Computers in school's daily life

A final report of the Educational Technology Project of City of Helsinki
1996-2000

Liisa Ilomäki and Minna Lakkala (Eds.)
Abstract

The Department of Education of the City of Helsinki has funded longitudinal (1995-2000) project, the Educational Technology Project, which has been the largest regional technology project in Finland, and its effects have reflected in many ways the national projects. Even though the project plan also included pedagogical goals, its primary focus was on the development of the technical infrastructure. The purpose of the technical investments, i.e., providing computers and setting up network, was to arrive at a situation where the educational use of computers has increased and improved considerably. The implementation of the goals was on the responsibility of subteams responsible for equipment, support services, local network, network for Internet connections, support services for learning (mainly teacher training), and research. The goals of the project were reached rather well. The Educational Technology Project also included a large research program for investigating and evaluating the realization and results of the project, such an evaluation being atypical of municipal administrative projects. This research-based evaluation and feedback indicates the farsightedness of the politicians who established the project. The purpose of the report is to describe the main pedagogical results of the project. The main research topics have been concentrated in the following areas: teachers’ self-reported skills and usage of ICT, and their pedagogical thinking, especially in relation to ICT in education; teacher communities and their collaboration with ICT; students’ self-reported skills and usage of ICT, and their pedagogical thinking, especially in relation to ICT in education; the technical infrastructure in Helsinki schools; parents and their conceptions about ICT in school; and implementing computer-supported collaborative learning (CSCL) practices in schools.

Key words  Information and communication technology, learning, teaching, computer-supported collaborative learning
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REFERENCES
Introduction

Finland is an advanced information society with extensive social welfare programs and open democracy (Castells & Himanen, 2001). Government at all levels supports the policy of extending the information society to all people, and this societal development is widely favored by the citizens. In education, two national information strategies have been adopted and carried out since 1996 (Ministry of Education, 1995, 1999). Local governments have then implemented the national policy in schools. One effective and large example was the Educational Technology Project of City of Helsinki (Hakkarainen, Ilomäki, Lipponen, Muukkonen, Rahikainen, Tuominen, Lakkala, & Lehtinen, 2000; Hakkarainen, Muukkonen, Lipponen, Ilomäki, Rahikainen, & Lehtinen, 2001), the capital of Finland. It has been the largest ICT investment in education of any Finnish city, and as such, it has provided experience and guidelines to other municipal administrators. Many of its positive results are valuable as models for developing the use of ICT in schools; just as important are those results that show shortcomings and problems which should be solved at the national level: issues of administration, employment and boundaries in the teaching profession, which complicate the development work. The Educational Technology Project also included a large research program for investigating and evaluating the realization and results of the project, such an evaluation being atypical of municipal administrative projects. This research-based evaluation and feedback indicates the farsightedness of the politicians who established the project.

The main goals in the Educational Technology Project of City of Helsinki were first decided in the year 1995 and revised in the year 1999. The original main goals were following:

- all schools, educational institutes and the administration are to be connected to the Internet by 1998;
- all schools will have the necessary equipment and basic software; which means 6 student per a computer;
- computers and printers will be connected to local networks;
- all students will have access to computers at least one hour per day;
- teachers' ICT skills will be greatly enhanced.
In the year 1999 the revised goals included, e.g., the following points:

- a Help Desk will provide technical support for teachers and schools;
- technical support will be extended, so that special support persons take care of network connections, each being responsible for about 5 schools;
- pedagogical support for the use of ICT will also be increased.

The implementation of the goals was on the responsibility of subteams responsible for equipment, support services, local network, network for Internet connections, support services for learning (mainly teacher training), and research. The project had a project manager and a management team. The subteams carried out the concrete steps. For example, the support-services-for-learning-group had a large training program; aiming especially to foster teachers’ technical ICT skills. Every year, during the five years’ of the project there were about 400 training courses for the teachers; and about 4200 teachers participated in them every year. The training in basic ICT skills consisted of short courses, which formed a 10-day program for each teacher. The courses in basic skills were, e.g., about word processing, Internet and email, and file management. There were also more demanding, advanced technical courses available to teachers, e.g., courses about producing www-pages and multimedia. The project also organized pedagogical courses: e.g., subject-dependent courses for language teachers; and content-independent ones, e.g., on the pedagogical model of progressive inquiry. The number of pedagogically directed courses increased during the second half of the project. The courses were free for the participants, and it was assumed that everyone who wanted to have training, had the opportunity for it. Further, the teachers participating in the courses had substitutes assigned to their classes, paid by the project; in all, the participation in training was easy and possible for any teacher.

As Erno Lehtinen has observed (in Ilomäki, 2002) that Finland was not the only country that invested in ICT for education in the mid of 1990. The goals for developing the technical infrastructure in the Educational Technology Project of City of Helsinki were, by international comparison, ambitious but not exceptional. To connect schools into Internet has been a typical solution for the majority of western countries, as well as of many countries in eastern Europe. By combining several international comparative surveys about the level and usage of ICT, we can sketch a picture of the Finnish school system and ICT:
relatively speaking, Finland has a good technical infrastructure, with rather many computers for students' use, and very good Internet connections. Teachers have had plenty of training in using ICT. In spite of this, the time available to students for the use of technology in schools is comparatively low.

On of the most important theoreticians of social development, Manuel Castells has written a book with philosopher Pekka Himanen, entitled, The Finnish Information Society Model (Castells & Himanen, 2001). The writers describe the characteristics of the Finnish model as follows: there is wide distribution, high utilization and consensus about the national strategy to support the development of high-technology know-how. One special feature of Finland is that the strong investment in high technology is combined with a strong emphasis of equality in societal development and in social justice. The technologies characterizing the information society have been rapidly distributed in Finland. Already, for a long time, mobile media, computers and Internet-connections have been a part of Finnish daily life. However, the situation in Finland, compared to other countries, is in rapid change, and e.g., the distribution of Internet connections in Finland is not any more on the same level as in the most advanced countries (Bradshaw, 2001). In any case, we believe that the results of the Educational Technology Project of City of Helsinki are still of interest, world-wide.

The purpose of this report is to describe the main pedagogical results of the project. The report is based on several research articles and reports, and especially on the final report of the Educational Technology Project of City of Helsinki (Ilomäki, 2002), which is in Finnish.

We acknowledge all our cooperation partners in the City of Helsinki, all researchers and research assistants who have contributed to accomplishing the studies, all writers and translators, who contributed and helped to get complete this report, and especially Hal White, who has corrected the Finnish-English into English.

Liisa Ilomäki Minna Lakkala
Advancing the use of ICT in schools

The research results of the Educational Technology Project of the City of Helsinki

The purpose of this report is to present the findings of the several surveys and studies by the Educational Technology Project of City of Helsinki. The research group in the Centre for Research on Networked Learning and Knowledge Building in the Department of Psychology, University of Helsinki, was responsible for the research of the Educational Technology Project. The group was formed in the year 1996, and, at first, it consisted of three researchers. Over the years the group grew until there were about 10, and its efforts are now divided among several research areas about ICT in education.

The main research topics have been concentrated in the following areas:

- Teachers’ self-reported skills and usage of ICT, and their pedagogical thinking, especially in relation to ICT in education. The teachers were from primary, lower and upper secondary and vocational schools.
- Teacher communities and their collaboration with ICT
- Students’ self-reported skills and usage of ICT, and their pedagogical thinking, especially in relation to ICT in education. The students were from primary, and lower and upper secondary schools.
- The technical infrastructure in Helsinki schools
- Parents and their conceptions about ICT in school. The parents were from primary, and lower and upper secondary schools.
- Implementing computer-supported collaborative learning (CSCL) practices in schools.

This research report summarizes results of some of these larger topics. For various reasons, the majority of the reports, papers and articles were published only in Finnish. Altogether,
the research group produced articles, reports and other papers as follows (1.5.2002) (refereed articles or papers)¹:

- General descriptions of the Educational Technology Project 8 (3)
- International reviews concerning ICT in educations 4 -
- Pedagogical evaluation of technical resources 2 -
- Research concerning teachers 10 (3)
- Research concerning students 6 (2)
- Research concerning intensive projects (computer supported collaborative learning, portable computers) 28 (21)
- Pedagogical development work 17 (8)
- National and international joint projects and comparisons 18 (5)

The research projects on these topics were carried out by means of large surveys with questionnaires and statistical analysis, and also with interviews. Research concerning intensive computer supported collaborative learning projects was carried out with intensive classroom observations, interviews and also some questionnaire-based analysis. This report is a summary of the main research topics, and the previous reports and articles are used as sources. The most important reference for this report is the final report of the Educational Technology Project, which is in Finnish (Ilomäki, 2002).

Appendix 1 presents a list of all articles and research papers which are available either in print or in www-pages in English concerning the Educational Technology Project of City of Helsinki.

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¹ The research group is still writing articles based on the data gathered during the project years.
The development of students' and teachers' ICT skills and practices of using ICT

Liisa Ilomäki

During the years 1996-2000, the Educational Technology Project of City of Helsinki extensively increased ICT resources in schools to support the educational possibilities of ICT. As explained in the Introduction, the Educational Technology Project increased the number of computers in schools, provided schools with local network and Internet-connections, built up a system for technical help, and trained teachers. The results and consequences of these major investments were evaluated, e.g., by surveys of teachers' and students' access to ICT, their actual skills and their actual usage of ICT. This chapter presents some of these results, based on two references (Ilomäki, Tapola, Hakkarainen, Koivisto, Lakkala & Lehtinen, 2001; Ilomäki, Hakkarainen, Lakkala, Rahikainen, Lipponen & Lehtinen, 2002). We summarize and compare the main results of teachers’ and students’ conceptions of their skills and usage of ICT across the three-year period during the Educational Technology Project.

The goals of the present investigation were 1) to examine whether and how skills and practices of using ICT in various groups of students and teachers developed during the three-year period, 2) to examine how students' and teachers' ICT resources both at school and at home, self-reported ICT skills, and ICT-usage for learning / teaching differed from each other.

Method

Participants

Students from 4 lower and 2 upper secondary schools answered a self-report questionnaire in the 1997/1998 (stage 1) and 1999/2000 (stage 2) academic years. Teachers from 32 primary, lower and upper secondary schools also answered a self-report questionnaire in the same academic years. Table 1 presents a summary of the participating students and teachers.
Table 1
The Participants of the Study

<table>
<thead>
<tr>
<th></th>
<th>Male students</th>
<th>Female students</th>
<th>N Students</th>
<th>Male teachers</th>
<th>Female teachers</th>
<th>N Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>454 (49,5%)</td>
<td>456 (50,1%)</td>
<td>910</td>
<td>122 (24,7%)</td>
<td>372 (75,3%)</td>
<td>494</td>
</tr>
<tr>
<td>Stage II</td>
<td>472 (49,9%)</td>
<td>473 (50,1%)</td>
<td>945</td>
<td>122 (30,1%)</td>
<td>372 (69,9%)</td>
<td>365</td>
</tr>
</tbody>
</table>

The representation of female and male students corresponds to their relative proportions (about 60% female, upper secondary level) in Helsinki schools. The proportion of female teachers in the first administration (1997/1998) of the questionnaire — corresponding to the known proportion, generally, for Helsinki — was approximately three-quarters of all teachers. In the second administration (1999/2000), the proportion of female teachers was somewhat lower than their relative proportion of teachers in reality. However, the participants are not the same ones in both years. Mean ages in the groups of participants were as follows in the first stage and second stages respectively: male students 14.8/15.0, female students 15.0/15.2; male teachers 43.1/41.2, and female teachers 44.0/43.0.

Assessment instruments

Instruments were designed to assess students’ and teachers’ skills and practices of using ICT. The self-report questionnaires consisted of Likert-type items; accordingly, the participants were asked to rate, on four- or five-point scales, a large number of statements concerning their skills and usage of ICT. Some questions simply assessed whether a certain ICT resource was present in the environment of the participants. (The overall design of the self-report questionnaires is reported in Hakkarainen et al., 2000, and Hakkarainen, Muukkonen et al., 2001.)

The issue of social desirability was considered in designing the self-report questionnaires, but no way of discounting it entirely was found. Another potential methodological problem was the use of self-evaluation for assessing skills and competencies. Women appear to have a propensity to underestimate their competence (Nurmela, 1998), and teenage boys tend to overestimate their competence (Hakkarainen et al., 2000). Because the mastery of

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2 The assessment instrument is based on four questionnaires: 1997 and 1999 for teachers, and 1998 and 2000 for students. The same teacher questionnaires were also used as assessment instruments for the studies presented in the chapters “The development of teachers' pedagogical thinking” and “ICT in teachers' collaborative use”.

ICT is still strongly associated with males (Clegg, 2001), the male participants might have been more likely to (inaccurately) present themselves as competent ICT users than were females.

**Results**

ICT-Resources Available to Students and Teachers

Computers and good connections to the Internet are essential for developing ICT competencies. The Educational Technology Project of City of Helsinki aimed to increase the ICT resources at schools both for students and for teachers. The results of the present investigation indicate that the project succeeded in this aim. It is notable, moreover, that, during the period examined, the number of computers in students’ and teachers’ homes increased remarkably. From previous research, it has been noted that in Finland, the families with school-aged children especially tend to have computers at home (Nurmela, 1998). From a pedagogical viewpoint, it is particularly important to have computers in the classrooms because they provide the possibility for all teachers and students to use and learn ICT in their everyday practice (Hakkarainen, Muukkonen et al., 2001). Table 2 presents the percentages of respondents who had access to a computer or an Internet connection at the times of the first and second administration of the questionnaire.

### Table 2

**Students’ and Teachers’ ICT Resources as a Function of Their Gender Groups (%)**

<table>
<thead>
<tr>
<th></th>
<th>Students</th>
<th>Teachers</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Computer at home</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>78,4</td>
<td>87,4</td>
<td>67,8</td>
<td>81,9</td>
<td>76,9</td>
<td>78,9</td>
<td>78,6</td>
<td>90,4</td>
</tr>
<tr>
<td>Computer in the classroom</td>
<td>37,2</td>
<td>42,0d</td>
<td>26,9b</td>
<td>35,4ab</td>
<td>54,4b</td>
<td>71,6d</td>
<td>32,2c</td>
<td>56,6ca</td>
</tr>
<tr>
<td>Computer available at school</td>
<td>89,1</td>
<td>93,9a</td>
<td>91,8</td>
<td>96,4a</td>
<td>98,2</td>
<td>99,1</td>
<td>97,8</td>
<td>98,4</td>
</tr>
<tr>
<td>Internet at school and at home</td>
<td>32,5a</td>
<td>57,4a</td>
<td>24,4b</td>
<td>47,8b</td>
<td>19,7c</td>
<td>46,3e</td>
<td>19,8d</td>
<td>45,6d</td>
</tr>
</tbody>
</table>

Note 2. a,b, etc. indicate statistically significant differences (p<.001) for every variable between groups with the same letter.

As can be seen in Table 2, almost 80% of the participants had computers in their homes. The analysis indicated, further, that female students had, in a statistically significant way, more computers at home at the second stage than at the first stage (p<.001).

Male teachers more often had a computer available in their classroom than did any other group in both years. In the first stage, there were statistically significant differences between male teachers and female students regarding the number of computers within the participants' classroom. The number of computers in the classroom had increased significantly for female teachers between the stages. In the second stage, there existed differences between male teachers and students as well as female teachers and female students. The difference between teachers and students might be partly explained by the fact that teacher group consisted also primary school teachers (about 20% of the respondents), and in primary school computers are typically located in the classrooms. In lower and upper secondary schools, computers are located in special computer labs. The difference between student groups is of interest: It is obviously based more on the subjective feeling of access to computers than on reality, because there are no gender-based classrooms.

The majority of both teachers and students had computers available, at least somewhere at the school, already in 1997. The Internet access was comparable among the groups. All groups had better access in the second stage than in the first stage, and there were no differences between the teacher/student and gender groups.

Other studies of teachers and schools in Finland have shown similar results. In one study (Sinko & Lehtinen, 1998), 83% of teachers had a computer at home, 71% of teachers had a computer available somewhere at the school, and 46% had a computer in their own classroom. In that study, about 83% of students had a computer at home at their own disposal, and more than half of the respondents had an Internet connection at their disposal both at school and at home. In other studies, conducted in 1998-1999, as much as 95-96% of lower secondary schools in Finland had access to the Internet for instructional purposes (Kankaanranta et al., 2000; Linnakylä et al., 2000).
ICT Skills

The participants' ICT-competence was measured by self-evaluation questions. The results (Figures 1 and 2) for competence in various applications are notable, especially the changes between the comparison stages, because they show the developmental trend of students and teachers, and of the two genders.

![Chart showing ICT skills by gender and role in the first stage of the study.](chart.png)

**Figure 1**

**Students' and Teachers' ICT Skills in the First Stage of the Study**

In self-rated word processing skills, there were statistically significant differences; the teachers estimated their own skills higher than the students did for themselves in the first stage (Figure 1), but in the second stage (Figure 2) the self-estimates did not substantially differ from one another. In the first stage, male students' and teachers' self-rated skills in many applications were higher than for female students and teachers, and the differences were statistically significant. Female students showed intriguing patterns: In some applications, they evaluated themselves as less competent than the male groups for
themselves, and their profile resembled the female teachers' profile, but for drawing and graphics, female students' self-ratings were as high as male teachers'.

The participants' assessment of their ICT skills changed from the first to the second stage. All groups of participants estimated that they had mastered word processing and information networks relatively well. Apparently, these ICT skills were considered by the respondents to be basic in the second stage of the study; this provided a strong contrast to the results of the first stage of the study, in which the information networks were reportedly mastered only by some participants.

A factor analysis with a rotated Varimax solution did not, in our view, produce a uniform result for structuring the competence of various skills. For teachers' competence, it was possible to construct two factors: a factor of basic skills (file management, word processing, spread sheet and information network) and another factor of more special skills...
(drawing and graphics, digital image processing, publishing and application generator). For students, there were not such clear and logical factors. This evidence suggests that the competencies of teachers and students may differ: teachers had good competence in some traditional applications and in information networks, but less competence in some other applications; students had broader competence in several applications.

Comparing the results of factor analysis with the results of competence in various applications, it is seen that although female teachers reported having less competence than girls for themselves, they accepted the statement 'ICT is a natural tool for me' as often as girls. This might mean that they were satisfied with a narrower competence than girls. ICT as a tool had a different meaning for female teachers than for female students.

ICT-usage in teaching and learning

We also compared teachers’ and students’ answers about using computers for teaching and for learning at the second stage in 1999/2000. Students were asked how often they used a computer in their studies or for the homework, and teachers were asked how often they used a computer for teaching (to make a difference from e.g., planning or administration). The results are presented in Figure 3.

![Figure 3](image-url)

**Figure 3**

*Computer Usage for Teaching / Studies in the Second Stage*

Students still used a computer for their studies rather seldom; about 40% used it at least weekly, but about 30% used it less than once in a month. About 35% of teachers used a
computer at least once in a week; 23 % of teachers never used a computer for teaching. Although the results are not directly comparable, they are somewhat conflicting. It is possible that students would like to use ICT more than they do, and for this reason they underestimate the usage. Teachers may feel pressure to use more ICT in education, so they overestimate the usage. In any case, the changes in students' use of computers in studies within only two years are remarkable, as presented in Figure 4.

![Figure 4: Students' Computer Usage for Studies in the First and in the Second Stage](image)

Both genders used computers at school equally. This is encouraging, and schools especially can and should help to support girls to acquire ICT competence.

**Conclusions about teachers’ and students’ skills and usage of ICT**

The results indicate that the Educational Technology Project succeeded in many of its aims. The amount of computers and Internet connections had increased. Such results are rather simple to measure; it is much more difficult to get measurable results about more complicated processes and their effects, like teacher training programs. Anyhow, our results indicate that especially young and middle-aged female teachers have gained from the organized training.
The results indicate further that there prevails both a generation and a gender gap regarding to the participants' skills and practices of using ICT. According to their self-assessments, teachers' self rated basic ICT skills were higher than students'. Students' self-ratings showed more extensive knowledge of various applications of ICT than teachers’. The gender gap shows that females, both students and teachers, have to overcome a gender-based barrier. For further investigation, this is an intriguing issue: how stable are the differences in ICT skills and usage? One indicator of changing culture is female students' assessments of their network skills. They estimate their skills as quite high, and this must indicate rather intensive use of the Internet.

According to the students' assessment, they still, too seldom in our view, have an opportunity to use ICT in school. Other studies (Hakkarainen et al., 2000) have shown that male students use ICT rather intensively, and, likewise, the results of this study showed that students' ICT competence is, in a way, broader than teachers'. According to the pattern of their answers, it is proposed that adult and young people's usage can be captured in the following metaphors; for adults, ICT is a tool; for young people it is primarily a way of life; secondarily a tool. Teachers and adults use ICT primarily to do "something useful". The adults' view of ICT as a tool, does, of course, support their development of skills, but not so effectively as the young people's way-of-life view supports their own development. According to Nardi and O’Day (1999), an orientation that involves taking technology as a tool is associated with an experience of mastery or control; i.e., technologies are seen as independent objects that the user controls, rather than vice versa. Young people use ICT as a tool, but also, e.g., for recreational surfing, and downloading games and music as well. Thus, they strengthen their productive ICT skills and, as suggested in the way-of-life metaphor, expand use of ICT to entertainment, hobbies, and schoolwork. This comprehensive approach to ICT comes close what Nardi and O'Day call information ecology: an integrated system of agents, practices, values, and technologies within a given environment.

It is a major social undertaking to prepare all citizens, especially the young, for an "information society" heavily reliant on computers and associated communications technology. Finland, as suggested by our data for Helsinki, has made great strides inapproaching the goal of adequate preparation, in general. Much, however, remains to be done in addressing disparities based on age and gender, despite the fact of female students.
have made some gains. Moreover, further research is needed to elucidate the specific causes and effective remedies for the inequalities discovered.
The development of teachers' pedagogical thinking

Liisa Ilomäki & Kai Hakkarainen

Teacher's pedagogical thinking deeply affects deeply how they use ICT on education and what they think about it, e.g. what kind of possibilities ICT brings to education, what kind of applications a teacher will use with students, or what kind of activities and practices a teacher develops for learning. For this reason, teachers' technical ICT-skills are only a starting point for enhancing ITC in classrooms; as important are the pedagogical skills for implementing ICT into learning.

In the studies of the Educational Technology Project we found out that teachers would like to have especially pedagogical support and models, not only technical training (Ilomäki et al., 2001); they still feel uncomfortable with ICT in their teaching, although the majority of they use various application already daily for other purposes. In addition, principals of Helsinki schools regarded the teachers’ lack of pedagogical skills for applying ICT in education as a major limitation on implementation of ICT in education (Ilomäki et al., 1999). We were especially interested in finding out how teachers think about the new ideas of education and technology; therefore, one large topic of the research of the Educational Technology Project of City of Helsinki concentrated on this. (The theoretical context of this study is presented in Hakkarainen, Muukkonen et al., 2001.)

The comparative study of teachers' pedagogical thinking and practices was carried out to determine whether there existed differences in the respondents’ pedagogical thinking between the years 1997 and 1999. That period of time represented the active implementation of the Educational Technology Project, and, e.g., a large training program was going on. The Educational Technology Project did not aim to direct pedagogical changes, nor was this a goal for the organized teacher training. This can also be noticed in the results of the comparative study of pedagogical thinking; the results show no major changes from the year 1997 to the year 1999 in the scales used for the study (Ilomäki et al., 2001.) There were, however, interesting changes between various teacher groups.

This study presents results of the comparisons of scales measuring pedagogical thinking and pedagogical practices of primary and secondary school teachers in Helsinki. The
present study describes theories and practices of progressive inquiry as principles and tools for educational, ICT applications, and employs a dynamic concept of knowledge. In Hakkarainen, Muukkonen et al. (2001), the construction of the pedagogical scales is presented in detail.

**Method**

Setting and participants

The participants were the same teachers as in the study presented in the previous chapter. Also the self-report questionnaires were the same as used for the teacher studies presented in the chapters “The development of Students' And Teachers' ICT Skills and Practices of Using ICT”, and “ICT in teachers' collaborative use”.

The teachers were asked to rate, on a five-point scale, 44 statements concerning their general pedagogical conceptions. Finnish teachers are quite familiar with the constructivist concepts of learning, so opinions that emphasize a learner's active engagement with exploratory activities are very common. It could not be assumed that corresponding pedagogical practices were, necessarily, so widespread. The problem was controlled by asking the teachers, not only their opinions about general pedagogical principles, but also how they actually applied these principles in their instructional practice.

The items were used to construct five scales. The scales were the following:

*Progressive inquiry / principle:* Teachers were asked to evaluate a set of items connected with the pedagogy of progressive inquiry, such as "I think that reflecting on students' own conceptions is as important an aspect of learning as adopting conceptions presented in textbooks", or "Students should be encouraged to ask questions even before introducing new material".

*Progressive inquiry / practice:* The same questions were used, as in the previous scale, but teachers were asked to assess how often the principle in question is actually implemented in their pedagogical practice.
ICT for progressive inquiry / principle: Participants were asked whether ICT is used for carrying out routine tasks or solving routine problems, or whether ICT usage is designed to facilitate the students' self-regulated research-like process of inquiry and solving of authentic, complex problems.

ICT for progressive inquiry / practice: The same content was employed as in the previous scale, but teachers were asked to assess how often the principle in question is actually implemented in their pedagogical practice.

Dynamic concept of knowledge: Teachers were asked to evaluate a set of items concerning the role of an individual student in the knowledge formation process; is it only assimilation of already existing knowledge or does it presuppose active interpretation and knowledge construction.

Number of items, means, Cronbach alphas and standard deviation (SD) for respective scales are presented in Table 3.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Number of items</th>
<th>Year</th>
<th>Cronbach</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive inquiry / principle*</td>
<td>6</td>
<td>1997</td>
<td>.72</td>
<td>4.1</td>
<td>.52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td>.78</td>
<td>4.4</td>
<td>.49</td>
</tr>
<tr>
<td>Progressive inquiry / practice</td>
<td>6</td>
<td>1997</td>
<td>.82</td>
<td>3.6</td>
<td>.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td>.82</td>
<td>3.6</td>
<td>.61</td>
</tr>
<tr>
<td>ICT for progressive inquiry / principle*</td>
<td>6</td>
<td>1997</td>
<td>.69</td>
<td>3.7</td>
<td>.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td>.69</td>
<td>3.6</td>
<td>.58</td>
</tr>
<tr>
<td>ICT for progressive inquiry / practice</td>
<td>4</td>
<td>1997</td>
<td>.84</td>
<td>2.6</td>
<td>.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
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<tr>
<td>Dynamic concept of knowledge*</td>
<td>7</td>
<td>1997</td>
<td>.69</td>
<td>3.6</td>
<td>.64</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1999</td>
<td>.74</td>
<td>3.5</td>
<td>.66</td>
</tr>
</tbody>
</table>

1 = fully disagree, 5 = fully agree
In scales marked with* there is a statistically significant difference between the years of the study.

There existed some statistically significant differences in pedagogical scales for the comparisons in the years 1997 and 1999. These differences were, however, contradictory. In the year 1999, the participants had higher values in the scale Progressive inquiry, principle, but lower values in the scale ICT for progressive inquiry / principle. The positive change in the scale Progressive inquiry, principle is probably partly due to the special guides and teacher training of progressive inquiry, which were organised in the project at
that time. The scale *ICT for progressive inquiry / practice* is measuring the application of the theories to practice with ICT. The more negative attitudes might be dependent on the increased knowledge about both ICT and progressive inquiry; therefore the participants might have been more critical (and realistic) about applying ICT in their own practices. Similar, contradictory results were also obtained in a study of teachers' pedagogical concepts in Helsinki vocational schools (Koivisto, Ilomäki, Syri, Lakkala, Hakkarainen, Lipponen & Lehtinen, 2000). In any case, the differences of the means were rather low, and the real changes, especially in teachers' pedagogical practices, are noticeable only after a longer period.

The contradictory results of the scales between the years can also be explained by the complexity of the phenomena, and by the difficulties in measuring them. The questionnaires would also have needed, e.g. data from classroom practices to testify the changes.

The pedagogical scales of the year 1999 were analysed with a variance analysis, and the age-gender groups were compared with Scheffe's test. In the majority of the scales, there were no statistically significant differences between the groups of young (20-35 yrs), middle-aged (36-47 yrs) and old (48-63 yrs) gender groups. The statistically significant differences were found in scale *Dynamic concept of knowledge*, in which the young and middle-aged women had higher values than the oldest male group. Another kind of difference was in the scale *ICT for progressive inquiry / practice*. The middle-aged males estimated themselves to use more ICT as a tool for progressive inquiry than the oldest female group.

The pedagogical scales were analysed also by the level of school (primary, lower secondary and upper secondary), but there existed no statistically significant differences between the teacher groups of various school levels.
The respondents of the year 1999 were divided with cluster analysis into three groups, on the bases of the frequency of using ICT, to compare the respondents’ pedagogical conceptions in relation to their ICT usage. Table 4 presents the mean frequency of using ICT, and the number of respondents in each group. The three groups were the following: Frequent users, (daily use of ICT), Occasional users (ICT is used almost weekly), and Rare users (ICT is used less than monthly).
The mean frequency of using ICT and amount of respondents in each group

<table>
<thead>
<tr>
<th></th>
<th>Mean frequency of using ICT</th>
<th>N=580</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent users</td>
<td>5,0</td>
<td>344</td>
</tr>
<tr>
<td>Occasional users</td>
<td>3,9</td>
<td>196</td>
</tr>
<tr>
<td>Rare users</td>
<td>1,8</td>
<td>41</td>
</tr>
</tbody>
</table>

The values of the pedagogical scales of each group were compared with each other, and the results indicated that the rich use of ICT has connections to higher values of the pedagogical scales, as Figure 5 indicates.

The Frequent users differed statistically significantly in all scales from the Occasional users and from the Rare users group in all scales, except the scale *ICT for progressive inquiry, theory*. The Occasional users-group and the Rare users-group differed from each other in a statistically significant way only in the scale *ICT for progressive inquiry, practice*.

**Discussion and conclusions about the research on teachers’ pedagogical conceptions**

In measuring teachers’ pedagogical thinking, we have to face the problem of social desirability; the respondent answers according to what she/he regards as a commonly accepted and approved thinking. This problem might affect our study, because the
respondents stated that they more highly valued the principles of progressive inquiry and ICT for progressive inquiry, than the practices of these principles in their own teaching. The difference between principle and practice is interesting in several ways. Is it possible that teachers' principles are more advanced than their skills in applying the principles? This would mean that, e.g., in teacher training, in teacher consulting and in pedagogical development projects, the implementation of pedagogical models should be emphasized and supported. It is not so necessary to spread out pedagogical ideas or to train the ICT skills but to integrate these two: the ideas of advanced pedagogical models, and guidance in using computers to apply and implement the ideas. Other studies have presented similar results (Venetzky & Davis, 2001). It is also possible that teachers would like to use more advanced practices, but the resources in schools are still too limited: computers are located in one or two computer rooms, and these are available too seldom. Computers can not be used as often as teachers would like to. In our studies, we found results indicating this conclusion (Ilomäki et al., 2001).

The two-year period between the comparisons is too short to find out essential changes in teacher profession, so it is natural that the results are very similar in both years the data were gathered. Actually, the differences between the age-gender groups and between the groups based on the frequency of ICT use are more interesting; of course, also the fact that there were no differences between respondents in different school levels. We can state that teacher groups in Helsinki are very similar in their ideas of process working, student's own thinking and self-directed knowledge constructing, and in the concept of knowledge. The major differences are between those teachers that use ICT very much and those who use it less. It is difficult to say the reasons for this. Are those teachers that use ICT frequently and often, already more advanced in the pedagogical thinking or does the use of ICT (also in education!) change teachers' pedagogical thinking towards more advanced ideas?
ICT in teachers' collaborative practice

Liisa Ilomäki and Minna Lakkala

The traditional independence and autonomy of teachers’ work has affected educational research, especially in schools. Teachers’ activities and points of view have been studied without giving any attention to the teachers generally and school community. It is as if the community has not been thought to have an effect on individual teachers’ goals, emphasis in curriculum, or development work. The community in which teachers find themselves has been thought to matter only in organizing concrete functions, such as organizing common celebrations or in administration. Nevertheless, an individual teacher is very dependent on his or her school structure, on organizational practices, and on the working culture in the school.

The emphasis in research on ICT in education has been mainly on pedagogical aspects, but ICT also radically affects teachers’ work, both with students and also with fellow teachers. Effective implementation of ICT in schools often requires that the teacher community have common agreements, practices, and goals of ICT usage. ICT also inspires teacher collaboration as a catalyst, since many learning processes in which ICT is used, become extensive, cross-disciplinary, and process-oriented; and their accomplishment requires special expertise of several teachers. Teachers become team members instead of independent workers. Social intercourse or even collaboration is not enough; pedagogical collaboration is also needed.

The purpose of this study was to examine how teachers in City of Helsinki think about the possibilities of pedagogical development work in their school, to find out if the teachers' collaboration increased during the Educational Technology Project of City of Helsinki, and to examine how the change in the teachers’ ICT-collaboration may have affected their thoughts of teachers’ pedagogical community. The results have been presented also in Ilomäki et al. (2001).
**Method**

Participants

The same questionnaire that was used to investigate teachers’ ICT skills and pedagogical conceptions (explained in the two previous chapters) also included statements for evaluating the features of the teachers’ community in the schools. In this study, we picked responses from those schools in which at least 50% of the teachers answered the questionnaire.

In all, 359 teachers of 23 schools answered to a self-report questionnaire in 1997, and 345 teachers of the same schools in 1999. The schools represented primary schools (9), lower secondary schools (7), upper secondary schools (5), and special education schools (2). In addition, 24 teachers from 4 schools (one primary school, two lower secondary schools, one upper secondary school) were interviewed in 1997 and in 1999, using a semi-structured interview.

Assessment instruments

The self-report questionnaire consisted of Likert-type questions, which called for ratings on a five-point scale, six items concerning the features of the teachers’ pedagogical community, and teachers’ collaboration in using ICT in teaching in the respondents’ school. Based on the theories and pilot studies of teachers’ conceptions of work communities, we formulated two sum variables for the statements that dealt with issues regarding the teachers’ community:

- **Teachers’ pedagogical community** – variable, which described teachers' beliefs about the teachers’ pedagogical community (discussion atmosphere, shared vision about the development of the school, school encouraging development work) (4 items, Cronbach alpha .778.)

- **ICT collaboration** – variable, which described teachers' common ICT activities (common ICT-based projects, ICT renewing pedagogical practices) (2 items, Cronbach alpha .564.)

A semi-structured interview was carried out with 24 teachers. The interview consisted of several kinds of questions; some of them focused on the teachers’ community and
pedagogical development of the school. Respondents’ answers to those questions were used in this study, in addition to the results of the questionnaire, to obtain a richer view of the teachers’ conceptions of their school community.

**Results**

The results of the questionnaire indicated that the majority of schools scored higher in the ICT-collaboration variable in 1999 than in 1997, and lower in the Teachers’ pedagogical community -variable in 1999 than in 1997. The difference was statistically significant in both comparisons (see Table 5).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ pedagogical community 97</td>
<td>3.53</td>
<td>.52</td>
<td>.001</td>
</tr>
<tr>
<td>Teachers’ pedagogical community 99</td>
<td>2.44</td>
<td>.42</td>
<td></td>
</tr>
<tr>
<td>ICT-collaboration 97</td>
<td>2.61</td>
<td>.55</td>
<td>.01</td>
</tr>
<tr>
<td>ICT Collaboration 99</td>
<td>3.20</td>
<td>.46</td>
<td></td>
</tr>
</tbody>
</table>

In *Teachers’ pedagogical community* –variable, the majority of schools (18) had lower scores in 1999 than in 1997. Only two schools had an opposite trend, showing increase in the conceptions of pedagogical community, and three schools had about equal scores in both years. In *ICT collaboration* –variable, the majority of schools (14) had higher scores in 1999 than in 1997. Four schools had lower scores in 1999 than in 1997, and 5 schools had about equal scores in both years. Both factor scores decreased in four schools. It is remarkable that two of these schools participated in intensive study projects with special emphasis in ICT during the Helsinki project. Two schools had higher scores in 1999 than in 1997 in both factors.

Preliminary results from the qualitative analysis of the interviews evidenced the following larger themes or dimensions concerning the teachers’ conceptions of their school community:

In the interview, the teachers’ were asked if the teachers in their school have a *shared vision about the development of their school*. In the year 1997, the main opinion was that the teachers have some vague ideas of the vision, but it is not deeply shared. In the year
1999, most of the interviewed teachers thought that there is a shared vision, although teachers had individual differences in their opinions. A smaller number of answers stated either that there are shared visions among smaller teacher groups teaching the same subject, or that there were no shared visions at all.

Conscious pedagogical discussion is needed for collaborative visions and strategies to develop. In both years, most of the interviewed teachers answered that in their schools they have both special meetings and informal occasions for pedagogical and development discussions. A few of the participants told us that they have meetings about pedagogical questions mainly within teachers who teach same subjects, and a few said that they don't actually have such meetings.

In the interview, the teachers were also asked, if they have teams for development work. In the year 1997, the main opinion was that some teams exist; in the year 1999, the main opinion was that they have conscious teams in their school for development work.

Teachers were also asked about their personal possibilities to affect the development of their own school. In the year 1997, the main opinion was that it is possible and easy to affect; depending on the teacher's own activity; but that the respondent was not interested in affecting the school development. In the year 1999, the main opinion was that it is possible within teams, and with active participation. There were also a few answers showing that teachers regard influencing the school as possible in smaller teacher groups, such as with teachers of the same subject; we also encountered answers that regarded a special group of teachers as having more "power" than others.

**Conclusions of the study concerning the development of the teachers' community**

According to the results of the statistical analysis concerning the questions regarding the teachers’ community in the administered questionnaire, a common trend in majority of the investigated schools was that teacher collaboration in ICT activities caused decreasing scores in the experienced pedagogical community. This might indicate that real collaborative activities cause conflicts and problems, and more needs to communicate also about disagreements. The satisfaction with the less-collaborative situation was in a way
self-evident. This result also indicates that teachers are on the way to work more as team members instead of independent workers. Collaboration in ICT activities might function as a catalyst in this process. A new challenge in the development of pedagogically more collaborative teacher community is how to support schools to have constructive discussions, and effective and positive working climate.

The interviews showed that, even within one school, teachers had rather different opinions about their schools’ pedagogical community, about their personal possibilities to affect school affairs, and about a common and conscious vision of the school development. This is a result worth noting, and needs more investigation. Maybe there is an on-going change in the teacher communities, which is caused by several trends in the society. The expectations of the teachers' communities are not stable.

Comparisons of the interviews conducted in 1997 to the those in 1999 showed some interesting differences. We presume those were mainly a consequence of a large amount of curriculum revision that was carried out in all Finnish schools during the two years’ period, unrelated to the Educational Technology Project. Visions of development for the schools were more conscious and shared in 1999 than two years before. In addition, a greater number of teachers regarded themselves as active participants in the pedagogical development work of their schools in 1999 than in 1997. These two changes, which came up in the interviews, are indications of positive development in school communities, although the results from questionnaires showed negative changes in the teachers’ opinions about teachers’ communities. This contradiction also supports the view of teachers’ currently changing expectations towards the their community.
Implementation and Use of Computer-Supported Collaborative Learning in a Helsinki Primary School

Lasse Lipponen & Marjaana Rahikainen

In the Educational Technology Project of City of Helsinki, one area of development work was the advancement of networked learning practices, which was, at first, mainly based on the activities of the research group, but later became supported also by a teacher training program. This work also linked students with a specially constructed Virtual Web School, a web-based learning environment. The research activities were concentrated mainly in a primary school, but some minor studies were carried on also in a lower secondary school. This chapter presents some of the results of the studies in the primary school.

Introduction

In recent years, there has been a growing interest in computer-supported collaborative learning (CSCL) (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999; Koschmann, Hall, & Miyake, 2001). As a consequence, students in more advanced schools are increasingly engaged in joint construction of knowledge through discourse activities in peer groups; there have even been experimental attempts to set up ‘communities of learners’ that gather students and research experts from different areas of science in the shared endeavor of inquiry. These activities are supported increasingly with technological applications. For many educators and researchers, some sort of CSCL application appears to be one of the most promising ways of using information and communication technology, not only to promote, but also to achieve desired changes in teaching and learning practices. Concurrently with the development of technical innovations, schools require new theoretical and pedagogical approaches that take advantage of the technological innovations; these include for instance, Knowledge Building (Bereiter, 2002), Progressive Inquiry Learning (Hakkarainen, Lonka, & Lipponen, 1999), and Community of Learners (Brown & Campione, 1994). Common to these approaches is their stress on the importance of sharing ideas and expertise in order to advance students’ discussions from personal opinions to collaborative knowledge.
There is evidence that this marriage of technology and new theories of learning and instruction has begun to have an impact on the quality of teaching and learning. Research literature has provided evidence of positive effects and potentials of computer-supported collaboration: enhanced individual learning outcomes; higher group performance, especially with regard to knowledge construction; improvement in the amount and quality of social interaction among students, and between teachers and students (Koschmann, 1996; Lehtinen, Hakkarainen et al., 1999; Scardamalia, Bereiter, & Lamon, 1994). On the other hand, attempts to scale up the models of intensive pilot experiments of CSCL have lately revealed that the implementation of CSCL presents not only opportunities, but also many obstacles (Lipponen, 1999; Stahl, 1999). Although the new technology and the theoretical and pedagogical ideas support each other, the attempt to promote educational use of CSCL technology, and at the same time implement new pedagogical and cognitive practices of learning and instruction, appears to demand the utmost of both teachers and students. Many of the technical, theoretical, and pedagogical insights have not been transformed into widely adopted, successful practices of teachers and students.

One possible explanation for students’ resistance of adopting these practices may lie in motivational dimensions: Computer-supported collaborative learning sets new challenges to students’ motivation by changing the features of the learning environment. While students are interpreting these new features, they are motivationally constructing them in a different way than in traditional classroom situation. Participation in the process of inquiry emphasizes cognitive reconstructing, by changing the cognitive division of labor between teacher and student. When a student takes responsibility for higher cognitive activities, it enables him or her to go to a deeper level of the learning process. This shift from teacher centeredness towards students’ activity presupposes strong self-regulative efforts from students, and at the same time offers more space for individual activities. This kind of meaningful and close relationship towards the learning tasks also may help students increase their intrinsic motivation (Järvelä, Salonen, & Lepola, 2001; Järvelä, Niemivirta, & Hakkarainen, 2002). However, the responsibility for setting up one’s own learning goals and monitoring one’s own learning activities can be quite demanding for some students, and further, collaborative interaction with other learners may be difficult to initiate. It may also be the case that motivation of the students cannot be enhanced...
without changes in course and curriculum objectives, especially where these are in dubious correspondence with students’ own objectives for learning.

The results from our previous studies (Järvelä & Niemivirta, 2001; Järvelä, Salonen, & Lepola, 2001, Järvelä, Niemivirta, & Hakkarainen, 2002) indicate that there is a positive relation between learning orientation and cognitive engagement in inquiry learning. However, there is no information yet about how and what kind of situational coping strategies students use while engaging in the process of inquiry. It is therefore essential to deepen our knowledge of situational coping in CSCL environments.

**The aims and methods of the study**

As part of the Educational Technology Project of City of Helsinki, intensive case studies were conducted to investigate the opportunities to implement and use computer supported collaborative learning in Helsinki primary schools. The general objective of the study was to investigate, within a particular theoretical framework, how elementary school students’ engage in computer-supported collaborative learning. Within this project there were several specific aims: The first was to describe elementary students’ processes of computer-supported collaborative knowledge construction; the nature of students’ questions, explanations, and communicative interactions supported by CSILE (Computer Supported Intentional Learning Environment, see Scardamalia, Bereiter, McLean, Swallow, Woodruff, 1989), and VWS (Virtual Web School, see [http://mauri.edu.hel.fi/](http://mauri.edu.hel.fi/)).

The second aim was to analyze and interpret the challenges and constraints of implementation and use of CSCL in schools. The third specific aim was to investigate and document students’ participation patterns and the quality of their discourse. The fourth aim of the study was related to motivational dimensions of the learning context; that is, to explore the situation-specific coping strategies of students with various, generalized learning goals as they take part in inquiry learning.
From a theoretical point of view, the study was grounded in the wide framework of sociocultural theories of learning (Vygotsky, 1978), and also in Scardamalia and Bereiter’s concept of knowledge building (Scardamalia & Bereiter, 1994).  

**Contextual and instructional settings**

The present study took place in a suburban elementary school district in Helsinki during the years 1995-2000. Two classes (hereafter, 'class A' and 'class B') participated in the study (class A participated 1995-1998, and class B 1998-2000) worked with CSILE and VWS learning environments. During the years 1995-2000, both classes conducted a number of CSILE projects, focused on topics in biology, physics, environmental studies, and geography; they produced, in all, about 4000 CSILE notes. In addition, class B conducted two VWS project and produced about 450 VWS postings. An intensive CSCL project lasted approximately 4 to 6 weeks. For example, class B students studied the topics 'Energy' in third grade, and 'Biological adaptation' in fourth grade. Both projects were posted for a four-week period, and about 6 hours per week. Usually, only one topic was posted at a time. The first year (1995-96) was an exception; during that year, class A performed several projects simultaneously. In the study projects, students worked individually, in pairs, or in small groups for subprojects under the main topic. It was mainly the teachers who selected the project topics and the time of the year when projects were conducted. To some extent, the researchers helped them in planning the projects. The project topics and pedagogical goals were always based on the curriculum. Within each project, there were three aims: to learn domain specific knowledge, to learn to conduct inquiry, and to collaborate with others through CSCL environments.

All CSILE projects, and a VWS project followed the same general instructional guidelines of the progressive inquiry model (for details, see Hakkarainen et al., 1999). In the beginning of the project, the teacher created a context for the learning, and tutored the students in generating questions for the topics, asking for example, "Tell me what do you wonder about energy?" This phase was conducted as a whole class discussion. Secondly,
students were instructed to answer their questions, constructing explanations on the basis of their prior knowledge. In the following phase, students were asked to evaluate the explanations they had generated or test them empirically. Fourthly, they were guided to search for new scientific information using books and the Internet for the advancement and refinement of their prior explanations. To facilitate collaborative learning, students were encouraged to post their questions and explanations to CSILE and to VWS, and to comment, there, on others' work in order to give and receive assistance and feedback. Thus, the purpose was to share all aspects of the instructional unit, from the setting up of questions, to information search, through the CSILE and VWS environments. In a nutshell, CSILE and VWS were used to facilitate a research-like process of collaborative learning, in which generation of the students' own questions, intuitive theories and conceptions, and search for scientific knowledge had an crucial role. The presented instructional unit, however, must be taken as a general model, because inquiry is never a linear process, but more an endless activity to advance individual and collective knowledge.

Two CSCL environments, CSILE and VWS, were used in the study, and in the following paragraphs we introduce both of them, briefly. CSILE (http://csile.oise.utoronto.ca/) is a networked learning environment designed by the CSILE team headed by Scardamalia and Bereiter (Scardamalia & Bereiter, 1994). It has been under development since 1986. CSILE is designed to facilitate collaborative knowledge building with a communal database at its core. Technically, it consists of a client application and a database. CSILE provides opportunities for students to collaborate on learning activities by working through a communal database that has text and graphics capabilities. Within this networked learning environment, students create computer entries called 'notes' that contain an idea or piece of information about the topic they are investigating. The notes can be labeled according to the topic but also according to the type of contribution or scaffold (“thinking icons”), such as “Problem”, “My theory”, “Plan”, or “New learning”. These scaffolds are intended to provide students with procedural facilitation, that is, to offer design characteristics that enable users to carry out more complex cognitive activities than they could do otherwise. The database of notes can be explored using search and browse facilities. The basic CSILE activity is discourse, intended to start with students’ own questions and theories.
Another CSCL environment used in the study was Virtual Web School, which was developed by the Media Center of the City of Helsinki during the Educational Technology Project. The Virtual Web School is an asynchronous Internet-based discussion forum designed for storing and sharing information. The users are able to access it from any internet-linked computer. VWS automatically tracks the discussion threads, logs all forum notes (postings) and represents which ones are replies to which others. Chat-rooms and e-mail are integrated in the system. Postings can be made in various formats (text, graphics). Messages sent to the VWS database can be sorted, for example, by person and date. The user can modify his or her personal portal to the VWS. Personal bookmarks may easily be collected and stored in the database, and when the user re-enters the VWS, his or her private bookmarks and e-mail preferences are loaded automatically. Discussion forums, public or private ones, can easily be created for each course. The primary users of VWS are elementary and secondary school students in the City of Helsinki.

Subjects

The students who participated in the study were 9 to 13 years old. There were approximately as many boys as girls in the classes. In each class there were approximately 3-4 students experiencing difficulties in academic aspects of schooling. They had problems in reading and writing, and some also had personal or family-related issues that might have affected their academic work.

Class A was taught by a teacher (hereafter, 'teacher A'), who had 7 years' teaching expertise in handicraft. The starting year (1995) of this project was also his first year as an elementary teacher. He was an expert in educational technology, continuously developing his expertise in this field. In 1996 he met members of the Canadian CSILE team and was in loose contact with them during year 1997. Class B was taught by two teachers ('teacher B' and 'teacher C'). Teacher B had three years of experience as an elementary teacher. In 1997-1998 she participated in a 15-credit-units special course in science teaching; she otherwise had no intensive experience in that subject. Teacher C had started working with the class B students in autumn 1999. The teachers volunteered to participate in the study.
In the beginning of the project, the teachers (and the students) were not familiar with ideas of computer-supported collaborative learning, and CSILE and VWS projects were their (as well as students’) first attempts to use CSCL environments to support learning activities. For this reason, in the beginning of the study, they were introduced to CSILE work and to the practices of inquiry by the researchers. There are two more points related to the teaching profession in Finland, for the elementary level, which are relevant to the present study. Firstly, in Finland, the same elementary-school teacher remains with the same class as they are promoted, i.e., virtually the same students, for four years following the class from one grade to another; for instance, teacher A worked with the same students during the years 1995-1998. Secondly, these teachers are rarely subject-matter experts, and are not necessarily experts in inquiry learning and science teaching. They teach many subjects, such as biology, mathematics, environmental science, and reading and writing. Further, teacher A's classroom was equipped with a server and six computers with CSILE 1.4 software, which provided students with access to CSILE whenever they needed it. Teachers B and C, instead, had to take their students to a computer room in order to use CSILE and VWS.

**Overview of the methodological design**

In the study, the basic methodological approach was to use a combination of quantitative and qualitative methods. By using both methods, the intention was to provide a comprehensive picture of elementary students' computer-supported collaborative learning. Qualitative content analysis (see Chi, 1997) was suitable for analyzing the quality of the knowledge created by the students, and with social network analysis (see, Haythornthwaite, 1999; Palonen & Hakkarainen, 2000; Wasserman & Faust, 1994) it was possible to identify key interaction and participation structures, which then could be analyzed further with qualitative content analysis. In addition, various units of analysis were used; data were analyzed on the individual level, the collective level, and the level of knowledge objects.

For the motivational analyses, two types of data were gathered. Firstly, all the students completed self-report questionnaires on learning goals and goal orientations related to school learning at the beginning of the project. Secondly, five students representing various goal patterns were selected from the class B in order to investigate individual
differences in their situational coping and their adaptation. Every lesson during the year 1998-1999 project was videotaped, and also selected lessons during the following two terms. Observational data gathered via videotaping enabled a valid procedure to capture students’ coping tendencies in an authentic context (Järvelä, Salonen, & Lepola, 2001); so, the focus of the tapings was on each student’s working procedures, and social interaction in the learning context.

There is one more point to be made. The analyses of the study did not deal with effects of CSCL, that is, whether the individual students learned something or not. The data and analysis are to be considered more as effects with CSCL – they inform one about participation, discourse, and motivational processes that might limit or promote learning in CSCL environments.

Results and discussion

In the present study, Helsinki primary students’ CSILE- and VWS-supported knowledge construction, quality of discourse, and patterns of participation were analyzed. Further, motivational dimensions of students’ participation and engagement of CSCL were examined.

Quality of knowledge construction and discourse

The empirical work revealed that elementary students’ CSILE- and VWS-supported collaboration was rather learning-topic oriented. Although representing learning topic orientation, the discourse was not always what we were hoping and striving for; the better part of the discussions was focused on factual information, representing factual knowledge construction. We do not deny the importance of factual knowledge and factual-oriented discourse; scientific facts should be an important part of every student's knowledge base. Yet, factual knowledge construction alone is not enough to further students' efforts to make inferences, offer interpretations, or to help them gain genuine, deep understanding. We did find, however, patterns of interaction that we considered very gratifying because of the depth they represented. These episodes included intensive participation, and engagement with explanations and understanding.
The most common pattern of interaction was a student presenting a question that was commented upon by another student with an answer. This type of interaction pattern led to episodes containing only few contributions. If the focus is simply on question and response, apparently there is little chance for multiple perspectives and reflection. This pattern of interaction reminds one of a common pattern of classroom discussions and question-answer-procedures, often illustrated in the IRE-form (initiation-reply-evaluation), in which the teacher values students’ right answers (Cazden, 1988). These results, factual knowledge construction, and short episodes of information exchange, reflect the general tendency of most on-line discussions so far examined: most of the messages posted in the public discussions spaces appear to be social in nature, or requests for factual information (Feldman, Konold, Coulter, Conroy, Hutchinson, & London, 2000). There is no single or simple reason for the occurrence of the tendency to factual knowledge construction, and short episodes of information exchange. On macro level, it might reflect the prevailing empiricist epistemology of school learning, and IRE-pattern of interaction; and at the micro level, for instance, demonstrate the implicit epistemological assumptions and cognitive design of CSILE and VWS projects. Or it might simply imply the difficulty of computer-supported collaboration; the theoretical and practical principles of CSCL may still be too immature to be widely applied in practical educational reforms.

In considering conditions that promote fruitful, collaborative exchanges in computer-supported environments, we propose that to go beyond perceptual knowledge and short episodes of information exchange, strong engagement of the teacher in students’ collaborative learning processes is needed. Such teacher engagement, however, requires profound changes not only in the ways learning activities are conceptualized and organized in schools, but also in the students' and teachers’ conceptions of learning and knowledge are. Thus, it necessarily involves, great changes in teacher development. To date, there is still too little research on the instructor’s activity related to effective discussions and participation in CSCL environments (but see Ahern, Peck, & Laycock, 1992; Lakkala, Muukkonen, Ilomäki, Lallimo, Niemivirta, & Hakkarainen, 2001).

It would, of course, be unrealistic to expect that discussions in CSCL environments would only represent building of deep understanding, and totally lack communication about social issues. One should rather ask, how are these two issues related, and how
communication about social issues supports knowledge building in CSCL environments. Since every on-line, or virtual, community to be effective, not only has to share knowledge concerning learning topics, but also has to keep up social relations. Different types of discourse, obviously, are necessary, for they serve different purposes for a learning community. In another case study, conducted also in the Educational Technology Project of City of Helsinki, the research group investigated a secondary level distance learning project, in which students collaborated mainly virtually with each other in a progressive inquiry project, using the VWS environment (Lakkala, Ilomäki, Lallimo & Hakkarainen, 2002). According to the analyses, the content of communication concentrated more on building up the learning community and organization of the group processes, rather than on epistemological subject matter issues. This result underlines the challenges in creating a learning community for students collaborating at distance, and for designing collaborative technologies to support social awareness.

Towards effective participation

The investigation of elementary students technology-supported discourse revealed that the number of discussion threads within the CSILE and VWS projects was high, and the threads were rather short. The results of this study are consistent with results of previous studies; most of the discussion threads in CSCL environments have tended to be very short, containing only few contributions (Guzdial & Turns, 2000; Hewitt & Tevlops, 1999). These results appear to indicate that, regardless of the educational level, there is often a lack of sustained and connected discussion in CSCL environments.

The study indicated also that students' participation in CSILE- and VWS-supported collaborative knowledge construction was rather broad. In most of the CSILE projects and in the VWS project, all students participated to some extent in the work. There were, however, substantial individual differences in the participation activity, ranging from absent to frequent. These results are in line with some earlier observations concerning students' participation rates, although the previous studies have mainly concentrated on students at a higher educational level (Guzdial & Turns, 2000; Hara, Bonk, & Angeli, 2000; Hewitt & Tevlops, 1999; Muukkonen, Lakkala, & Hakkarainen, 2001). Put briefly, these studies indicate that students do not participate very intensively in CSCL environments. Thus, one question that needs to be addressed in the near future is, how to
induce teachers and students to engage with CSCL technology, along with new pedagogical approaches.

The study further revealed that participants had quite different positions in the CSILE- and VWS-supported interaction, some of them having a central, and others an even isolated position. The obvious challenge is to get the isolated and inactive students to participate more actively. To support active and meaningful participation and discourse, one should, for instance, alternate face-to-face and electronic discussions, and propose alternative views for students to debate. Further, one must anchor discourse to students' personal experiences, and, perhaps most importantly, make the CSCL discussion a central part of legitimate classroom activity (Hoadley & Linn, 2000).

The results — fact-oriented knowledge construction, shallow discussion, low and unequal participation levels, and short discussion threads — led us to think, what, then, would effective participation and reflective discourse in a CSCL environment look like? One of the main outcomes of the study was setting of the general guidelines for effective participation and discourse in CSCL environments: these included dense interaction, decentralized participation, and reflective and constructive communication. We believe that these criteria can serve as a heuristic tool for evaluating the quality of interactions in CSCL environments, especially when one evaluates the mediating and limiting conditions of computer-supported collaborative learning.

**Motivational dimensions**

In the motivational analyses of this study, students generalized learning goals were identified, and the goals’ relation to situational coping strategies was examined in a context of computer-supported inquiry learning. The results showed that the students with learning-oriented goals had almost no off-task periods, and they were generally involved in the inquiry process, as was found out in the case of three girls. Among the non-learning-oriented students, two kinds of tendencies were found. Some of them had difficulties engaging in the working procedures, and their coping tendencies can be described as regressive. A lack of teacher’s concrete and precise guidance in both cognitive and motivational sense appeared to partly explain this phenomenon. However, other students indicated more progressive coping efforts with increasing task-
engagement. The data showed possible reasons for this progressive coping, such as an authentic and meaningful learning task — perceived as such — provoking intrinsic motivation (Hidi & Berndoff, 1998).

The results also revealed the importance of a situative perspective in instructional design, since the students not only differed in their coping attempts regarding their initial motivational orientation, but also according to their individual situational interpretations. As Järvelä, Lehtinen and Salonen (2000) have stated, students’ subjective interpretations are variables that one must take into consideration in the instructional environment. It would be especially important to reveal the mechanisms behind the reciprocal formation of coping tendencies between the teacher and the students in this novel learning context.

Previous research about this phenomenon has been conducted in more traditional, teacher-centered classroom settings (Lehtinen et al., 1995; Salonen, Lehtinen, & Olkinuora, 1998), and is not entirely applicable to a CSCL situation that is more ill-structured. As found in our previous studies (Rahikainen, Lallimo, & Hakkarainen, 2001), a teacher may have major difficulties in guiding those students who cannot genuinely externalize their own concepts and the inquiry process themselves. It is, of course, important to provide teachers sufficiently concrete models, or examples, for finding productive ways to guide students with varying cognitive and socioemotional skills (Brophy, 1999); however, it is also very important to create proper scaffolds, both cognitive, and motivational, for the students who have difficulties adopting these new working procedures. Naturally, the teacher has a major role in providing this kind of support, but also the learning environment itself could foster students’ efforts to structure their learning processes.

**Implementation of CSCL: From technical infrastructure to social infrastructure**

The study appears 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, include learning the skills to use information technology, developing skills of basic knowledge acquisition, 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. The present study 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.

In a large frame, we interpret the results of the study, at least partly, as indicators of the challenge of implementing technology at schools; how technology is introduced to the students and teachers, how it is put into use, to what purposes is technology used, what kind of social support is given for users, what meanings students and teachers give for technology, and so on. Although technology, in some cases, may serve as a catalyst for change, nowadays it seems very clear that technology itself does not necessarily make any deep changes in learning activities in school. One of the major challenges of CSCL, or educational technology in general, is scaling-up; how to expand and implement the good practices that researcher and teachers have found and developed. In other words, what is needed in successful implementation of technology? Whilst creating new learning environments or learning communities, it is not just a matter of implementing and putting into use new technology but in many cases, also applying simultaneously new practices of learning and instruction.

Lipponen (1999) proposed that we should pay more attention to the factors that inhibit or support the implementation and use of CSCL at schools. To successfully implement and use CSCL in natural settings, one has to resolve technical, organizational, and pedagogical challenges. Bielaczyc (2001) has presented a parallel idea. According to her, one of the key factors in successful implementation of CSCL is to build an appropriate social infrastructure around the technical infrastructure. Thus, instead of focusing extensively on the technology, one should turn towards thinking about the social settings that support the implementation and use of technology.

We propose that there are two other advanced possibilities to think about this issue. First, one could explore and find the advanced and innovative pedagogical practices (or needs) that already exist in the particular context that aims to take technology in use. When these practices and activities are found, technology could be implemented to support and extend those already existing, good practices. In this case, the social infrastructure is primary to the technical infrastructure. An even more advanced idea would be to find the zone of proximal development of the particular community, and to implement technology
that has the potential to help to transform the community towards more advanced learning activities through an expansive learning cycle (Engeström, 1987). The third alternative is that technological and social infrastructure co-evolve. This is what happens, of course, in the two previous alternatives too. But what we propose is that the idea of co-evolution should be the starting point for thinking about implementing technology and new forms of learning activities. This approach is very much pedagogy and activity driven. It implies that technology should be very flexible and tailorable. Learners are not the same as the everyday people or experts, but need software designed especially for the learners. As far as we can see, the concept of social infrastructure has the potential to help us to think about the problems of implementing technology and building learning communities, and should be carefully studied in the future.
Parents and ICT in schools

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As we evaluate the use of ICT in school, parents’ conceptions also have an important function. Within the Educational Technology Project, parents’ conceptions of the usage of ICT in schools were measured with a questionnaire rather similar to that in the student and teacher studies. In this chapter, the central findings of the parent study are presented. These results have been reported in Finnish in Koivisto Syri, Ilomäki, Tapola, Hakkarainen, Lakkala, Lehtinen, Lipponen, Muukkonen, and Rahikainen (2000).

The goal of the study was to clarify what the parents think about the role of computers in learning. The explored themes included a) whether parents get enough information about how schools use computers; b) what kind of attitudes parents have about the use of ICT; c) what, in the parents’ view, are the problems of using ICT in schools; and d) how important is it, for the parents, to increase equality in access and use of ICT.

As we took in the questionnaires returned, we found that mothers were more inclined to fill in the questionnaire: 68 % (n = 386) of the answers were from female respondents, and only 29% (n = 163) from male respondents. A majority of the respondents were 40-49 years of age. Female respondents were, on average, younger that males. Most commonly, the respondents had a child or children in the lower primary level. Second most commonly, the children of the respondents were attending both the lower and upper-primary level schools. Parents, whose children were solely at the upper-primary level, represented only a little over ten percent of the respondents, and parents of secondary level students represented five percent. A majority of parents in this study (61 %, n = 319) used ICT in their own work, but were not working in the IT-sector. From the parents, 8 % (n = 40) were employed in the IT sector, and on average every third parent (32 %, n = 167) did not use ICT in their work at all. The male respondents were more often employed in the IT sector. In was also less common for females than males to answer that they used ICT in their work. From the female respondents 15 % (n = 24) answered that they did not use computers at all in their work, while among the male respondents this figure was only 5 % (n = 17).
Based on the results of the study, it can be concluded that parents hold the conception that computers have a positive influence in pupils’ studying and their school motivation. Most of the parents felt positively about the use of ICT in schools as tools for learning. Parents clearly wanted ICT to be part of studying, already from the lower-primary level school. Again, a majority of parents preferred to have ICT applications used as an integrated form of work at school, instead of having it as a subject apart.

It is important to note that the parents did not form a homogenous group; several variables, such as professional position, education, age, and gender, influence parents’ conceptions strongly. We also observed an effect of students’ school level on some of the parents’ conceptions. Based on parents’ conceptions, two distinct groups could be identified: Parents who were interested in the use of ICT at school, and parents who thought negatively of it. In the latter group, a number of parents were in favor of teacher-lead pedagogy. The groups diverged from each other in terms of background variables, such as education, own use of ICT, professional position, age, and gender. It is important to note that the parents do not form a homogenous group, but several factors, such as professional position, education, age, and gender, strongly influence parents’ conceptions. We also observed an effect of students’ school level on some of the parents’ conceptions. Based on parents’ conceptions, two distinct groups could be identified: parents who were interested in the use of ICT at school, and parents who thought negatively of it. In the first group, a number of parents were in favor of teacher-led pedagogy. The groups diverged from each other in respect of background variables, such as education, own use of ICT, professional position, age, and gender. Parents' with higher education, higher professional position, and who used ICT in their own work, were more satisfied with the use of ICT in school. They represented a less teacher-centered pedagogical approach, and they had a rather realistic view of the possibilities of ICT.

In this study, 42 % of the parents were satisfied with the way ICT was used at school. Least satisfied with the current situation were the parents with the least education for they apparently desired more teaching of ICT. Those parents who had completed only the primary level studies used ICT least often. Most likely, they considered their own ICT skills too limited to be able to guide their children in the use of computers: Therefore they had higher demands for the teaching of ICT at school, compared to other parents.

A major part of parents reported that they felt they did not know enough about how their children used ICT at school and wished to know more about the use of computers at school.
Based on these results, it can be recommended that the collaboration between parents and school should be increased. For instance, development could focus on projects that join the use of ICT at school and at home, or students could provide “evening schools” for parents on the use of ICT. Naturally, schools should regularly provide information on, e.g., their ICT projects, aims for the use of ICT at school, and ICT resources; so that parents are kept well informed of the current situation and development plans.

Although parents value the use of ICT at school, they do not consider it unproblematic. They see especially that the Internet is potentially risky in terms of ethics and upbringing. More than half of the parents saw that schools should pay more consideration to the security risks related to Internet usage. A majority of parents thought, for example, that information which reveals the identity of a child should not be made available on the Internet without permission. Parents with more education, who were employed in IT-intensive field or used ICT intensively themselves, showed less fear regarding the use of computers and the Internet. Female respondents, less educated parents, and young parents saw the security risks most worrisome. Most of the parents were in favor of setting up technical limiters, which would prevent access to pages meant for adult users. At current, schools are basically relying on edification and have not used such limiters. Parents considered that this approach was enough for students in the secondary level, but not necessarily for lower levels.

Parents who have no experience in the use of computers were most concerned with the use of ICT. They were likely to consider the Internet as a threat that they do not know or master well enough. In order to establish a secure way of using computers at home and at school, schools should pay attention to these worries. One way would be to develop together good practices for the use of Internet. This is a possible way for schools to support parents as they guide children in the safe use of computers.

Parents considered that it is of great importance that schools use ICT in teaching and studying, since it provides an equal opportunity for all students to learn to use ICT. The results of the study revealed that the children of well-educated and employment-wise higher status parents used computers most frequently at home. This may lead to inequality, if children of higher-educated and actively ICT using parents develop a more natural stand and attitude towards ICT, compared to children of lower-educated and seldom ICT using parents. This is one reason why teachers should integrate the use of ICT as part of the
curriculum they are providing. It appears to be the only way to assure that all students have equal opportunities to learn to use computers as tools. Schools could also take more responsibility, especially for developing students’ ICT skills and provide them the possibility of using ICT in schoolwork, so that the use of ICT becomes a natural and routine part of studying at school.
Finnish society has approved of a special information society strategy in which education and training are playing a central role. Both national educational policy and the municipal educational administration have systematically aimed at supporting this development during the recent years. The Department of Education of the City of Helsinki has funded longitudinal (1995-2000) project, the Educational Technology Project, which has been the largest regional project in Finland, and its effects have reflected in many ways, the national projects. Even though the project plan also included pedagogical goals, its primary focus was on the development of the technical infrastructure. The purpose of the technical investments, i.e., providing computers and setting up network, was to arrive at a situation where the educational use of computers has increased and improved considerably.

According to the a report of City of Helsinki about information strategy (The information administration strategy of educational department, 1995), knowledge and skills are emphasized in the information society, and therefore, basic education should be able to provide such basic skills needed. An essential issue for the Education Department of the City of Helsinki is to utilize all the investments as efficiently as possible, and as a challenging issue is the production of new learning services and content, including networked models, knowledge, and e-learning solutions. Learning and knowledge are seen as central factors in the process, and teaching and learning through the network as an important new step. The report also mentions constraints of network solutions, such as undeveloped state of networked pedagogy, incompleteness of networked learning platforms, lack of standards, and undeveloped state of content production. In addition of production of suitable content for digital learning, basic education faces also the challenge to improve teachers’ knowledge and skills, and application of ICT in all fields of learning. Further, assessment and evaluation methods of learning outcomes should be developed in order to evaluate investments.
Assessment of the effects of educational ICT projects has been generally experienced to be problematic since the expected effects have been difficult to measure; some of the effects may not occur until longer period of time has passed. Scrimshaw (2001) studied schools’ innovative regional ICT development projects and presented a classification for expense-profit analysis, which allows approaching the question of effectiveness in a versatile way. In this assessment instrument the effects were classified into 1) direct support for learning (more efficient learning, supporting active learning, supporting autonomous learning, development of group work skills, development of citizen skills, development of communication skills, and development of ICT skills), 2) indirect support for learning (development of teachers’ expertise, better administration and management, development of assessment, better possibilities for employment), and 3) attaining the goal of regional community (improving social equality, ensuring availability of skilled labor force).

The results obtained for the Educational Technology Project make it possible to examine direct and indirect support for learning in mid-range time period. The results neither offer empirical information about long-term effects, nor it is possible to examine how the region’s (City of Helsinki) general goals were fulfilled. If the ICT skills and, more broadly, experience of use of networked environments, are considered as important factors both for individual coping in the future, in economic life, the results of this project provide a possibility to evaluate the achievement of social equality, and goals related to availability of qualified labor force.

**Setting up the technical facilities**

Even though evaluation of success of this kind of large, long-term, and manifold project is difficult, quantitative evaluation of the fulfillment of goals established for technical solutions, is relatively easy.

According to the results of the substudies, it may plausibly be concluded that the Educational Technology Project succeeded with its goal to set up networks in schools. The number of computers (workstations) increased, but it remained short of the original goal, which may, however, be reached soon. In that respect, the project succeeded. Examination of the process of equipping technology raised some central questions which are not
sufficiently dealt in educational ICT projects in general, and which the Educational Technology Project has not definitely answered either:
- How does one define a “right” or adequate number of computers in relation to number of students?
- What kinds of differences there are in technical infrastructures between schools?
- How does the City of Helsinki and its Department of Education prepare for rapid change of technical solutions and software, and related to these, aging of technology?
- What kinds of arrangements of the technical resources best support instruction and learning in schools?

The level that the City of Helsinki became technologically equipped, during the project, is that all schools are equipped with an Internet connection, and there is, on average, one computer per seven students; this corresponds well to the goal set for the year 2000 in many advanced countries that, like Finland, invested actively in the educational use of technology (Sinko & Lehtinen, 1998). It is also comparable to the achievements of ambitious educational ICT projects of other big European cities (e.g., see http://www.edu.stockholm.se/), but it is lower than in those European countries where the most massive ICT-investments have been made (Basic indicators on the incorporation of ICT into European education system, 2001).

According to the latest international comparative surveys in the majority of European countries, insufficiency of technology is the most typical reason for lack of use of ICT. In these international surveys, Finnish teachers have not stated their reasons; however, the teachers in the Educational Technology Project have said, towards end of the project, that one important constraint on the educational use of ICT is lack of computers. Two explanations may be proposed for this finding: First, regardless of the increased number of computers, and setting up of networks, individual solutions in each school may not be arranged in such a way that teachers can use the technical resources in a flexible way. Another explanation may be that a new teaching culture that utilizes technology has successfully been created during the project. Therefore, there may be an increased need for technology, which the schools are not able to answer even though they have relatively good resources.
An adequate number of computer in relation of number of students has been a central issue in both international and national discussion of the educational use of ICT (Sinko & Lehtinen, 1998). The ideas range from one personal computer for each student, to 2-3 computers per classroom to well-equipped common media centers. The idea of the adequate quantity of technology seems to be in line with the pedagogical ideas of which the proposed use is based. Evaluating results from international comparative surveys, Collis (1996) stated that a sufficient number of computers is not so much a certain ratio between the number of computers and students, but actually a much more complex pedagogical issue. If computers are used mainly in addition to traditional teaching, and students work with individual drill and practice programs or educational games, it will be inevitable that the number of computers will be insufficient.

A completely different picture of an adequate number of computers emerged in a large international study, which focused on teachers and classes that were known to use information technology innovatively as a part of new pedagogical solutions (Collis, 1993). These classes seldom used computers for playing educational games or for working with drill and practice programs; instead, teachers, in various ways, integrated computers into their teaching. Computers could be used as a presentation tools, sources of information, common information storage tools and so on. These teachers seldom cited an insufficient number of computers as a constraint on the educational use of ICT. It is obvious that active pedagogical development work is a basic presupposition for the schools becoming furnished with sufficient technical tools for adequate access and use, and such work can develop innovative practices even with limited technical resources.

The international surveys concerning the level of technological equipment of schools have revealed large differences between schools within countries. There can be many different reasons for these differences. In a highly decentralized educational system, economic possibilities of individual schools can be quite different, depending on the general socio-economic situation of the school district. The school’s own activity can also affect its level of being technologically equipped. The best technological resources accumulate to those schools with teachers who actively use educational technology. In Finland, the models that have been used to finance schools’ technological investment have mainly been based on projects that have favored active schools.
The Educational Technology Project has not, at least consciously, directed investments according to the activity of schools. The goals of the project were to reach all the schools of the city. However, according to the results of the follow-up studies, differences between schools’ technical infrastructure have remained quite large, even though the goal of the project was to create a quite equal basis for the schools. Although rewarding active schools can be a justified operation in some situations, an important goal for municipal educational administration is to support weaker schools, and, thus, to prevent extensive differences between schools. For instance, in a large scale and successful educational technology project in Barcelona, a special emphasis was given to support for the city area that are socially and economically in a weak position. (Scrimshaw, 2001). Perhaps this kind of support with particular focus on the socially and economically weaker areas would be the most satisfactory approach in future advancement of ICT in education, in the City of Helsinki.

The rapid development of ICT and ageing of software will cause several problems for schools. If schools invest a great deal of money for technical equipment at one time, they usually cannot invest almost a same amount of money, again, after two or three years, even though this is required if they want to keep their devices up to date. It is not easy to find a satisfactory solution for this rather common problem. What makes the problem even more difficult is that technical development provides completely new tools for educational purposes, such as mobile technologies. At the municipal level, there should be a specific strategy for using devices in an adequate way for as long a time as possible. This kind of strategy could include, for instance, recycling of devices, creating special spaces for different purposes, and taking care of updating software and technology. When modernizing the device, a special emphasis should be put on the development of the pedagogical use. This poses great demands, in the future, on the organization in charge of technical maintenance.

Along with the number of devices, placement of the equipment in the school building is an important prerequisite for the educational use. According to the results, the majority of the teachers thought that inappropriate placement made educational use difficult. This result is not a specific feature of schools in Helsinki, since the very same problem is apparent in all developmental projects related to the educational use of ICT. In general, it is hard to find a solution to the placement of computers that fits all instruction and learning situations.
Specific ICT-labs (or classes) are appropriate, for instance, when students are learning ICT skills; media centers that are placed in libraries encourage independent search for information, and decentralization of computers into classrooms supports integration of ICT into various pedagogical practices. The traditional architecture of schools also constrains the use of technology. If versatile pedagogical practices are emphasized in the use of ICT, it seems to be required that one the proportion of decentralized and flexibly movable technology is increased.

Setting up the infrastructure is essential in respect to the organization of technical support. Nationwide, this question has arisen as one of the central prerequisites of educational use of ICT. Even though schools have been equipped with networks and have obtained a great deal of new technology, still the technical support, the instruction in usage, and the maintenance of software have often been neglected. This has led to inappropriate use of ICT, or to overload of the teachers who have tried to take care of the maintenance. The Educational Technology Project succeeded in solving this problem. The division of labor between centralized and school-centered support worked in an appropriate way, and the teachers in charge of school-centered support did not have big problems of overload. The experience obtained from Helsinki highlights the fact that much more resources should be invested in technical support than municipalities have been generally doing. Furthermore, it is essential to organize activities systematically and divide responsibilities clearly among the parties.

**Teacher training and mastery of new learning environments**

The role of the teacher remains important in an information society even though one goal for the use of ICT is to develop students’ own responsibility and self-regulative working procedures. Therefore, at the very beginning, one central goal of the Educational Technology Project was to train teachers to use ICT. The quantitative goals were reached quite successfully. However, the level of skills, even after participating in courses, did not give the teachers the confidence that is needed to use educational technology in a versatile way. Differences related to gender and age also remained big in ICT skills; though both organized training and increased usage of ICT appear especially to have supported the improvement of skills of young and middle-aged women. Despite the rich availability of
courses, a high level of ICT skills is still essentially concentrated in young male teachers, the same ones who are in society at large, interested in ICT and know it extremely well. Conventional teacher training models have neither appropriately taken into account the big differences of the skills of the participants, nor utilized these differences.

Training ICT skills in special in-service courses that have no direct connection to application of the skills in the person’s own work, has in general proved to be quite an ineffective way of training. Teachers learn to use some applications for certain tasks, e.g., word-processing for planning or email to communicate with friends (as we found in the studies, see Ilomäki et al., 2001), but they do not reach a level of skills such that they can also use ICT in teaching their students. There are several feasible ways of supporting teachers’ learning, at the same time, to use ICT with students, such as combining teachers’ collaboration with ICT and conscious development work with tutoring experts and reflective practices; supporting teachers’ communities organizing teacher training according to the needs; supporting networking and sharing ideas with colleagues and experts; as a matter of fact combining work and learning in teachers’ professional development. Extensive teacher training carried out as a part of the Educational Technology Project has naturally increased the possibilities for teachers to create connections with teachers from other schools. This is not a goal that has been emphasized, so far, in teachers’ technical training and in support activities, for them. In future, teachers’ networking should be stressed more in training, in developmental projects, as well as in using virtual learning environments.

**Students’ information-society skills**

Recent international comparative studies of students’ school achievement have rated Finnish students’ level of achievement as high compared to that of students in the schools of other countries. In addition to more traditional skills, these studies, lately, have also examined a set of gradually specified skills that can be referred to as “information society skills”. From this set, the easiest skills to define are related to direct use of technical devices, even though these also are changing deeply in a short period of time due rapid technical development.
The increase of students’ ICT skills was one goal for the Educational Technology Project. The project succeeded quite well in reaching this goal even though the differences between the students are still notable. Children and young people typically acquire advanced technical skills at home and with hobbies outside of school. The special task for schools is to ensure these skills for those students who have no opportunities or apparent interest in improving these skills at home. It can be said, as a general estimate, that the Educational Technology Project has likely moved toward this goal, but the results are not yet sufficient definitely to say so.

The differences in students’ skills between the genders are still large, and the practices developed during the project have not been able to diminish these differences. Differences between the genders is not just a typical phenomenon for Helsinki, but it reflects a quite common international situation. There are however, notable changes happening, and many regional projects have discovered innovative ways to encourage girls, also, to become interested in ICT (Venetzky & Davis, 2001).

It is not possible to conclude from the research results how much the project has helped to produce, in students, more general information society skills. Experiences from the intensive studies that were carried out as a part of research suggest that if the use of technology-based environment becomes common, then also certain learning processes can be specified; these include the following: increased skills of information search and processing, and better capability of media criticism, as well as the ability to act collaboratively in groups and networks. Based on general experience (e.g., Sinko & Lehtinen, 1998), it is apparently not an easy task to establish, in a wider context, the best practices carried out in some individual subprojects as part of everyday work, and, especially, to disseminate them to other schools. Dissemination of the best practices, however, was not a goal in the Educational Technology Project, and it remains as a challenge for future developmental work.
School management and teacher community as a prerequisite for advanced use of ICT

Many recent reports which have evaluated successful strategies for applying ICT, emphasize the importance of a teacher community. The shift from traditional teaching to learning environments that utilize ICT on large-scale, has not usually been successful if the shift is a made a matter of each individual teacher's responsibility. Large-scale and lasting changes require that individual teachers get ongoing support from a community, and that there be a common vision, strategy and agreements for the change. Such collaborative responsibility means that the principal or the school manager organizes resources for the change and is her or himself very committed to the development.

The need for school management’s commitment to pedagogical and technical reforms is universally stressed. It was clearly evident in the Educational Technology Project that management of the Department of Education had, in fact, strongly committed itself to carry out the technical investment program. It also started to emphasize pedagogical reform related the use of ICT, more strongly, during the project time. At the school level, the issue is no longer ambiguous. For instance, when schools were asked to participate in the intensive studies, there were voluntary schools, in which ICT was seen as an essential part of the pedagogical change process and of the search for new procedures in a whole school’s developmental strategy. In other schools, introduction of the technology and development of new pedagogical ideas was left to individual teachers or groups of teachers, while school management showed only moderate active support. There is evidence, therefore, that, on the whole, school management in the Helsinki schools is committed the development work of ICT in several, quite different ways.

The teacher community that develops teaching and pedagogy collaboratively was also a notable issue in the research conducted in the Educational Technology Project. Collaboration among teachers both within schools and between schools increased, and the teachers reported that collaboration related to use of ICT had increased, in particular. At the same time, apparently, expectations of a larger community that would support collaboration
increased. It is obvious that the challenges related to use of ICT have generally increased teachers’ willingness to find common and collaborative solutions.

**ICT in school development**

In the following sections we will describe some promising developmental trends and possibilities for application of ICT to education, instead of individual scenarios.

Networked learning is emphasized in the recommendations presented in the final report of the Educational Technology Project. This focus can be considered successful if the goal is to utilize possibilities that networks are offering in a versatile way in education. This goal is becoming more problematic if the idea is to shift the teaching practices entirely to so-called virtual environments. According recent research results, it is obvious that schools that offer physical space for learning will remain essential learning environments; though, their nature and procedures will surely be changed. It is important to notice that deeper level innovations through networked learning also require a change in teachers’ pedagogical skills and working culture, towards true learning organization and culture of expertise.

**The challenges and possibilities of virtual learning**

E-learning is a popular slogan in educational discussions. The new learning possibilities offered by ICT have been sketched with concept, such as virtual school, virtual university, and virtual learning. There are also many different projects, in which ICT-supported learning procedures are developed. We still, however, have quite a few independent research results about how networks can be utilized to support learning and development of expertise. Although virtual learning projects seem to offer new opportunities for learning, there are also important pedagogical challenges and problems related to them.

Utilization of networked technology in learning and instruction is offering promising new learning opportunities. According international evaluations outcomes of learning and instruction can be dramatically improved with the help of networked learning (Pea, Means, Hsi, Tinker, Bransford, Brophy, Linn, Roschelle, & Songer, 1999). Learning environments
that utilize modern ICT have promised to lead to a learning revolution. Development of networks, of inexpensive laptops, wireless networks, and “intelligent” technology—these are but a few the new, ICT-related opportunities for learning which are to be extended to a multitude of functioning environments, both inside and outside schools.

Technology can support learning activities by mediating communication among the participants of learning communities, by developing new, more powerful and intelligent tools, and offering support for instruction when students visualize and model complex situations. It can help to search, to present, and to analyze information, as well as to participate in collaborative research projects and build instructional support from research project to learning. While students use networks, they can be helped to solve more authentic learning tasks in more realistic situations. Particularly promising is to offer students access to expert knowledge in quite an early stage of learning. There are good experiences of collaboration between universities and companies. With the help of this kind of collaboration, working together, it is possible to get new human resources to support learning, and various tools to support collaborative inquiring activities (Hakkarainen & Järvelä, 1999; Feldman, Konold, Coulter, Conroy, Hutchison & London, 2000). The problem is, however, that this kind of collaboration is easy to arrange when only a couple of schools are participating in experiments. If the collaboration is to be extended to the whole school system, there have to be entirely new means to retain the workload of university and company personnel at a reasonable level.

Apart from the practical constraints, there are essential pedagogical constraints related to the use of networked technology. The availability of technology alone does not guarantee meaningful access to information sources. Providing different sources of information or learning material through networks available to students does not necessarily support deep understanding. For even though networks provide opportunities for communication that can be free from time and location, they offer quite limited possibilities for reciprocal communication and collaboration compared to face-to-face situations (Roschelle & Pea, 1999).

There is also unreliable and purposefully misleading information in networks, and its processing requires a great deal of work, and the ability to read critically (Geisler, 1994). In respect to learning what is intended, the huge amount of weakly organized information can
lead to inappropriate overload. Even though a network may offering students the
opportunity to their output, for the time being the www-based learning environments are
still used more for browsing of information than as tools for knowledge building.
Producing high quality learning material or learning environments on the network is highly
expensive, and usually conventional learning materials are just digitalized without utilizing
possibilities of multimedia or interactivity of networks.

From the pedagogical point of view, it is especially alarming that virtual learning is often
developed according old pedagogical principles without deep analysis based on networked
pedagogy or learning theories (Lehtinen, Hakkarainen, Lipponen, Rahikainen, &
Muukkonen, 1999). Virtual projects seem to adopt the idea of transferring learning
materials and instruction to a network to create a kind of distance learning environment
built on contents, to serve as a substitute for conventional learning. It seems that in the
background is a one-sided conception of learning, that is, knowledge transmission from
information sources to learner’s mind. It is assumed in this approach that if information
sources are brought to learners, they will be offered notably better opportunities for
learning. Sometimes this is the case: It is true that networks can offer new opportunities for
learning when an individual cannot participate in conventional learning. In basic education
that leads to examination such benefits, however, only hold for a small group of students.
Meaningful use of networks should be based on how teaching and learning can be enriched
and deepened in educational institutions.

**Collaborative technology as a support for versatile learning processes**

Virtual learning, as we have stated, is often understood as a form of distant learning
mediated by networks. This kind of distance learning brings about special challenges for
learning when students have to take in complex knowledge entities and to learn to apply
knowledge in order to solve purposeful problems. Research shows that without support
from a learning community and a teacher’s guidance, virtual distance learning typically
leads to increase in differences in students’ performance (Lehtinen, Lehtiö, Nurmela &
Hakkarainen, 1999). This phenomenon is apparently induced by differences related to
students’ motivation, knowledge base, and general learning skills, which independent
learning in the network emphasizes.
Networked environments lack some central social mechanisms that support learning in conventional communities and are necessary for their functioning. For instance, it is typical to honor agreements arising in face-to-face situations, whereas this kind of social pressure seems to absent in many kinds of virtual communities, for instance, those in which members of the community are not continually present, e.g., those where the work of the community takes place almost entirely through various networked tools (e.g. e-mail, discussion group, networked learning environment). For individuals occasionally to break their agreements and to withdraw is easier where there is only a virtual community and no conventional community.

Virtual distance learning, in general offers productive, new resources for learning only when learners have no other possibility to participate in learning situations. A much more promising solution than pure virtual learning is the combination of networked learning and teaching, with conventional learning and teaching. In this solution, such learning environments play important role, which can help members of the learning community to share their learning process and communicate also between the face-to-face meetings. For instance, the networked inquiry learning model developed by the research group of the Educational Technology Project seeks to combine conventional learning and networked learning on the basis of collaborative technology and on the pedagogy of inquiry learning.

**Development demands and challenges of networked inquiry learning**

The teacher or tutor has a very important role in networked learning. It seems that without a teacher/tutor, networked inquiry learning generally does not favor significant learning outcomes. A teacher or a tutor should encourage students to regulate their learning themselves and to participate in more demanding learning processes, such as posing questions and explaining them, without controlling students’ activities too much. On the other hand, a teacher should guide students’ progress and explain difficult issues when help is needed.

The importance of the teacher’s guiding role is emphasized especially when students don’t have possibilities to get direct support from a learning community. In the same way as in conventional learning, also in networked learning participation can be minor or it can be distributed unevenly among participants. Therefore, it is extremely important that a teacher
or a tutor be closely following students’ participation. At the same time, when students are encouraged towards self-regulative learning, it is important to set common goals for the networked learning. An important task for a tutor is to structure the participation of networked learning in a way that it supports equal and active participation. This means, on one hand, to divide students into small groups that are an appropriate way supporting them to carry out their tasks. On the other hand, it is essential to set up sub-goals that structure the participation of networked learning, and help to ensure that students do not drop out, and that they divide their labor in a meaningful way according the phases of the project.

One problem related to networked environments is that they do not sufficiently support the dynamic division of experiences and knowledge among users. *Social navigation* means utilizing information offered by other people’s activity when making up one's mind and directing one’s own activity (Dieberger, Dourish, Höök, Resnick, & Wexelblat, 2000). Creation of tools that could support social navigation in networked environments could be a promising solution to help users to learn from each other’s experiences. It would be possible to create systems that classify the relevance of information sources according how relevant the previous users have considered them to be. The tools for social navigation are especially important for those students who are insecure and have gaps in their knowledge. These students may be uncertain about how to act in a situation of unstructured information search. It would be important to investigate empirically how participants of varying ability utilize social navigation. For instance, related to information search, there could be a danger that some paths are over-emphasized.

Networked environments do not offer yet enough sense of community, which is one feature related to potential of social navigation. They offer insufficient information about presence and activities of other users (Dertouzos, 2001). An important challenge in the development of networked environments is thus to create tools that can help users to be aware of other users’ activities (i.e. ‘awareness tools’). These tools offer information, e.g., about which others are on-line, what they are doing at the time, and what kind of intentions they have. In addition, different Avatar-worlds, which are based on activities in virtual spaces and use of virtual characters, create a strong sense presence. Strengthening of the networked learning environments that are based on text and pictures with Avatar-worlds is an interesting possibility.
From time to time the conversational culture related to networked learning focuses on superficial and inessential issues. The discussion and knowledge building in a networked environment can easily split into different directions instead of forming of new common understanding. This can lead to a failure to create of deeper knowledge structures (Feldman, Konold, Coulter, Conroy, Hutchison & London, 2000; Stahl, 1999). Drawing conclusions and summing up discussions are not only pedagogical challenges, but require also new technical solutions and tools.

**Challenges of equality**

In order to promote equality in use of ICT it is crucial to create conditions under which girls would become more interested in ICT. The research results shows that there are indeed essential differences between boys and girls in the use of ICT, and in ICT skills. As anticipated, boys use more ICT, are more skillful and more interested in ICT than girls. The differences in the use of ICT are bigger for leisure time use than in the school-time use; boys select more challenging ICT tasks and develop the ICT skills. It is encouraging that a notable proportion of girls are ready and interested in expanding their use of ICT in learning, beyond their present levels. The differences in the attitudes of boys and girls towards ICT are larger in older age groups. This can be interpreted as indicating that there is a new generation of girls, which has been socialized in the use of ICT and developed corresponding cognitive and motivational readiness at home or during the first classes of school. It is also possible, nonetheless, that present-day “male-biased” ICT-culture will readily pass over girls in respect of their extended use of ICT and suffocate their motivation. The latter proposal seems to be more plausible according the international research results, and it also explains the fact why only a small proportion of computer science students is female (Littleton & Bannert, 1999; Kirkpatrick & Cuban, 2000).

In order to prevent girls’ alienation from ICT, it is important also to use, in schools, software and activities that are equally interesting for both boys and girls. Whereas boys’ willingness to use computers is not dependent on the special characteristics of computer software, activities, and projects, these seem to have quite an essential effect on girls’ interest (Littleton & Bannert, 1999; Brunner, Bennett, & Honey, 2000). There is a great deal of research which shows that both genders are equally interested in collaborative learning supported by computers. In many learning experiments, girls in particular have
been dominant. Young girls are truly interested in interactive technology that enables reasoning in complex social dilemmas and solving them flexible ways, activities in writing, exploration of virtual reality, problem solving and so on. When girls and boys work with computers together, it is important to make sure that boys are not too dominant, but that girls also have access and opportunities to develop their skills and pursue their interests.

Another question of equality is related to use of ICT to promote learning in the students with learning difficulties. The results obtained from the Educational Technology Project are, in this respect, promising. Even though the inclusion of ICT environment in learning does not automatically give better opportunities for learning, it seems to offer possibilities for positive change in students’ motivation and learning strategies. The new networked learning environments, however, pose specific challenges to young students’ self-regulation (Järvelä, Lehtinen & Salonen, 2000). When a student has notable knowledge gaps or learning difficulties, he or she may have difficulties learning to regulate his or her own learning. In this situation, it is quite important to offer enough guidance, support, and structuring of the activities, so that the student is able to set realistic subgoals. Teachers should learn to recognize these new challenges related to motivation and learning skills, and to support weaker students with the help of opportunities offered by networked learning environments.

With the help of ICT, it is possible to try to create a common school where individual differences are respected, instead of expecting all students to be developed similar way. It is essential to offer different paths towards common goals in such a way that it is possible, afterwards, to replenish knowledge gaps or lack of skills by participating in various forms of virtual learning (Clay, 1996). For a student, it is essential to get specific support according his or her own needs, instead of being labeled and lumped into a broad and vague group of those with ‘learning difficulties’ (Lehtinen, Vauras, Salonen, Olkinuora & Kinnunen, 1995). With the help of new technology, it is possible to offer well focused and need-appropriate support to students in their efforts to overcome learning difficulties (Kajamies & Husu, 2000). In the future, more technology-based applications and practices are needed, which can offer support to students with learning difficulties both in general level questions, such as, motivation and learning strategies, as well as in specific questions, such as difficulties with particular subject domains.
Towards a new culture of learning: the dissemination of innovative models

It can be discouraging for teachers to discover that software and networked environments do not always meet their needs, and teachers often do not have a feeling of ownership of such environments. In addition to using ICT, teachers are required to make quite notable efforts to acquire and develop new functional pedagogical models. Therefore, the change in pedagogical culture is an extremely slow process. For instance, development of new instruction and learning culture that is based on ICT and knowledge-building pedagogy can take 3-5 years for a teacher to implement (Feldman, Konold, & Coulter, 2000). Adoption of new learning procedures also takes time students, especially young students who are, at least partly, already growing into ICT culture, at school.

Based on national and international experiences it can be assumed that more large-scale utilization of ICT in education would require broader collaboration between schools, maintainers, and researchers. One problem is a lack of mechanisms that could mediate best practices. Obviously, new forms of collaboration need to be constructed. The development of networked innovative learning environments is a process that is based on reciprocal learning and communication between researchers, maintainers of schools, representatives of business life, teachers, and students. There are now innovative new learning environments that are suitable for everyday school life and at the same time helpful in gaining essentially better learning outcomes; their development requires combining expertise in research, pedagogy, application development, as well as creating a common process to develop hardware, software and procedures.

In order to solve these problems, supporting procedures would be needed, which would reduce the distance between innovative projects and schools’ everyday life, and would offer, for instance, a teacher or a tutor an opportunity to move gradually towards deeper change in pedagogical models and practices and in use of technical tools to support this change. On our view, this goal can be reached by developing innovative networked learning models, and giving support to this kind of pedagogy by creating flexible modular learning environments and investigating the use of it. It is very important to offer strong pedagogical support for teachers to implement innovative, networked learning with the
help of so-called learning objects or other digital learning material, as well as to generate solutions to the problems of supporting activities of virtual learning communities.

Tyack and Cuban (2000) reviewed the history of technological innovations from an educational system point of view. Promises of revolutionary changes have been present throughout the history of educational technology, starting from blackboard, radio, television, and VCR. Very often technical innovations have been brought to schools from outside, without proportioning or tailoring them to fit in teachers’ prevailing practices and goals. If only small minority of teachers has started to use new technology, the majority of teachers have been accused of being conservative and stubborn, only looking backwards. The problem has, however, been that in implementing innovations, schools’ everyday life has not been respected enough; enrichment of instruction by new technology has demanded many special arrangements, and a teacher who has a special interest in it.

At the moment, schools are at a front of change again. This change differs from the previous ones, since the computer is a kind of meta-tool that offer access to large set of other mental, intellectual, and social tools (Pea, 2000). The use of computers to increase the level and quality of instruction requires, however, that previous experiences be observed and taken into account. New tools should be developed in collaboration with teachers, and these tools should support best practices; they should be tailorable to teachers’ needs and interests, and at the same time offer ideals and models for change. One special challenge is to combine classroom teaching and computers so that the use of computers becomes a natural part of classroom activities, which has been mastered by the teacher.
Appendix 1

List of the articles and research papers which are available in English concerning the Educational Technology Project of City of Helsinki.


References


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