Eurasia Journal of Mathematics, Science & Technology Education, 2009, **5**(2), 103-118

Adoption of ICT in Science Education: a Case Study of Communication Channels in A Teachers' Professional Development Project

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Received 15 June 2008; accepted 07 January 2009

This paper analyses the use of various communication channels in science teachers' professional development project aiming to develop versatile uses for ICT (Information and Communication Technologies) in science teaching. A teacher network was created specifically for this project, and the researchers facilitated three forms of communication concentrating on the topic of ICT in science teaching. The three forms of communication were face-to-face interaction, mediated interaction, and mediated quasi-interaction. Based on case study data and participating teachers' self evaluation, during the course of the project, the use of ICT in science teaching increased. As predicted, face-to-face communication appeared to be felt more effective than mediated interaction or mediated quasi-interaction. However, informal discussions in small groups turned out to be more important than expected. The results suggest that the design of future professional-development projects should make room for more informal communication.

Keywords: Case Study, Communication Channels, ICT, Professional Development

INTRODUCTION

For longer than a decade, one of the key challenges to the professional development of teachers has been to help the integration of ICT into education. Rationales for an increase in ICT use are based on the assumption that the future will be dominated by knowledge-intensive professions, and employees need, therefore, sophisticated information processing skills and versatile ICT tools. Therefore, ICT in teaching is considered important in the facilitation of equal opportunities for citizens to study and develop their own knowledge to ensure the success and welfare of the nation (Schie, 1997; Moursund & Bielefeldt, 1999; OECD, 2004; UNESCO, 2008). However, the implementation of ICT innovations into school practice is difficult. Thus, it is important to initiate research and development in this field in order to discover what contributes to successful adoption of these innovations.

Research literature has shown promising results on benefits of ICT use in education: it supports student collaboration and knowledge building. Further, in the context of science education, it offers possibilities for interaction with the nature; tools for real-time data logging. However, several problem issues have been identified which explain why ICT is not used in teaching in such extent as it could be appropriate according the potentials reported in the literature. Teachers feel a lack of up-to-date computer equipment and software. One interpretation could be that computers tend to be located in computer labs, not in ordinary classrooms or science labs (Newton, 2000; Hakkarainen et al., 2000). The second interpretation could be that teachers have

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ISSN: 1305-8223

had insufficient time to learn about the use of ICT and its applications in science classrooms (see e.g., Russell & Bradley, 1997); consequently, they have no confidence in ICT use. The third interpretation is teachers' 'technophobic' attitudes about ICT in science teaching (Demetriadis et al., 2003). Research suggests that in any topic, including the benefits of ICT in education, it has been difficult to change teachers' beliefs about teaching and learning (Tobin et al., 1994, 64; Willis, 1997). Teachers' beliefs have remained stable, and their resistance to change is one of the main explanations behind the diminutive adoption of ICT in education (Haney, Czerniak & Lumpe, 1996). Knezek and Christensen (2002) found evidence that teachers' beliefs regarding the usefulness of ICT in education appear to be surprisingly consistent across nations and cultures.

For these reasons, many countries have launched programmes to promote the use of ICT in education. New educational policy statements, renewal of curricula, professional development projects, and the production of new pedagogical study materials have been some of the ways to promote the adoption of a new pedagogical innovation, such as the use of ICT in education (Fullan, 1991, 37; Lazarowitz & Tamir, 1994, 121; OECD, 2004). However, it seems that the programmes rarely feature sufficient guidance and in-service training. A shortage of facilitators or trainers and a general lack of ability of educational organisations to provide effective training and facilitation for teacher collaboration are factors interfering with programme success (Moursund & Bielefeldt, 1999).

Even if teachers are doubtful about the use of ICT in education and about their own ICT competence, strategies and in-service training have built on computer-mediated communication between teachers. For example, in Finland, two-thirds of teachers considered their pedagogical and technical ICT skills inadequate in 1999, but the form of in-service training suggested in the Finnish national ICT strategy was to establish virtual schools or computer-supported professional development networks (SETRIS, 2000; see more Niemi, 2003).

The paper focuses on communication in a professional development (PD) project. Several channels were constructed within the project. Thompson (1994, 35–37) distinguished communication channels (media) on the basis of the nature of the interaction. Face-to-face interaction requires that participants share a common spatio-temporal reference system (they are in the same place at the same time) and interaction is dialogical (two-way information flow). Typically, mediated interaction involves the use of a technical medium (phone, e-mail and/or a newsgroup program over the Internet). In this kind of interaction, participants cannot use expressions 'here', 'now', 'this', 'that', etc. unequivocally. Participants must add contextual information to their messages. The third of Thompson's categories is mediated quasi-interaction, typically mass communication (www-pages, newspapers, television). Mediated quasi-interaction has one-way flow of information; and there is a clear distinction between the producer and a receiver of information, even if some kind of consumer feedback may be possible.

Adoption of ICT in science education through communication channels

Following Voogt and van den Akker (2002), we introduced several educational information and communication technologies for the teachers in our PD project: 1) Simulations and modelling systems (compare with professional CAD software); 2) Multimedia; 3) Microcomputer-based laboratory; 4) Basic tools (e.g., word processors, spreadsheets, graphic software); 5) Communication applications (e.g., e-mail, videoconferences, newsgroups, course management systems – compare intranet solutions to share documents) and 6) databases. They emphasise that in the early years of computers, educational applications were mainly drill and practice programs designed for specific and limited purposes. Nowadays, it seems that software in schools does not differ essentially from software used professionally. In particular, tool applications, databases, multimedia, and social media application (web 2.0) are mostly the same for both schools and professionals

The innovation discussed in this research is a versatile use of ICT in science education. The very important feature of the innovation is that teachers themselves, in communication with researchers (writers of this paper) and other teachers, designed the final version of the innovation. The use of ICT with pupils in a classroom forms a unique application of the learning environment that can be seen as an innovation. This kind of use requires flexibility, both from the technical (ICT) and the pedagogical (teaching methods) aspects of the innovation.

Diffusion as defined in this project, is a process by which the versatile use of ICT in science education (innovation), is communicated through face-to-face interaction, mediated interaction, and mediated quasi-interaction (communication channels) organised over a three year period (time) among the teachers participating in our PD project (social system) (Rogers, 1995, 35; Thompson, 1994, 34–37). Based on the general model of Rogers (1995, 10-11), the diffusion and adoption of an innovation are similar to different kinds of innovations and social systems. A common characteristic is that these processes can be charted on a S-shaped curve. Individuals in different phases of adoption process can be called: novice, advanced beginner, competent, proficient, and expert (Eraut, 1994, 124).

Rogers (1995, 11-35) has differentiated the adoption process from the diffusion process and defined the adoption process as an individual's mental process through which he or she passes from first hearing about an innovation to final adoption (or rejection). He emphasised the importance of an interpersonal diffusion network that influences an individual's adoption process (Rogers, 1995, 281-334). The adoption process can be divided into several stages: awareness, interest, evaluation, trial, and adoption. Individuals who are members of the society adopting the innovation can be categorised in adopter categories such as innovators, early adopters, early majority, late majority, and laggards.

Rogers (1995, 5-6) emphasised that communication, a process in which participants create and share information with one another in order to reach a mutual understanding, was essential to the diffusion of innovations. Messages of this kind should be about new ideas, in our case about new uses for ICT in science education.

Research questions

In this research, we followed the teachers participating for three years in the professional development project called the Finnish Virtual School for Science Education. During the project, there were opportunities to share experiences about the use of ICT in education through several communication channels. To explore the way innovations began to be used (in this case, ICT in science education), we asked the following research questions:

How participating teachers' ICT use in science education changed?

Which structure of communication was felt significant in a teacher PD project?

The research method and results

In order to understand how ICT could be integrated into science education (an adoption process), and observe communication about it, we followed Yin's (1994) suggestions to collect case study evidence from multiple sources (data triangulation). Yin (1994, 79) categorised six sources of evidence for case studies: documentation, archival records, interviews, direct observations, participant observations, and physical artefacts. Table 1 describes the data collected during the three years of our PD project activities.

In order to answer the research question concerning the change of teachers' ICT use in science education, teachers were asked to self-evaluate their ICT use in the beginning and in the end of the PD project. During the project, the researchers noted preliminary interpretations about the activities under observation. In order to answer the research question concerning efficient communication channels, the case study data (Table 1) were analysed to describe the key issues and interpretations of the project.

The analysis of the case-study data was conducted in the following way: The first author carefully read the data and selected relevant sections to identify and to obtain information about the communication channels and which of them were efficient from the point of view of how the teachers adopted the use of ICT in science education. The analysis focused on teacher interviews, open answers from teacher surveys, evaluation and planning memoranda, and field notes. During the reading the categorisation of communication channels got its shape. This approach can be called deductive content analysis. Our analysis was based on Thompson's (1994) communication categories. Extracts of text dealing with the use of ICT in science education were read as a whole and different ways teachers utilised or talked about communication channels were used to interpret the felt significance of each communication channel.

The case of Finnish Virtual School for Science Education

This section describes the proceeding of the professional development project based on case study data. During an informal meeting in a previous project, two teachers and one of the authors of this paper made the first moves towards establishing the Finnish Virtual School for Science Education (FVSSE). The group developed the initial goal: to improve learning and teaching in science through the effective use of ICT. The authors presented their plans to the experts working in the Economic Information Office (of Finnish industry) EIO, who saw that the planned Virtual School fitted well within their school collaboration programme. Three municipalities came to be part of the virtual school at the suggestion of the EIO, and two teacher training schools joined when one of the authors asked them to participate (Table 2).

There were large differences in the professional backgrounds of the participating teachers, even if they were all teachers of chemistry and/or physics (and a majority also taught mathematics). There were textbook authors, active participants in the activities of the teachers' pedagogic association, one of them held a PhD in education, another had a broad (Master's) degree covering mathematics, chemistry, physics, and education, a few were members of the Finnish National Curriculum Renewal Committee, and one teacher co-ordinated his own ICT development project financed by the European Structural Fund. There were freshly graduated teachers, retiring teachers, and "ordinary"

Table 1. Case study data collected over the three years of the FVSSE

Type of the evidence	*Description*
Documentation	
E-mail distribution list. Altogether over 230 messages were sent.	Includes mainly information from researchers to participants: about applications, surveys, agendas, and seminars.
Newsgroup postings	During the distance sequences, a simple newsgroup was used to provide a possibility to report and comment on teaching experiments. There were, for example, about 50 postings during the second year, 25 on the experience of using ICT in co-operative learning.
Evaluation and planning memoranda (13)	A researcher wrote a memorandum and evaluation of each seminar and the previous distance sequence, as well as another on planning for the next seminar and distance sequence. A data projector was used for presentation.
Newspaper clippings (5) and journal articles (4)	These documents presented the project to local areas and distributed the newly-developed teaching methods to other teachers.
The project applications	Produced collaboratively in the launching seminar. Researchers made the first draft and participating teachers added aspects that they saw important. The applications were finalised collaboratively in the first seminar.
Seminar agendas (13)	The teachers who hosted the seminar planned the agenda, taking into account the evaluation of the previous seminar.
Annual reports	The researchers wrote an overview of the project and every participating school wrote a description of their developing efforts. Altogether, three annual reports (of 30 – 50 pages) were written.
Archival records	
Budgets	The FVSSE was a municipalities' project. The researchers helped teachers to draw up budgets for each budget year.
Participant records	Contains information about participation in the seminars. The average number of participants was 23 per seminar (including researchers).
Pupil surveys (2)	A web questionnaire asked school pupils how they saw the use of ICT in science education, how easily available computers were, and how they saw their own ICT competence. Conducted at the beginning and at the end of the project.
Teacher surveys (3)	Annual surveys on the use of ICT and project success, including questions about specific teaching methods.
Interviews	
Group interviews (10)	In the spring of 2002, teachers from participating schools were interviewed. One interview was conducted per school. Altogether, 19 of 24 active teachers were interviewed. They were asked to evaluate the project, their own action in the project, and the outcomes of the project.
Open-ended questionnaires (3)	Teacher surveys included several open-ended questions. Teachers were asked to write evaluations similar to those of the interviews. We used three surveys and two teaching-method questionnaires.
Observations	
Participant observation field notes	Researchers wrote field notes during the seminars about working in the seminar and teachers' descriptions of teaching experiments.
Physical artefacts	
Developed teaching methods	Descriptions of the newly-developed teaching methods were published in the web.
Introduction slides	A researcher or a participating teacher started a discussion on a topic. These slides were available on the Internet.
Teachers' written reports	The final reports of the teaching experiments were available on the Internet.

chemistry and physics teachers. Common for all was that they had interest in the clarification of constraints and opportunities for the use of ICT in science education and the improvement of teaching. All of them joined the project voluntarily. Some participating teachers and researchers had experience on many professional development projects, e.g., already in the eighties on the somewhat similar FINISTE project that was a national sub-project of the UN-initiated INISTE network (Kuitunen, 1996).

Appendix 1 describes the seminars' key issues and their interpretation based on content analysis of case study data (Miles & Huberman, 1994; Yin, 1994; Patton, 2002). In the launching seminar, sponsored by the EIO, participant teachers joined the effort to finalise the project plan. In the project plan, the goals of the FVSSE were: (i) to develop new approaches for science education where ICT can be used in a versatile manner within several teaching methods, (ii) to help science teachers to adopt and develop pedagogical models for utilising ICT in science education (e.g., distance learning), and (iii) to foster collaboration between schools and universities and other institutions in the provision of professional development opportunities for teachers.

Twenty-eight teachers, four researchers, and two invited experts participated in the launch seminar. Nineteen were upper secondary school teachers and nine lower secondary school teachers. Only six were under 40 years old; thus, the level of teaching experience was high. As for their main teaching subjects, seven taught chemistry, seven mathematics, and fourteen physics. At the beginning of the project, there were twelve female participants.

In the first seminar (Appendix 1), participants prepared an application for additional funding to enable researcher participation in all seminars as trainers and facilitators, e.g., helping the teachers to be aware of the innovation. The plan was finalised after the first data collection period in September 2000, where the aim was to clarify the teachers' current use of ICT (Table 3). This can be seen as the first step of the decision process that can lead to either the adoption or rejection of an innovation (Rogers, 1995). Teachers gained knowledge about the ICT use in science education.

In the beginning, the project had features of in-service training. Teachers arrived at the seminar and researchers (as trainers) commissioned tasks to be done at their schools before the next seminar. The goal was to help teachers become aware of the advantages of the innovation through introductory lectures. The researchers tried to influence the teachers' attitudes towards the innovation (Rogers, 1995, 20; Rogers, 2001, 7541). Researchers focused on three viewpoints:

Table 2. The municipalities participating in the FVSSE

Municipality	*Description*
Kiuruvesi	Rgural area in eastern Finland, small indursty.
Oulu	Urban area in northern Finland, high-technology industry.
Helsinki – Vantaa	Capital area in southern Finland, one million inhabitants.
Kauhajoki	Western Finland, rural area, small industry.
Eurajoki	Rural area in Western Finland, a site of a nuclear power plant.

Table 3. Using ICT in different ways for teaching science. Distributions are compared with χ^2 analysis.

Computer application category [e]	*Autumn2000* *n = 25* *Median* [a]	*Spring 2003* *n = 22* *Median* [a]	χ^2 [b) c) d)]
(1) Simulations and modelling systems			
Java applets and other simulations	1	2	5.1*
(2) Multimedia			
e.g., Radiation multimedia	2	2	8.6**
(3) Microcomputer based laboratory	1	2	4.6*
(4) Basic tools			
Word processing	2	3	13.3***
Spreadsheets	2	3	8.1**
(5) Communication applications			
E-mail: teacher – student	2	3	5.9*
Newsgroups and learning management systems	1	2	9.4**
Teachers' web publishing	1	2	13.5***
(6) Databases			
Pupils search information on the Internet	2	3	13.2***

a) 1 never; 2 seldom (1 – 3 times a month or 1 – 10 times a term); 3 occasionally (1 – 2 times a week or 11 – 30 times a term); often (3 – 6 times a week or 31 – 100 times a term); 5 daily (several times a day or over 100 times a term).

b) The groups were combined in the $\chi 2$ analysis to get no zero frequencies and 20% of the frequencies over 5.

c) Situations autumn 2000 and spring 2003 are compared

d) * $p < 0,05$, ** $p < 0,01$, *** $p < 0,001$

properties of innovation that enhance learning, compatibility of the innovation for the present learning concept of the participating teachers, and external pressure to increase ICT use in education.

The first area of development, decided by teachers according to their interests, was learning by reading and writing activities. One of the "sub-" innovations was to use the Internet as a source of information. The challenge was to design assignments for school pupils and students that prevented use of the copy-and-paste method. Teachers were engaged in the development of the innovation from the very beginning of the project. One crucial reason for the chosen development area was that computers in the schools were by that time almost exclusively in computer labs, not in science labs. Thus, learning by reading and writing activities was supposed to be easy to start with (cf. Rogers, 2001, 7542).

Teachers from the city of Oulu arranged the logistics for the second seminar (Appendix 1). These teachers chose the teaching experiments and designed the tasks to be done before the next seminar by themselves. The objective of the introductory lectures was to show the advantages and adaptability of the innovation so that participating teachers could evaluate it (cf. Rogers, 2001, 7541–7542; Rogers, 1995, 11–35). The researcher who introduced the innovation, focused on the values, past experiences and needs of teachers to show that the use of ICT in education is consistent with participating teachers' views of learning. Teachers had the skills to use search engines and word processors, but they needed fresh ideas (such as how to use poems, booklets, databases of local newspapers and so on) for versatile computer use in teaching. The researchers challenged teachers to reflect and study what kinds of practices they already used in their classrooms, what they already knew about ICT in science education, what else they wanted to know, and how they might apply new approaches developed during the project in their everyday teaching.

From the beginning of the project, at the end of each seminar there were collaborative evaluation and planning sessions (see Table 1). Researchers acted as facilitators taking notes of participants' comments and ideas. Various approaches (e.g., the principles of creative problem solving) were followed to promote a positive, non-judgemental atmosphere. For example, there was room for free ideation and all ideas, even absurd or impractical ones, got positive feedback (Parker, 1991; Higgins, 1994, 119). In this way, the lectures and workshops organised during seminars were based on teachers' reflections and suggestions.

After one academic year, teachers started to focus on their own main interest areas. These areas included inter-school learning management system projects, MBL, using simulations or videos, and progressive inquiry. The role of the researchers was to help teachers arrange teaching experiments and make trial runs of the innovation (cf. Rogers, 1995, 11–35). For example, teachers used the course management system of the university. They could consult a researcher on such details as how to design a web course. Researchers provided both technical and pedagogical advice. The objective was to make the innovation less complex and to help the teacher try course management systems (cf. Rogers, 2001, 7542).

In the above paragraphs, the progression of FVSSE was described. Table 3 shows the self-evaluations of participating teachers' use of ICT at the beginning and at the end of the project. This table indicates that there was a positive general development with statistically significant changes in all categories.

Channels of communication structured in the professional development project

The virtual school of science education FVSSE was launched as a professional development project for teachers. The main idea was to create a collaborative community reaching a critical mass to help teachers share and develop their ideas about the use of ICT in science education. According to Rogers (2001, 7540): "Research on the diffusion process shows the essentially social nature of adoption of new ideas. Innovations spread in a population through a process of people talking to others." In the FVSSE our challenge was to create versatile channels for communication about the innovation, which was the use of ICT in science education. Tables 4 to 6 show the channels of communication based on collected data. The tables have been named according to Thompson's (1994) distinction between forms of interaction: face-to-face interaction (Table 4), mediated interaction (Table 5), and quasi interaction (Table 6). These Tables are based on content analysis of the case-study data.

Face-to-face interaction

Plenary lectures. At the beginning of the project, researchers gave lectures on how to integrate ICT in a versatile way in science teaching. They gave an overview and demonstrated several teaching methods such as collaborative work, concept mapping, learning by reading and writing, and practical work in school laboratories. Teachers saw that in principle these lectures were important for further development work. However, some teachers were of the opinion that they were quite familiar with the teaching methods being presented.

I just thought that these lectures were about basic teaching methods. They started from the beginning. What was the objective? Was the goal that everyone speaks the same language? … I think there was a very good repertoire of basic models of teaching, introduced and reviewed. I can't

Table 4. Face-to-face interaction. Case study data were analysed using this categorisation.

Channel of communication	*Description*
Plenary lectures	Teachers, researchers and other experts gave introductory lectures during seminars.
Plenary discussions	Discussions, evaluation, and planning during lectures. Before and after small-group sessions, a researcher led the discussion and wrote memoranda.
Formal workgroups during seminars	Typically, teachers discussed and worked in small groups. Teachers from the same school were encouraged to join different groups. Sometimes groups were formed on the basis of ongoing sub-projects. Teachers were interviewed twice.
Informal discussion groups during seminars	Teachers chatted during lunches, coffee breaks, dinners, excursions, bus journeys, and even in plenary lectures.
Formal workgroups between seminars	Subgroups of teachers from the same school had meetings to plan teaching experiments. In addition, a subgroup of teachers from the capital area planned inter-school experiments. Participating teachers organised local in-service training.
Informal discussion groups between seminars	Teachers on the project in the same school discussed ICT in science education. Participating teachers discussed the topic with other teachers and administrators in their own district. Teachers participated in and communicated with other projects before and simultaneously with the FVSSE.

Table 5 Mediated interaction. Case study data were analysed using this categorisation.

Channel of communication	*Description*
Newsgroup discussion	Between seminars, teachers were asked to write preliminary reports and about their experiences in teaching experiments.
Personal e-mail	Teacher – teacher and teacher – researcher communication.
Course management systems	WebCT was used to plan the inter-school teaching experiment.
Web surveys	Multiple-choice questionnaire (see Table 3) and open questions.

Table 6. Mediated quasi-interaction. Case study data were analysed using this categorisation.

Channel of communication	*Description*
Annual reports	Demanded by the funding institute.
E-post mailing list	Information was easy to send to all participants via a web-form e-mail program.
WWW-based instruction materials	Multimedia for pupils, teaching methods guide, an MBL guide, the home page of the project, and other pages on the Internet.
Publications	Articles in newspapers and in the professional magazine for science teachers.

say that I was aware all of them, even if many of the teaching models were familiar. … Lectures were useful and of high quality. [GA]

There were also teachers, who saw the lectures by researchers to be appropriate and important. Some participating teachers saw – and some did not – the value of the introductory lectures.

As I said earlier, those lectures were super. Like today, concept mapping [given by the second author of this paper]. I had a clue only about concept mapping and we got a lot of theory about it. I had not had time or energy to find material about it. Now, it is seen and we know where to find more on the Net. [GB]

I'm not sure, if they [introductory lectures] need to be so much simplified to this [FVSSE] team. [DA]

Some teachers wanted something else from the lectures, such as one teacher who wanted summaries of the most recent research literature, and another who did not find anything new in the lectures wanted reflection on visions for the use of ICT in science education. A few experts were invited to the seminars to give lectures; they were mainly foreign guests from other projects. Other experts showed up-to-date, high-tech innovations. Some teachers felt that most of the lectures were too abstract or too distant from school practice and teachers even felt anxious about what was expected of them as participants.

The technical aspect [of a learning management system] was too prominent. I'd like to know how to use it. [DB]

Sometimes concreteness and praxis were forgotten. Someone could give a lecture about "what's up" in science education. [NN, open questions, spring 2001]

In the launching seminar, the officer from the National Board of Education spoke with too much complexity and used specific jargon. I'm sure that only about one-third understood something. [GC]

Teachers saw that it was important to formally present, in a lecture format, their experiences from their teaching experiments. Teachers' readiness to take responsibility increased during the project. They presented their experiences and their versions of the innovation. Teachers saw their responsibility and considered the lectures given by their peers very fruitful for the development work.

Teachers are so critical that if we were given a format to proceed – this is the model [to integrate ICT into science education] and that's it – in this project, I'm sure that most teachers would quit. Working models develop all the time and it is wonderful to see how feedback from the previous seminar has been concretised in the current seminar. [GE]

Practical examples [presented by participating teachers] are easy to adopt and further improve on the design. [GF]

During the site visits, the hosts sometimes explained (and the teachers saw) how ICT is used in chemical and physical processes in industry. Unfortunately, some of the introductory lectures before a site visit concentrated on the financial aspects of the operation although the hosts were asked to focus on ICT use. However, teachers found the visits to be important for their work. They could explain something extra – real-world applications of chemical and physical processes – to their students. During seminars, the teachers visited several schools and saw how ICT has been implemented in other municipalities participating in the project. Teachers from the host schools demonstrated their ICT infrastructure. This was interesting to the other teachers.

Our visit to the oil refinery was unpleasant. It was a financial presentation, a good dinner anyway. … Maybe the nuclear power plant visit was most important from the scientific-literacy point of view. [DC]

I most liked seeing how they work in different schools. … It is relieving to see that things are done in a similar way elsewhere. [GH]

It was difficult to find the optimal level for the introductory lectures. Almost always a few teachers thought that the introductory lesson was too difficult, and a few thought that it was too easy. Our intention was to avoid long monologues. We tried to facilitate discussions. Thus, the distinction between a plenary lecture and a plenary discussion is conceptual only.

Plenary discussion. Researchers encouraged teachers to make comments and ask questions during lectures on technical opportunities, technical difficulties, pedagogical values, and any topic they saw as interesting. When someone else was lecturing, researchers asked questions and addressed aspects of the topic relevant to the activities of the FVSSE. Few teachers took part in the plenary discussions; most of them just listened. However, everybody had opportunities to express their ideas in small groups after plenary sessions. They were gradually inspired to participate more and more in discussions. In the evaluation memorandum of the tenth seminar, an unidentified teacher wrote: "We asked plenty of questions [in the plenary discussion during the site visit], more than ever before. We have learned to ask questions." One teacher was disappointed about the lack of feedback. His ideas and teaching experiments were quite radical compared to other teachers' ideas.

The problem is that one can't say clearly: I don't understand you. The critique is hidden in another, wicked form. [GI]

However, teachers positively evaluated the discussions.

The peer group discussion is very important. We have the chance to share ideas, and we get feedback and new ideas. Now we are encouraged by peers to share unsuccessful experiences, too. [NN in final evaluation]

Sometimes a plenary (or small group) discussion theme facilitated generating ideas for other topics.

Now and then, there were plenary discussions and then you get inspiration, something from a sideline, to do that and that while writing notes even if the researcher asks an opinion about the theme of the discussion… [GG]

Still, there were teachers who noticed the importance of the plenary discussions about the topic or about the evaluation and planning of the seminars.

You can get these introductory lectures nowhere. And, if you start to read [books or web materials], you don't get the idea like you get it while discussing in the [plenary or small] group. [GJ]

I respect him [the second author of the paper], how he created the spirit for the project supporting and giving opportunity etc. [GK]

In the end of each seminar, there were discussions about co-operative planning and evaluation. Plenary discussions were arranged before and after formal workgroups and after plenary lectures. During seminars, there was a continuum from plenary lectures through plenary discussions to formal and informal discussion groups.

Formal workgroups during seminars. Typically, teachers discussed how to use some software or promote ICT use in their teaching. They exchanged experiences and redesigned educational innovations and teaching experiments. One important topic in the workgroups was the evaluation and planning of seminars. The teachers wanted more and more small-group working time during the project. They felt that small groups were very appropriate for discussions about innovations, in spite of the ubiquitous lack of time.

It takes a while to create effective group dynamics and to concentrate on the focal point … It's quite seldom that there are only chemistry and physics teachers who get together. You can think and chat on this and that, and everyone understands you. [GL]

The MBL [microcomputer-based laboratory] workgroup showed many aspects I had not understood before. [GD]

This project has given confidence to try many things [innovations related to ICT], first theoretical introductory, then we have collaboratively planned teaching experiments and lastly we have conducted these experiments. [DA]

A few times, we tested a teaching experiment with writing in small groups. It seemed effective, but the teachers did not see reporting to be of such significance that the limited time should be used for that.

In the beginning, we finalised the new material during each seminar. I would not say if reporting is appropriate or not … [GD]

The basic form of the seminars was considered adequate. Plenary lectures and plenary discussions facilitated discussion between the participants on the planning and redesign of the model of ICT, which had been introduced for science education. The seminars included coffee and lunch breaks, and the seminars were held in different locations, so teachers had plenty of time outside of formal proceedings.

Informal small-group discussions during seminars. Teachers continued their discussions about the themes of the previous lectures outside of the lectures. They also discussed general educational themes such as national educational policies, and so on. There were usually at least three locations per seminar: a local school, a site for local industry, and a hotel. Thus, during each seminar, there were ample opportunities to sift through the material. Bus trips in particular were considered very useful. They offered plenty of time to reflect on proceedings and to plan teaching experiments without any pressure to produce something to be presented.

The distance to the steel plant was quite long. It seemed that the long distances to industrial sites was not a handicap. [GH]

The seminars have been very fruitful, even if they are quite intensive. In the FVSSE, we have succeeded in combining effective working and free time. Even free time serves the goals of the project. [NN]

Some teachers hesitated to share their thoughts with everyone. They were sometimes worried that their ideas might not be relevant to the topic. Then they had an opportunity to test their ideas in a small, informal group.

I chatted in the corridor and the general conclusion was that it [learning management system] is not so essential, it does not bring anything new. [GM]

Now and then, we have spoken in whispers; this could be a good idea etc. [GC]

Discussions went late into the night. Themes were typically humorous, but topics hovered around the current seminar or another relevant educational issue such as planning for the next seminar.

The social programme of the seminars was not only for pleasure – we have talked a lot, shared experiences. [GN]

Yes, it [bioenergy plant] would be interesting, but we had to run through all these visits [bioenergy plant, local newspaper, ecological cheese dairy] because there were so many places to see. Well, in the school equipment manufacturing plant we had time to spend the evening. [GG]

While spending time in the lobby, she [DC] phoned the company (with the aim to organise a site visit); it was easy, because she knows the manager so well. [GJ]

Formal workgroups between seminars. Teachers from one school gathered to discuss how to organise teaching experiments. A subgroup of teachers in the national capital area arranged planning meetings.

These meetings with [GD] and others were long-lasting and results were quite [modest], but these meetings stimulated thinking. [GO]

Meetings were excellent; even if the result [inter-school teaching experiment] satisfied almost no one. We had different objectives than the others expected. [GI]

Typically, a few teachers taking responsibility of administrative affairs arranged budget-planning meetings. Overall, teachers rarely met formally (at a mutually agreed time and place) to plan or to reflect teaching experiments (or else they did not inform the researchers about their meetings).

One goal (especially from the point of view of educational policy) of the project was to distribute the results. Teachers organised local meetings where the FVSSE teachers introduced pedagogically meaningful ways to use ICT in science education with their peers in the district.

I organised a training session for about ten teachers on how to use the developed radiation multimedia. [GJ]

Informal small-group discussions between seminars During breaks, teachers talked about teaching experiments, how to use ICT in the school, and how to conduct teaching experiments.

We wonder in the school: what we are expected to do? On the other hand, it helps us to develop the use of ICT. … During breaks, they [two teachers in the same school] worried if this [teaching experiment] was going to work at all. After doing the teaching experiment, they were pleased, and their pupils have given positive feedback. … When we [teachers from the same school] are preparing demonstrations, we talk about the use of ICT, and other topics of the project. … It is an easy way to communicate; we do not have to schedule in advance. [GF]

One teacher found this very difficult, because he was the only physics and chemistry teacher in his school, so he could not discuss the issues with anybody in an informal way. All the other schools had at least two teachers in the project. Despite the number of science teachers in a school, the topics discussed between teachers are often limited.

Well, practical help I have got, mainly we discuss the topic [use of ICT] during seminars. Here [in our school], we have our own topics. [GL]

It has been fruitful to discuss with a colleague [in the same school], what went wrong. [GI]

Other teachers in the same school might ask the FVSSE teachers to say something about the innovation. These discussions could even lead to interdisciplinary co-operation, and some level of subject integration. Teachers helped their colleagues to become aware of ICT in (science) education.

I use web-based instruction material a lot. I try to find applets etc. to show myself and them [other teachers in the school] that in the Web, there is plenty of useful material and I show them ways to use Web materials. [GK]

When chemistry and physics were funded and they were in the spotlight, the status of these subjects rose in the school and in the local administration. Local educational administrators consulted the FVSSE teachers about ICT in education in general.

Our city is buying a learning management system and educational administrators have interviewed me four times to find out what is needed for it. [GC]

In contrast, in the districts without experience with projects like the FVSSE, teachers faced a lot of problems from local administration. The consequence was usually that the teacher who was the link person between school and school administration conducted less teaching experiments. They were very experienced teachers and they were very active in school discussions.

My role in the project [on the school level] is that I communicate with administration and the others understand the topic. [DC]

On the other hand, the differences between the teachers' values and the school's working culture may be too many and too big. Consequently, other teachers may not be interested in the innovation.

We have shared materials [with other teachers]. We have rarely received any feedback. [GA]

We have laughed that we do not have normal office hours in the school, but others do. Thus, we have not pressed our experiences on them. [GN]

Many teachers had participated in a development project before the FVSSE. These teachers were more ready to start new development work. They had experience in how to manage the changes and what is essential in development projects in general. When a teacher participates in one project, it is easier to join another project.

This virtual school project was for the facilitator to say: 'yes, I'll join that project' [chemistry and home economics integration]. [DA]

So perhaps I have joined too many projects, perhaps I should in the meantime develop myself. [DC]

Many teachers participated in other projects in parallel with the FVSSE. Teachers were active in the pedagogical association, in textbook writing, in the national core curriculum renewal project, and in professional development projects or in giving in-service training courses, even at the district level.

Mediated interaction

Newsgroup discussion. Almost all participating teachers wrote and posted reports on their experiences of teaching experiments at least once to the newsgroup of the FVSSE. However, only a small number of teachers were active in the discussion.

The newsgroup, in the beginning it worked quite well. Now it doesn't work. Is it so that the conducted discussion had no consequences? … We have to find a tool for communication between seminars. [GI]

Some teachers felt guilty because they were not actively writing in the newsgroup. On the other hand, the teachers felt that long-distance communication needed improvements and they saw its potential. The teachers suggested that a facilitator was required.

We need more detailed guidelines, it is difficult to give comments if it is not possible to write anonymously. It is also a problem when one does not know with whom they are talking. We need a leader or a facilitator, it is good to comment on others' comments. [NN, Evaluation session in the end of the second seminar]

We have more co-operation, but why there is no functioning discussion in the newsgroup? Obviously, people are not meant to have discussions on a keyboard. Obviously, there was no urgent need for discussion. [NN, the final evaluation discussion]

The newsgroup has not functioned exactly as it was [planned] or I do not know if there were any expectations. Some people have submitted their reports there. Commenting has been restricted to a few people, a faithful few who have written reports there, if they promised to do so. However, they do not write comments. [GG]

When some of the more active teachers posted messages on the newsgroup, the majority of the participating teachers did not comment or give feedback. However, they frequently read the newsgroup postings.

In the beginning, we always circulated the summaries of our formal meetings between seminars, but there were no comments. It is rather difficult to react, when one knows nothing about what other people have thought, said, or written. It is like writing a message in a bottle. Probably somebody will read it, but certainly there will be no *feedback. Although we had a channel for giving feedback, we did not use it. [GI]*

It is easy to read a paper in a newsgroup, but I have it so difficult to write comments like 'Hi, well done!' I could do it but I am not used to do so. Better yet would be 'you could add to it …' or would you mind if I steal your idea and add this …?' It could be a way to create something new in the Net! [GG]

It is so much easier when we are face-to-face during our meetings! [GL]

Teachers felt that writing and making comments on the newsgroup was very difficult. One teacher evaluated the discussion and he felt that it was difficult to decide how much contextual information was needed so that the discussion made sense. He felt that others do not understand his ideas, even when face-to-face.

The problem is how to share all you think. How do you 'say' essentials and how do you show that you have understood others' writing. How do you write facial gestures? How much more writing is needed? … Even during face-to-face discussions, it is quite difficult to get productive feedback. [GI]

Personal e-mail. The teachers planned and evaluated seminars, teaching experiments, and educational ICT innovations. The researchers supported teachers in conducting teaching experiments and with advice on how to write an annual report. A template for teaching experiment reports was prepared to help the teachers in their writing efforts. Teachers preferred e-mailing for mediated communication.

These contacts are created when there are reasons for them. When one has this kind of real co-operation, there are reasons to send e-mail. One does not send greetings here. [GE]

Course management systems. A subgroup of teachers tested and evaluated a course management system to share documents while planning the inter-school teaching experiment. They found it frustrating, because the course management system was too clumsy and the benefits were rather limited. It was easier to build simple web pages or use e-mail attachments.

Furthermore, I'd like to have more co-operation between schools, for instance using user-friendly platforms. [NN, open question in teacher survey 2002]

I have waited for more virtuality … to have virtual contacts with other schools. [DB]

Web surveys. The teachers were also asked to evaluate themselves within the context of the project. They had to reflect on how they understood the innovation and how they evaluated the project and their own adoption of the innovation. The teachers listened very carefully to each others' reflections.

It was a big surprise to receive this questionnaire [on using reading and writing activities]. Perhaps it was why the return percentage was lower than usual, we wondered what this actually is… [GA]

When we filled in the questionnaire, we certainly used less time than you [the researcher] reading it. [NN, feedback for analysis of teacher survey 2001]

Mediated quasi interaction

Annual reports. Teachers reported their experiments and other activities at the school level (Table 1). Researchers polished the annual reports for submission.

E-post mailing list. Mostly the researchers sent information via the e-mail distribution list about seminars, applications, annual reports, and so on, to help in the administration of the project. A group of teachers organising a seminar sent informative e-mail about logistics and other practicalities. A few times, a small number of teachers sent messages to inform the others that they had published something for others to comment on. A few teachers posted messages on the newsgroup, which were distributed using the e-mail list.

I submitted the last request and guidelines for experimenting with the Web materials on nuclear energy. See the newsboard message dated 18th August! We'll meet in Eurajoki. The group from Kiuruvesi will arrive already by Thursday night, so we might go sightseeing. [GJ]

WWW-based instruction materials. A subgroup of teachers was contributing as authors to the design of radiation multimedia produced by the EIO. One teacher who already had an M.Sc. degree completed his Master's thesis for his M.Ed. about design of the teaching materials. Other teachers tested and commented on the multimedia product. We utilised the teachers' reports when we further developed the web-based teaching guide for science teachers. The teachers' reports were available for viewing on the FVSSE homepage. The MBL-guide, developed at our Department was introduced to the teachers. They talked about ready-made simulations and other contents available on the Internet, which could be utilised in science education.

Free, easily-available learning materials, guides for demonstrations and practical work etc. were probably rather useful. [NN, teacher survey, 2002]

If students do a project and find materials on the Internet, the outcome is messy, it does not convince that anybody understood a thing. The Net materials on nuclear energy were produced with intensive effort. And it worked! [NN, final evaluation]

Or the introductory lessons were good enough, but the slides could have been available in the Net so that we could have seen them in advance and used them as background material for discussions. [GO]

There [fourth seminar] we made acquaintance with Applets available on the Internet, they were useful and I have used them in my work. [GA]

In everyday work I have noticed that I need more skills in editing Web pages. Ready-made materials are not necessarily good [for pupils]. The Web server of the City *does not allow easy access, but the door is open. [GI, evaluation memorandum, 10th seminar]*

Publicity. The FVSSE seminars were noticed by local newspapers. The teachers were quite pleased about the increase in public awareness and respect. We wrote articles on how to use ICT in science education based on the teachers' reports, which were published by the pedagogical association of science teachers. Local teachers seemed to be quite satisfied.

Due to the project we have got money and positive publicity in local newspapers. [NN, final evaluation]

DISCUSSION

The purpose of this research was to evaluate the efficiency of communication channels during a project in which subject teachers developed versatile uses for ICT in science education. We particularly wanted to discover how different communication channels appeared to teachers, as how effective they evaluated them, and how the channels seemed to promote the adoption of ICT in science education.

Participating teachers' self evaluation indicated that they had increased their use of ICT in every tested computer application category. Thus, the project appeared successful, and the description of the project can be considered a positive research result, providing features of efficient professional-development projects (see also Lavonen, et al., 2006). The chosen strategy to gradually increase teachers' responsibility for the progress of the project appeared to be an important aspect for the participators' full engagement. Our analysis of communication channels showed the efficiency of face-to-face communication. The interpreted importance of mediated interaction or mediated quasi interaction appeared to be unexpectedly low. An analysis of the face-to-face communication channels indicated that informal communication on the adoption of ICT in science education was surprisingly important. In summary, the present research, which explored communication between teachers about ICT in science education during a three-year development project, indicated that face-to-face interaction are interpreted the most significant form of communication. During informal small-group discussions teachers could share their ideas about pedagogical aspects of the innovation. This perhaps helped teachers to shape their values and attitudes positive towards ICT use in science education.

Teachers participating in the FVSSE identified problems which limited the use of mediated communication similar to those reported by Ferraris, Manca, Persico, and Sarti (2000). One of these problems is the fear of criticism associated with the public and written nature of communication. In the FVSSE, the newsgroup discussion was open to anybody with Internet access. Because the project was publicly funded, openness was required as a matter of policy. Publicly mediated communication was also supposed to help in avoiding criticism that this project were too closed to other than participating teachers. The Internet offered here better tools than what were available to the FINISTE project (Kuitunen, 1996). Our experiences differ with Ferraris et al. (2000) with regards to which tools were used. In the beginning of the FVSSE, the mediated communication channels were the newsgroup and personal e-mail. Participating teachers were familiar with those media. However, teachers frequently indicated a desire for a communication medium only available to participants. Therefore, a subgroup of teachers used a learning management system for collaborative knowledge building in teaching experiment design, but found the tool clumsy. Trainees in the Ferraris et al. (2000) project met face-to-face once a week. Thus, they waited for their face-to-face meetings and ignored mediated communication. We found a similar tendency in the FVSSE. Participating teachers preferred face-to-face communication, even though they only met face-to-face twice each term. Teachers participating in the FVSSE could not overcome the restrictions of mediated communication. Perhaps they did not become familiar with adding contextual information to their newsgroup messages (cf. Thompson, 1994).

Even if it was expected that face-to-face communication would be perceived as more significant than mediated interaction or mediated quasi-interaction, the strong preference for informal discussion groups was unexpected. As described above, the project had many features of a traditional in-service training course in the beginning. A group of teachers, previously unknown to each other, gathered together to listen to lectures and participate in workshops.

We arranged the formal workshops in such a way that teachers from the same school were in different groups. In a free-choice situation, individuals tend to interact with those who are very similar, forming homophilous groups (Rogers, 1995, 19). We expected that participants would share a mutual (science teacher) language and a common understanding, which would ensure effective communication. Thus, we thought that this was enough, and the teachers were not too similar to each other. It turned out that the teachers' views of learning were quite different, their ICT capability varied, and ICT availability differed widely between schools. Therefore, at the beginning of the project, teachers spent coffee breaks, lunches, site visits, and other informal discussion time mostly with their colleagues from the same school. During the project, teachers got to know each other, and they continued working with the formal workgroup themes in informal situations.

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They shared information about the innovation and started to develop their own ideas about it. This change from very homophilous to more heterophilous groups demonstrates the importance of providing a good mix of formal workgroups and opportunities for informal discussions.

Our experiences suggest that opportunities for informal discussion should not be only during breaks in the programme, but that they should be written into the schedule. If, for example, coffee breaks went on too long, teachers might feel the agenda is too loose. The plainest example of the FVSSE might be bus trips. In the seminar held in the city of Oulu, we had a site visit at a steel plant. The visit was the only reason for travelling together by bus (the trip from the city centre to the plant took about one hour). In the bus, two to four persons could easily talk together and continue planning and chatting during the visit. In addition, a social programme easily creates a positive atmosphere. During dinner, it is easy to make silly or unreal suggestions for new innovations. The informal atmosphere of dinners proved to be particularly facilitative in the sharing of information. At these times, teachers often shared their ideas for nationally or locally important aspects of the project. They had a feeling that they could have influence on many levels: at the school level (teachers in the same school), at the district level (core curriculum of the municipality, local projects), at the national level (textbooks, the matriculation examination, renewal of the national core curriculum, pedagogical associations, teacher education) and even at the international level (international surveys such as PISA or ROSE and participation in international conferences). Such ideas encouraged teachers to be active developers rather than passive implementers. They formed a critical, but collegial and supporting, community in which they could share and distribute expertise.

During the journey home, teachers from the same school had plenty of time to discuss and plan teaching experiments. Therefore, the programmes should be attractive and pleasant enough that teachers will repeatedly spend their Saturdays travelling. In the FVSSE, teachers collaboratively planned seminar programmes this way. They even waited enthusiastically for seminar weekends. Finding an optimal itinerary for each programme was important, because content was the reason for teachers to leave their pupils with substitute teachers and even to participate in the whole project.

Although face-to-face interaction appeared to be successful, mediated interaction was not. Experiences in the project indicate that mediated interaction (or mediated quasi-interaction) requires a clear and shared motive for communication. In pre-service training, students can be required to communicate by newsgroups and social media applications, but in in-service training, which is based on the free will of the participants, communication is based on intrinsic motivation. If mediated communication as such is considered important, there has to be some way to stimulate intrinsic motivation. A key could be collaborative development work with clear shared goals.

Another reason for the lack of participation in mediated social knowledge building could be the fact that teachers had to develop ICT in science education while they were still novices with ICT themselves. Even if this was the case, the teachers felt that the efficiency of mediated communication was low: they strongly criticised web pages, newsgroups, platform for knowledge building, and e-mail distribution lists. They talked about how to improve mediated communication without finding a solution. Their general opinion of the web materials was positive, although they rarely studied them before the seminars. This indicates that Internet resources are useful in the right context. These resources should be ready to use, if needs are apparent.

The fundamental goal for the professional development of teachers is that their pupils will learn better. When teachers participate in projects they see as meaningful, they are likely to be more enthusiastic and it is likely to have a positive influence on their students. Teachers were given autonomy in budgeting and in the content of the project: they learned what it was like to be an empowered member of a development project (see Lavonen et al., 2006).

Our intention was to describe the progress of the project in as much detail as possible, in order to ensure the transferability of results. Thus, it could be possible to evaluate how well the project and the conclusions of the present paper correspond with the reader's cultural and educational context. Table 1 and Appendix 1 show a summary of the whole project (cf. Miles & Huberman, 1994, 90–142). The data show the triangulation approach which is one of the essential features of our research project. We report in another context (Lavonen et al., 2006) that the FVSSE was successful in reaching its goals as a professional development project.

The main lesson learned is that professional development projects for teachers should not put too much weight on mediated interaction between teachers. Conversely, the present case indicates that more emphasis should be placed on providing opportunities for informal communication.

Acknowledgements

Special thanks to all participating teachers and schools. The in-service training activities in the context of the Finnish Virtual School for Science Education was funded by the Finnish National Board of Education, and the municipalities of Vantaa, Kiuruvesi, Oulu, Kauhajoki, and Eurajoki. We are grateful to all of the companies which hosted the site visits for their kind hospitality. Thanks are also due to the Economic Information Office for their support of the project

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Appendix 1. Contact meetings (seminars) of the FVSSE. Key issues derived from the case study data and interpretation of the effect of the key issue for the progress of the project

Seminar	*Key issues*	*Interpretation and comments*
2000		
Launching seminar	The EIO sponsored the preliminary seminar. The project application was drawn up in the seminar.	Many teachers were very confused. Neither they nor the researchers knew what to expect. The project had features of in-service training.
Seminar 1 [Tampere]	In the first seminar, distance tasks were distributed to the teachers. The first development area was learning by reading and writing. Preparation of the training fund application so that the researchers could travel, and thus participate in seminars as "trainers".	Many teachers were anxious. Lectures given by outsiders (researchers from the Technical University of Tampere) seemed to be too abstract and introduced innovations too radically. On the other hand, some teachers found the lectures very interesting.
Seminar 2 [Oulu]	The first industry visit to the hi-tech company. Introductory lecture of the first survey. Finalising the reports of the teaching experiments and reflecting present teaching practices in small collaborative groups. Discussion of the first survey of the teachers' and students' ICT competence and use of ICT in science education	The working model of the project was ready. The first day of the seminar in the company offered lunch, coffee, and dinner and free use of seminar halls. Second day, Saturday, in the local school: Short lectures and working in collaborative groups and reflections.
Seminar	Key issues	Interpretation and comments
2001		
Seminar 3 [Helsinki – Vantaa]	The second area for development was ICT in practical work. Visitors from Scandinavian and Baltic countries introduced ICT instruction materials.	There were too many visitors. The schedule was too tight and people felt they had to hurry all the time. The discussion was not very reflective, although it took place in small groups.
Seminar 4 [Kauhajoki]	A participating teacher gave an introductory lecture for the first time (on the use of Java applet simulations in physics education). A template for teaching experiment reports was introduced to the teachers. The hosts introduced development projects underway in the municipality. Progressive inquiries using learning management systems.	Teachers from urban areas (Helsinki, Vantaa, and Oulu) saw that in the rural area, there were high-quality development projects in education and in industry. Some of these projects were financed by EU structural funds.
Seminar 5 [Eurajoki]	Teachers' presentations of their development projects at the school level. Introductory lectures about the teachers' self-evaluations of the first year of the FVSSE. A subgroup of teachers started to collaborate to develop inter-school teaching experiments. Visit to the nuclear power plant.	Teachers saw how peers had interpreted and implemented ICT in science education (ICT in reading and writing, practical work, and distance learning). Teachers concentrated in one or two development areas. Researchers' role was to help teachers conduct teaching experiments.
Seminar 6 [Kiuruvesi]	The teachers were responsible for the programme. The first long distance bus drive to the site visit. Introductory lecture about collaborative work by a local teacher (PhD in education and the principal of the school).	During the bus trip, a subgroup of teachers decided to start designing a collaborative teaching experiment using WebCT. Distance communication was frequent during the winter.

Seminar	*Key issues*	*Interpretation and comments*
2002		
Seminar 7 Helsinki	Co-operation with the EIO to further design radiation multimedia (www.tat.fi/2003/nuoriso_ja_koulupalvelu/verkkokoulu_ydinasiaa.shtml). Teachers presented the results of their collaborative teaching experiments. Long bus drive to the location of the site visit.	The presentation at the site visit was financially oriented. Thus, it did not meet the interests of the teachers, which are ICT in industry or physics and chemistry in the industrial processes.
Seminar 8 Oulu	Site visit to a steel plant and a dinner in the plant's reception room. Preparing reports on the teaching experiments. Long bus trip to the site visit. Two teachers prepared a poster for an international conference See www.girep.fysik.lu.se/abstracts/abs	The teachers recognised the uniqueness of the project. There were textbook writers, members of the Committee for Renewal of the National Core Curriculum, etc. Over sixty per cent of the teachers also participated in some other project.
Seminar 9 Vantaa	Teachers from the city of Vantaa organised a reflective discussion about the project. Teachers presented their focus areas (use of modelling in chemical education, video editing). A visitor from Israel presented a web-based instruction project.	The researcher's role was to participate and to write the memorandum. Teachers recognised that the project seemed to meet high international standards. Teachers had taken the responsibility of the project from the planning to the reflection phase.
Seminar 10 Kauhajoki	Teachers from the city of Kauhajoki organised a programme showing the wide variety of ongoing educational development projects in the district. Long bus trips.	Local development projects offered issues for teachers to reflect on in informal groups during bus journeys. Researchers were needed to help teachers in their critical reflection.
Seminar	*Key issues*	*Interpretation and comments*
2003		
Seminar 11 Eurajoki	Presentations of the ICT innovations. Planning the distribution of the project results.	Teachers saw themselves ready to organise local in-service programmes. Teachers planned a subsequent project for FVSSE.
Seminar 12 Kiuruvesi	The last seminar. Visiting a brewery and a hi-fi speaker factory. Planning the dissemination of the project outcomes. The final self-evaluation of the project.	Planning the distribution of project results. A subgroup of teachers decided to apply for further funding for a project where subject teachers would help class teachers start to teach physics and chemistry. This was important since the renewal of the Finnish National Core Curriculum will introduce physics and chemistry to be taught in primary schools.