning, supported by WebKnowledge Forum, in one or two courses. Each

course comprises of six lessons. WebKnowledge Forum is a software program that has been developed by Dr. Marlene Scardamalia and Dr. Carl Bereiter of the Ontario Institute for Studies in Education at the University of Toronto, in succession to the Computer Supported Intentional Learning Environments (CSILE) (Scardamalia and Bereiter, 1992). It is a network system that provides support for collaborative learning and inquiry. At the centre of the software is a communal database, which can be filled with contributions, or "notes", by students and their teachers. The database is only accessible to students and teachers by authorisation. Students enter their own notes, and/or build on and react to each other's notes in order to find the answer to a question or to solve a problem. All notes are saved in the database and are available for all students who have access to it, within the class, in different classes, or in different schools. Because the software's architecture is open and content free, it can be used in all areas of the curriculum. Moreover, it can be used outside the school because students and teachers can log in from other computers connected to the Internet. The aims and the philosophy behind WebKnowledge Forum correspond with the new views on learning and instruction described above.

The six classes were taken from different types of the Dutch school system. Teachers were recruited based on their willingness to participate in this study and the type of courses they were teaching. A total of five teachers were involved in this project. The courses content areas were biology (2 teachers), history (2 teachers) and physics (1 teacher). The class levels included: 1 Gymnasium, 3 pre-university education (VWO) and 2 senior secondary education (HAVO), third and fourth grade. Figure 1 illustrates which classes were involved and what activities took place during this study.

Activities	**Biology HAVO 42**	**Biology HAVO 43**	**History GYM 3**	**History AT 3**	**Physics VWO 41**	**Physics VWO 43**
Pre-test 1	X		X	X	X	X
Course 1	healthcare	healthcare	discrimination	Discrimination	planets	planets
Cognitive test	X	X	X	X	X	X
Course 2	ecology	ecology	civics	Civics		
Cognitive test	X	X	X	X		
Evaluation	X	X	X	X	X (written)	X (written)
Post-test	X	X	X	X		

Figure 1. Classes and Activities

The researchers were present during class activities for technical support. Before starting the first course and after finishing the second course, two questionnaires, both developed by other European partners in the project, were administered. In the first course the teachers kept a journal of their class activities. In the second course, class activities were audiotaped. The study projects were chosen from the normal content of the curriculum. The outlines of the different study projects were developed by the teachers in co-operation with the researchers. All courses had more or less the same structure:
The students were randomly divided into pairs and several pairs worked on the same subject matter. As preparation, traditional learning materials, such as book chapters, were used

Lesson 1: Instruction in WebKnowledge Forum (except the biology classes).
Lesson 2: Activating advanced knowledge in a so-called brainstorm session in groups working on the same subject matter. Students create their own research questions and enter them into the database.
Lesson 3-5: Student Pairs try to find the answers to their research questions, gather information about their questions in the library or from the Internet, and put their knowledge into the database. They comment on information of others in the database and ask questions if they want to have something clarified.
Lesson 6: All student pairs make a resume of the knowledge they have acquired and make comments on the resumes of other student pairs.

After these six lessons, the researchers made a resume of all information gathered in the database, which served as material for a cognitive test. During the first course, teachers had no specific task beyond teaching their lessons. During the second course, the researchers asked the teachers to make more comments in the database, trying to lead the students to better and deeper understanding by asking conceptually deep questions. The teachers were instructed not to give direct information, as perhaps he did the first course, but should help students to find it by themselves.

Instruments

In this study two different questionnaires were administered: 1) The “goal orientations and motivational beliefs questionnaire” (Niemivrita, 1998); and 2) the “metacognitive questionnaire” (Ligorio, 1998). Both questionnaires are administered in all European countries.
The goal orientations questionnaire consists of sixty-seven questions rated on a five-point scale. It is comprised of fourteen sub-scales, including: action orientation, need for cognition,

learning orientation, performance orientation, avoidance orientation, means-ends beliefs of effort, means-ends beliefs of ability, means-ends beliefs of luck and chance, agency of ability, self assessment motive, self esteem, fear of failure, meaningful engagement and superficial engagement.

The metacognitive questionnaire (Ligorio, 1998) consists of 3 open-answer questions. The first question inquires about external knowledge sources, as well as where students get their information. The second question asks about knowledge monitoring and what criteria are used by students to regulate their knowledge acquisition process. The third question inquires about the communication process and students' perception of the usefulness of communication.

In addition to these three questions, there were administered three questions about the type of communication, when, where, en with whom the students communicate.

The contributions in the databases and the audiotaped lessons provide data concerning student-student communication, as well as teacher-student communication. Data concerning evaluation are collected by means of interviews (teachers) and electronic questionnaires in the database (students).

Results

Looking closely at figure 1, only two classes were involved in all activities, history AT3 (n=29) and history GYM3 (n=21). Students who did not fill in both questionnaires (pre- and post-test) were deleted. After this first selection the questionnaire was screened for validly of the respondents. Because of the reliability, the persons who always filled in the same value of all the questions in the motivational questionnaire were deleted too.

The motivational test.

The questionnaire was tested on reliability of the fourteen dimensions, which were described above. Nearly all the dimensions received a low value of reliability, ranging between alpha value of 0.3 and 0.5. For that reason, the fourteen dimensions were rearranged into four new dimensions, namely:

a) Cognition, containing the dimensions *need for cognition* and *learning orientation.* In total 11 questions (α 0.8253).
b) Motivation, containing the dimensions *means-ends beliefs of ability*, *means-ends beliefs of effort*, *means-ends beliefs of luck and chance* and *agency of ability.* In total 13 questions (α 0.7217).

c) Metacognition, containing the dimensions *meaningful engagement* and *superficial engagement.* In total 6 questions (α 0.7481).
d) Self-confidence, containing the dimensions *self-assessment motive*, *self-esteem*, *fear of failure* and *avoidance of orientation*. In total 15 questions (α 0.8111). None of these four dimensions showed significant differences between the pre-test and the post-test.

The metacognitive test.
As described above, the metacognitive questionnaire consists of three main questions concerning the external knowledge source, knowledge monitoring, and the communication process. The reliability was assessed by using two independent raters.
Without having analysed this questionnaire completely, it is almost certain that there are no significant differences between the pre- and post-test. Nevertheless, some results will be presented, for the responses to the questionnaires provide some interesting insights.

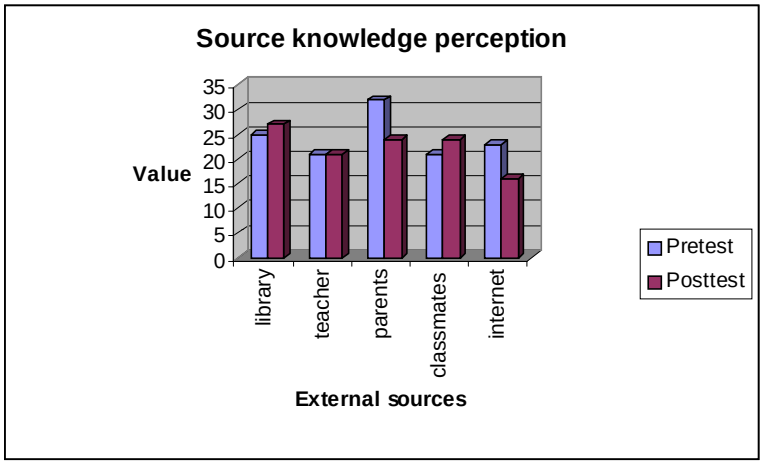

Figure 2 External Knowledge Sources

Figure 2 shows the various external knowledge sources of the students and the differences between pre- and post-test. Eye-catching, is the decrease of the Internet as resource. A reasonable explanation could be the fact that in the evaluation, students point out that it takes a lot of time to find information on the Internet. For the knowledge monitoring question, few differences between the pre-test and the post-test were observed. Most of the students score high values on internal style both in the pre- and the post-test.

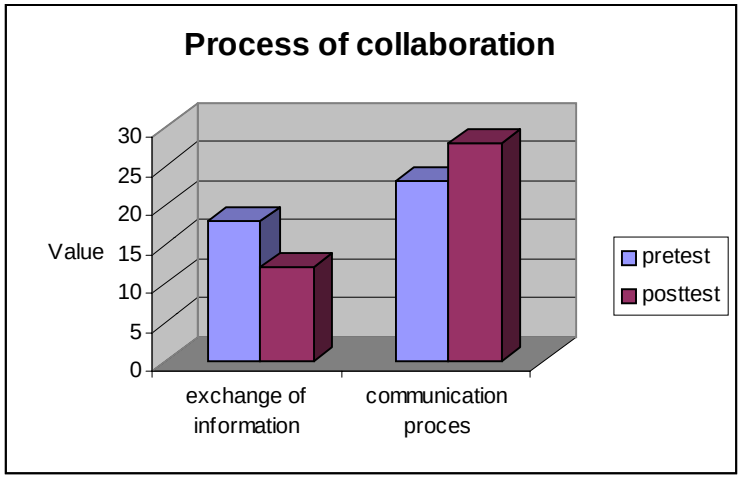

Figure 3 Process of Collaboration.

The third question of the metacognitive questionnaire, concerning the communication process, reveals a striking difference between the pre-test and the post-test. As is shown in figure 3, students change their perception of communication as useful for an exchange of information, to communication as useful as part of the overall metacognitive process. None of the students mention that communication is not useful.

The most important part of the communication process takes place during the lessons, sometimes after school, but seldom at home. Figure 4 illustrates the collaboration network. The student finds his partner in the person next to him, or in another classmate. It is surprising that the students never mention the teacher in the collaboration network.

As pointed out before, these are preliminary results; further analyses of this questionnaire have to be accomplished.

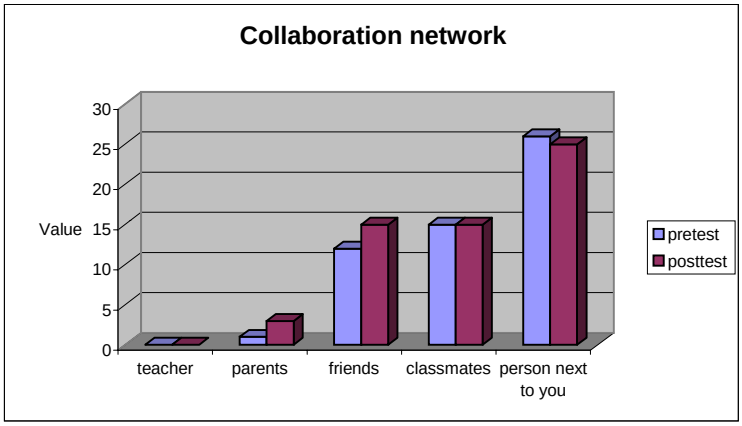

Figure 4 Collaboration Network

Databases

For the quantitative analyses of the database a computer-program was used, called The Analytic Toolkit for WebKnowledge Forum, also developed by the OISE/UT research team. With this program, all kinds of quantitative analyses are possible: number of notes, build on notes, read notes and a survey of all activities of one class or a single student. Figure 5 gives some general information about activity in the database.

	Course 1		**Course 2**	
	GY3A	**AT3A**	**GY3A**	**AT3A**
Number of views	6	6	8	8
Number of students in the class	21	29	21	29
Total number of notes in the database	215	213	172	152
Number of notes contributes per student	11.16	8.18	5.32	4.02
Percentage of notes that have been read by the student	20	16	7	9
Percentage of notes that are linked	39	25	24	24

Figure 5 General Information on the 2 Classes (history)

The number of notes contributed per student decreased in the second course. The reason for this development was that the students in course 1 could give reactions to every other student in the database and in the second course they could only give reactions to students in their own view. This explains, also, that the percentage of notes that has been read by students decreased from the first course to the second course. Although the students had the possibility to look in the other views, they rarely did. The high percentage of notes that are linked in the first course in the GY-class is due to one student, who reacts on every note written by another student.

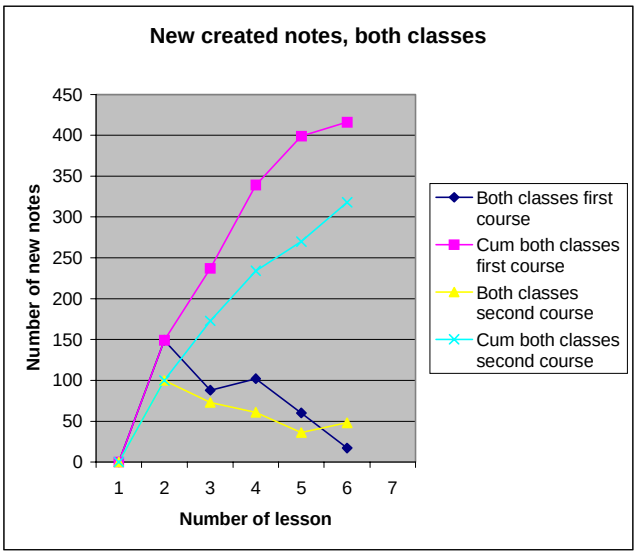

Figure 6 New created notes, both classes

Figure 6 reproduces the new created notes during both courses for both classes. In the first course there has been a great fluctuation in note creation, ending with a decrease in note creation. The second course was more structured by the teacher by making comments on notes and asking questions in the database. This resulted in a more gradual way of creating new notes per lesson during the course.

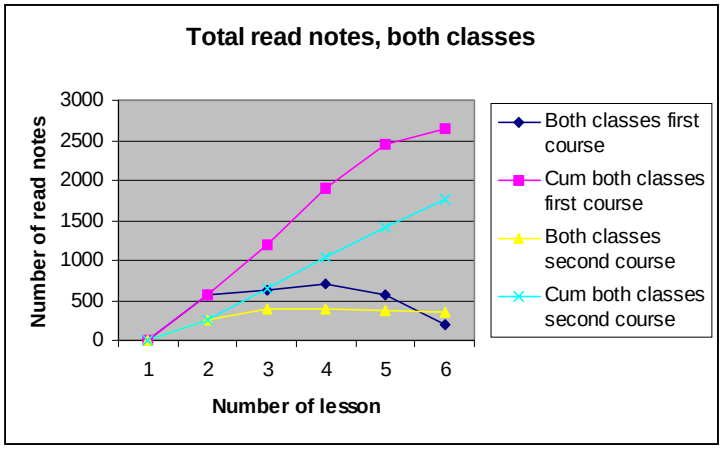

Figure 7 Total read notes, both classes

Figure 7 gives the overview of the read notes during the course. As previously mentioned, less notes were created at the end of the course than at the beginning. The total number of notes never changed much, especially in the second course. One of the goals of WebKnowledge Forum is that students can give reactions and comments to each other. The build-on notes form a thread, or a branch. Branching allows students to attach sub-discussions in a main discussion, facilitating deeper examination of a particular question without disrupting the

thrust of the higher level discussion (Hewitt, Webb, Rowley, 1999). We can conclude that during these two courses, the students used this option less than we expected in comparison with the expectations.) Of all the notes, approximately 25% has a branch of one or two notes. Again, a further analysis is necessary, especially on the content of the notes and the influence of teacher's activities.

The opinions of students and teachers

Students evaluated the first course and their first experience with Web Knowledge Forum (WKF) by answering 8 questions in a view of the database. Most of the students were positive about working with WKF. Figure 8 shows the opinion of the students. (n=35)

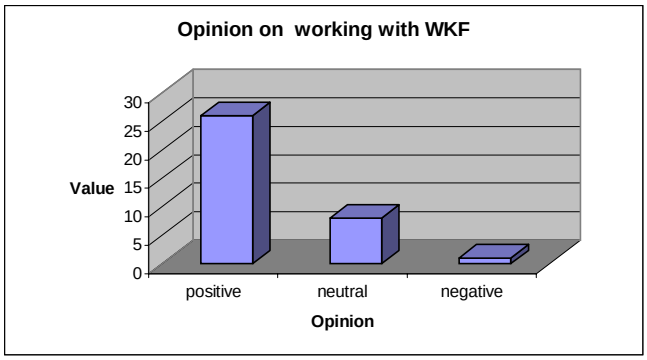

Figure 8 Students' opinions on working with WKF

The students provided various reasons for their positive opinion: variety, self-employment, surfing on the Internet, working with the computer and collaboration and communication with others. The negative aspects they mentioned were: subject of the first course (discrimination), difficulties with finding information (especially on the Internet) and the time-consuming way of working

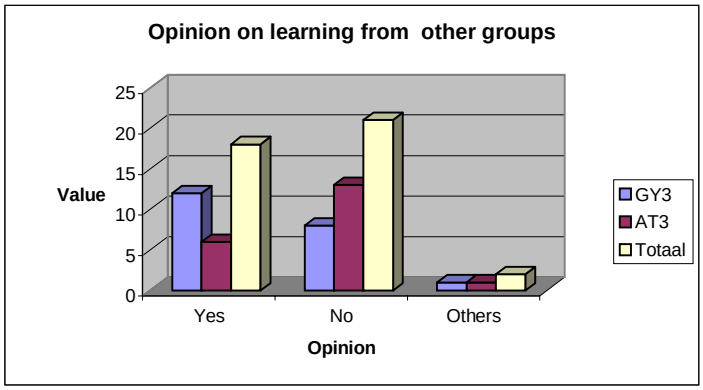

Figure 9 Student's opinion on learning from other groups

Most interesting was the question about collaboration. Nearly al the students mention that collaboration was a positive experience. In contrast, the reaction to the question “did you learn from other groups?” contradicted the previous finding.
Figure 9 describes the opinion of the students. After the first course, students preferred collaboration within dyads or triads, as opposed to group collaboration. After the second course, students often mentioned the collaboration with other groups in the database. Further analyses will investigate collaboration and the dyadic, triadic and group levels of collaboration. Of note, there was a significant difference in responses between classes. We suspect unique socio-cognitive variables extant in these two environments gave rise to this difference. Further research will elucidate this finding.

Five teachers were involved. Four teachers had fifteen years of experience or more, with the exception of one teacher, for whom this was his first year of teaching. One of the experienced teachers is an expert in educational technology and provided technical support to all the teachers in the school. Two teachers were female. The teachers taught: biology (2), history (2), and physics (1). All five were interviewed. Their opinions on working with WKF were as follows: it is a transparent program, not difficult to work with, neither for students nor for teachers, although students not always used it correctly. The English language is not a problem for the students. Problems at the start were quickly solved. Teachers are not aware of all the possibilities of the program. To read all notes and comment on them is very time-consuming.
By introducing this kind of new technology into school, the main problems are:
the availability of computers connected to the Internet, number of students in the class, insufficient time to participate in the database or develop a deep understanding of the functions of WebKnowledge Forum, fear of failure by teachers, no extra funding for introducing new technologies, and lack of structure in the tasks.
Although at the start some teachers were unfamiliar with collaboration in classroom teaching, by the end of the project, teachers were stimulated to use other forms of collaboration, with or without the computer, in their teaching. All teachers will continue to work with the program and do some projects on CSCL, even when the support by the researchers stops.

Discussion

The purpose of the study is to present the preliminary results of the research on implementing CSCL in Dutch Secondary Education. Although further analyses have to be accomplished, some observations can be mentioned.

First, the results concerning metacognition and motivation were not significant. These findings correspond to the expectation that a significant change in motivation and (meta)cognition only can be found in longitudinal experiments. A new culture of inquiry emerges only gradually through exploration and testing of new tools and practices (Hakkarainen & Lipponen, 1999).

In this education project we used the WebKnowledge Forum program as a tool for research on communication and collaboration. It gives the students the opportunity to be more active and constructive in their learning. Looking back, the students were very enthusiastic to work and learn at this way, especially the collaborative part and the independent way of building knowledge. A lot of students logged in to the database in the library, even after school, to complete their tasks. Also, the activity of the students as measured by contributing notes and reading notes, decreased over time. The passive participation of the teacher was in part, responsible for this outcome.

The first class contributed more notes than the second class. Although this difference is not significant, we are interested in exploring if this increase in notes contributed by the first class might also be influenced by the first class teacher's participation in the database.

We expect that further analysis may reveal an inverted relationship between number of notes created and quality of content. As mentioned, there was an observed decrease of notes created over time. We look forward to performing qualitative analyses on these notes to determine if indeed the content embedded with the note improved over time. In other words, does the quality of the students' notes improve over time?

Another important part of study was to look at the collaboration within groups, as well as the influence of the teacher in this process. One of the main goals of the WebKnowledge Forum is to share one's knowledge with other students, thereby increasing the collective knowledge of the group as well as one's own personal knowledge (Kleine-Staarman and Trimpe, 1999). As previously mentioned, nearly 25 % of the notes were build-on to one or more notes. We are not certain what percentage of the database should be linked at this early stage. Our expectation and hope was that at least 50% of the notes would be linked, reflecting a high degree of collaboration among participants. However, we are nonetheless pleased that 25% of

the notes were linked since the course was of such a short duration (4 weeks). Further research may investigate collaboration by measuring weekly collaborative activity. In this way, each class would provide its own baseline data and collaboration could be measured over time with an eye to understanding increases and decreases in collaborative activity.
In comparing to the regular way of teaching, we can say that this is a moderate value of collaboration during the learning process. This means also that the interaction between students can increase and has to be stimulated. A problem with implementing these kinds of new technologies at school is that teachers themselves have only limited experience and students require guidance in the knowledge building process. Support from researchers in the form of project designs, well-structured tasks, technical support and pedagogical expertise seems to be essential.

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