



ESSI RYYMIN

## Teachers' Intelligent Networks

Study on Relationship-based Professional Development  
supported by Collaborative Learning Technologies



ACADEMIC DISSERTATION

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*People who dialogue can gain insights that could not be achieved individually (Senge, 1990).*

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May 2008, Essi Ryymin

## **Abstract**

Four studies investigated teachers' professional development in the context of implementing collaborative learning technologies in teaching. The studies investigated teachers' professional development especially in the context of implementing a pedagogical model of technology-supported inquiry learning, participating web-based knowledge building with other teachers, and sharing knowledge related to Information and Communication Technology (ICT) in the networks of a teacher community.

The first study (Article I) explored how pedagogical innovations of technology-supported inquiry learning should be disseminated and consolidated in the long-term practices of schools. The goal was to learn what possibilities, challenges and problems teachers confront when implementing technology-supported inquiry learning. The findings indicated that the experiences and practices of technology-supported inquiry learning can be transferred to everyday school life when pedagogical, technical and organizational factors support teachers in the implementation. Especially true is that teachers require pedagogical guidance and support not only during, but, if needed, after development projects.

The second study (Article II) investigated what possibilities, challenges and problems teachers confront in using synchronous, web-based knowledge building in their in-service training and what kind of advantages a web-based learning environment may offer to teachers' collaboration. The findings of the study showed that synchronous web-based knowledge building, which is based on clear, authentic, real-life problem statements, may support teachers' collaborative problem-solving and professional development in a meaningful way. In addition, a web-based learning environment may provide, as a collective memory and a platform for shared writing, a unique possibility for the development of teacher communities.

The goal of the third study (Article III) was to learn in what kind of networks teachers share knowledge of web-based learning and what are the factors in the community that support or challenge teachers' professional development. The findings of the study revealed that there were teachers who are especially active, the so-called "central actors", in the teacher community who dominated and shared knowledge of web-based learning. Their networks included both internal and external relations in the community and involved people, technologies and a variety of media. The factors that supported teachers' professional development in the community were; the possibility to learn from colleagues and from everyday working practices, an emotionally safe atmosphere, the leader's personal support and community-level commitment. Also, the flexibility in work planning, challenging pupils, shared lessons with colleagues, training events in an authentic work environment and colleagues' professionalism were considered meaningful. As challenges in professional development, teachers reported organizing time and facilities and the need for peer support amongst others.

The purpose of the fourth study (Article IV) was to examine the network structure of a teacher community in relation to their use of Information and Communication Technology (ICT). The results revealed that there were a few central actors in the community who dominated technical and pedagogical knowledge exchange and to whom their colleagues actively turned when seeking advice. These actors also tended to have their own external networking relations that helped them keep up their high level of competence. The community members' ICT-related egocentric networks were very personal and complex and differed in size, density and media use. In further, there were some actors central in the network of informal interaction that were, simultaneously, peripheral in

ICT-related networking activities. On the other hand, the central actors of ICT were not necessarily the socially central persons in the community.

Together these four studies indicate that teachers' professional development related to the implementation and the use of collaborative technologies is a complex phenomenon. Teachers' professional development is related to interactive relationships with other teachers and in personal and community-level networks that include not only colleagues and other actors but also technologies and media. The collaborative learning technologies may support the networks and the professional development innovatively. On the basis of the studies, it is suggested that teachers' professional development should be reflected in close relation to teachers' networks and the use of collaborative technologies. These three elements; *professional development*, *networks of relations* and *use of collaborative learning technologies* could be advanced and developed together and called as *teachers' intelligent networks*. Teachers' intelligent networks may offer especially for teachers' in-service training new perspectives and empowerment.

**Keywords:**

teachers' professional development, collaborative learning technologies, web-based learning, phenomenography, social network analysis

## Tiivistelmä

Tämän tutkielman neljä artikkelia käsittelevät opettajien ammatillista kehittymistä yhteisöllisen teknologian soveltamisen kontekstissa. Artikkeleissa on tarkasteltu opettajien ammatillista kehittymistä esimerkiksi projektissa, jonka aikana opettajat sovelsivat tutkivaa verkko-oppimista opetukseensa sekä kehittämishankkeessa, jossa opettajat osallistuivat verkossa tapahtuvaan yhteisölliseen tiedonrakenteluun. Lisäksi on lähestytty opettajien ammatillista kehittymistä tutkimalla opettajayhteisön tieto- ja viestintäteknikan opetuskäyttöön liittyviä tietämyksen jakamisen verkostoja sekä etsimällä ammatillista kehittymistä tukevia ja haastavia tekijöitä opettajayhteisöstä.

Ensimmäisessä tutkimuksessa (I artikkeli) selvitettiin kuinka tutkivaa verkko-oppimista voisi vakiinnuttaa koulun käytänteisiin kehittämisprojektin päätyttyä. Tutkimuksen tavoitteena oli saada selville minkälaisia mahdollisuuksia, haasteita ja ongelmia opettajat kohtaavat soveltaessaan tutkivaa verkko-oppimista opetuksessaan. Tulokset osoittivat, että tutkivan verkko-oppimisen kokemukset ja käytänteet voidaan omaksua jokapäiväiseen opetukseen, jos uuden pedagogisen mallin käyttöönottoa tukevat sekä pedagogiset, tekniset että organisaatiotason tekijät. Opettajat tarvitsevat erityisesti pedagogista ohjausta ja tukea omassa työssään kehittämisprojektin jälkeen.

Toisessa tutkimuksessa (II artikkeli) tutkittiin miten opettajat kokevat synkronisen verkkotiedonrakentelun osana täydennyskoulutusta ja minkälaista hyötyä verkko-oppimisympäristö saattaisi tarjota opettajayhteisöille. Tulosten mukaan hyvin ohjattu synkroninen verkkotiedonrakentelu, joka perustuu selkeästi määriteltyyn ja autenttiseen ongelmaan, voi edistää opettajien yhteisöllistä ongelmanratkaistua ja ammatillista kehittymistä merkityksellisellä tavalla. Lisäksi verkko-oppimisympäristö voi tarjota ainutlaatuisen työvälineen opettajayhteisöjen kehittämiselle tarjoamalla yhteisölle kollektiivisen muistin sekä foorumin jaetulle kirjoittamiselle.

Kolmannen tutkimuksen (III artikkeli) tavoitteena oli saada selville minkälaisissa teknologioihin ja sosiaalisiin suhteisiin perustuvissa verkostoissa opettajat jakavat erityisesti verkko-oppimisen tietämystään. Lisäksi selvitettiin mitkä tekijät opettajayhteisössä tukevat tai haastavat opettajien ammatillista kehittymistä. Tutkimustulosten mukaan yhteisöstä löytyi keskeisiä toimijoita, jotka olivat erityisen aktiivisia verkko-oppimiseen liittyvässä tietämyksen jakamisessa. Keskeisten toimijoiden verkostot käsittivät sekä työyhteisön sisäisiä että ulkopuolisia vuorovaikutussuhteita ja sisälsivät ihmisten lisäksi erilaisia työvälineitä ja medioita. Tekijät, jotka edistivät opettajan ammatillista kehittymistä yhteisössä, olivat mahdollisuus oppia kollegoilta ja jokapäiväisistä työskentelyrutiineista, emotionaalisesti turvallinen ilmapiiri, rehtorin henkilökohtainen tuki ja yhteisötason sitoutuminen kehittämishankkeisiin. Myös joustavuus työajan suunnittelussa, haastavat oppilaat, yhteiset oppitunnit kollegoiden kanssa, koulutus omassa työskentely-ympäristössä ja kollegoiden ammatillisuus koettiin merkityksellisiksi oman ammatillisen kehittymisen kannalta. Ammatillisen kehittymisen haasteiksi voivat muodostua esimerkiksi ajan ja välineiden riittämättömyys ja tarve vertaistuelle.

Neljännessä tutkimuksessa (IV artikkeli) selvitettiin opettajayhteisön verkstorakenteita liittyen tieto- ja viestintäteknikan opetuskäyttöön. Tutkimustulosten mukaan opettajayhteisössä oli muutamia keskeisiä toimijoita, jotka dominoivat sekä teknisen että pedagogisen tietämyksen jakamista ja joiden puoleen heidän kollegansa aktiivisesti kääntyivät tietoa etsiessään. Keskeisillä toimijoilla oli omia työyhteisön ulkopuolisia verkostojaan, joiden avulla he ylläpitivät omaa melko korkeaa osaamistasoaan. Yleisesti ottaen opettajayhteisön jäsenten tieto- ja viestintäteknikan opetuskäyttöön liittyvän tietämyksen jakamisen egosentriset verkostot olivat hyvin persoonallisia ja kompleksisia ja erosivat toisistaan muun muassa koon, tiheyden ja medioiden käytön perusteella.

Lisäksi ilmeni, että jotkut opettajat, jotka olivat sosiaalisen vuorovaikutuksen verkostoissa keskeisiä, saattoivatkin samanaikaisesti olla tieto- ja viestintätekniiikan tietämyksen jakamisen verkostoissa reuna-alueilla. Toisaalta tieto- ja viestintätekniiikan keskeiset toimijat eivät välttämättä olleet yhteisönsä sosiaalisesti keskeisimmät opettajat.

Yhdessä nämä neljä tutkimusta osoittavat, että opettajien ammatillinen kehittymien yhteisöllisen teknologian soveltamisen kontekstissa on kompleksinen ja monimuotoinen ilmiö. Opettajien ammatillinen kehittyminen liittyy vahvasti vuorovaikutussuhteisiin toisten opettajien kanssa ja se tapahtuu henkilökohtaisissa sekä yhteisötason verkostoissa, jotka eivät sisällä ainoastaan kollegoita vaan myös erilaisia teknologioita ja medioita. Yhteisöllisen teknologian avulla on mahdollista tukea sekä opettajien verkostoja että ammatillista kehittymistä innovatiivisesti.

Tutkimusten perusteella ehdotetaan, että opettajien ammatillista kehittymistä tulisikin tarkastella suhteessa sekä opettajien keskinäisiin verkostoihin että yhteisöllisen teknologian käyttöön. Nämä kolme toisiinsa nivoutunutta elementtiä eli *opettajien ammatillinen kehittyminen*, *verkostosuhteet* ja *yhteisöllisen teknologian käyttö* on mahdollista ymmärtää myös yhdessä kehittyväksi ja kehitettäväksi kokonaisuudeksi, jota voidaan kutsua nimellä *opettajien älykkäät verkostot*. Opettajien älykkäät verkostot voivat tarjota erityisesti opettajien täydennyskoulutukselle uusia voimavaroja ja näköaloja.

**Avainsanat:**

opettajien ammatillinen kehittyminen, yhteisöllinen oppimisteknologia, verkko-oppiminen, fenomenografia, sosiaalinen verkostanalyysi

## List of original publications <sup>1</sup>

- I Ryymän, E., Veermans, M. & Lakkala, M. (2005). Dissemination practices of technology-supported inquiry learning. *Learning the Skills, Special Edition of The Finnish Journal of Vocational and Professional Education*, 65-85. <sup>2</sup>
- II Ryymän, E. (In press). Web-based knowledge building and teachers' professional development. In T. Varis (Eds.) *Online Education and Professional Development*. Saarijärven Offset-paino: Saarijärvi.
- III Ryymän, E., Lallimo, J. & Hakkarainen, K. (In press.) Teachers' professional development in a community: a study of the central actors, their networks and web-based learning. *E-learning and education (eleed)*. <sup>3</sup>
- IV Ryymän, E., Palonen, T. & Hakkarainen, K. (2008). Networking relations of using ICTs within a teacher community. *Computers & Education*, 51(3), 1264-1282. <sup>4</sup>

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<sup>3</sup> The authors designed the study together. The first author collected and analysed the data, interpreted the results and wrote the manuscript. The second and the third author provided theoretical and methodological guidance during the research process.

<sup>4</sup> The first author collected and analysed the data, interpreted the results and wrote the manuscript. The second and the third author provided theoretical and methodological guidance during the research process and contributed to the study design.

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## **1. Framework for Teachers' Intelligent Networks**

### **The Goals of the Study**

My goal in this study is to acquire new knowledge about teachers' professional development in the context of implementing collaborative learning technologies in teaching and to present new perspectives on teachers' professional development through their networks of relationships. My approach is to focus on teachers' experiences and social interaction relations. The main aim of this study is to answer the question, "How do teachers contribute to each others' professional development in their working environment when implementing collaborative learning technologies?" Furthermore, I am aiming to find answers to the questions of how to support teachers in transferring experiences and practices from the development projects of collaborative technologies to everyday schooling and how to benefit collaborative learning technologies in teachers' professional development. In addition, my objectives are to highlight what kind of network structure may exist in a teacher community as regards the use of information and communication technologies (ICT) and to reflect, how this network structure may support or challenge teachers' professional development? I also examine what kind of media teachers use in their social interaction in this study.

I hope that the results of this study offer new views to the discussion on how to use collaborative learning technologies in teachers' professional development more efficiently and how to help teachers to transfer experiences and practices generated from development projects to everyday schooling.

Educational discourse usually treats the school as a bounded system, a container of classroom processes and curricular texts, an institutional shell waiting to be filled by the actions of teachers, students and administrators. Teaching has traditionally offered quite an isolated working environment and a "flat" career profile which does not contain the same range of opportunity that is generally available, for instance, in a business setting. The post-modern business career often features even more pace and variety, while education remains relatively unchanged. (Ruohotie, 1999; Fullan 1996; Hargreaves, 1996.) Application of the research into professional development

in interaction, knowledge sharing and networking requires, therefore, a consideration of the unique circumstances of school environment in public school systems.

The public (state run) school system is still a virtual monopoly which operates largely as it has for many generations; it is quite hierarchical and relatively static. Consequently, teachers' growth and development largely depends on their own motivation and possibilities rather than an organizational structure or intention. However, currently, as schools become more open through the impact of technology and the influence of societal change, the narrowness of this reality is changing. (Ruohotie, 1999.)

New perspectives offered by professional development in interaction, knowledge sharing, knowledge communities and networking, mainly applied in business settings, have relevance in teachers' professional development too. Teachers' work, in the transformation with ICT, is more and more knowledge intensive and such concepts as knowledge, expertise and competence characterize teachers' activity throughout their working lives. For example, teachers are required to develop several new conceptual artefacts, such as *information strategy of the school*, which takes up their working time and intellectual resources to a larger extent than before. Regarding this, it is also essential to know how such pedagogical communities, which focus on creation of new knowledge and novel social practices, function and how these kinds of communities can deliberately be cultivated. (Hakkarainen, Palonen, Paavola & Lehtinen, 2004.)

Also, a teacher's personal life, formal and informal relations and accumulation of experience all affect her or his work behaviours. This is one of the realizations that broaden the perspective on professional development of teachers from individual achievements to a larger framework of relations, where professional development is contributed to by the interaction of relationships of networks. In addition, the networks of teachers do not consist of people only, but also mediative tools and other intelligent artefacts and this establishes the need to reflect the social networks in an innovative frame of reference of intelligent networks of relations. (Hakkarainen, Lonka & Paavola, 2004.)

The "Teachers' Intelligent Networks" is divided into four chapters. In the first chapter, I find it meaningful to have an overview on the latest findings on career research, sociocultural turn in studying professions, collaborative technologies and teachers' professional development in collaboration for re-defining teachers' professional development. These writings form the

theoretical framework for my studies. At the end of the chapter I draw the synthesis of the theoretical frame of references and present in more detail the key concepts of this study, which have had a particular role in my process of comprehending, defining and re-defining the phenomena under examination (see in Tables 1-3). In the second chapter I introduce the methods of the study, the phenomenography (Marton, 1988) and social network analysis (Scott, 1991) and describe the processes of data gathering and analysing. In the third chapter, I represent an overview of the empirical studies, and in the fourth chapter, I report the study results. In this last chapter, I also present my conclusions and ideas on the basis of the study results how teachers' professional development could be seen innovatively as *relationship-based professional development*, which cannot be considered as separate from *teachers' social networks* and the *development of collaborative learning technologies*. Instead, these three fields should be seen as the overlapping elements of *the teachers' intelligent networks*.

### **Professional development and sociocultural turn**

The days when teachers entered their classroom, closed the door and got on with teaching, to be visited only on occasion by inspectors, are gone. There is now an emphasis on self-evaluation, reflective practice and continuing personal and professional development in teacher's profession (Neil & Morgan, 2003). According to Beairsto (1996) intellectual development involves an extension into the unfamiliar and the emergence of new concepts, skills and behaviours. In other words, professional development can be used to describe the process of extending into qualitatively new areas of knowledge or ability. In this study, teachers' professional development is reflected in the context of developing new skills and new knowledge when implementing collaborative learning technologies: the qualitatively new areas of knowledge are aimed in this process.

In ongoing societal and educational change (e.g., rapid creation of knowledge, complexity of knowledge, technological innovations and global competition) make continuous professional development essential. When external factors create a need for organizational changes to tasks and duties, individuals must respond to these changes in order to retain their competence (Ruohotie, 1996 referring Dubin, 1990). However, educators, who are managing with educational reforms and innovations, know that an uncritical acceptance of every new "external factor" and idea leads only to stress and confusion. Furthermore, the role of educators is far more active, autonomous and new-creating than just responding to the needs of global competition. The critical question is then, as

Ruohotie (1996) puts it: “When does a failure to change result in obsolescence and when is it an indication of stability and mature judgement”?

### *Competent and obsolete professionals*

An interesting view of teachers’ professionalism and professional development is offered with the concepts of competent and obsolete professionals (Kaufman 1974; 1990). Obsolescence of skills and knowledge can be defined, for example, as a lack of the up-to-date skills and knowledge necessary in order to perform current and future tasks. A competent professional demonstrates innovative solutions to problems, seeks challenging assignments which involve advanced knowledge and have active interaction with colleagues. An obsolete professional, in turn, is no longer inclined or able to solve novel problems, is unfamiliar with the latest strategies and equipment for her or his work and experiences decreased respect and credibility among colleagues.

When and how then do teachers get involved with professional development activities?

Maurer and Tarulli (1994) have found some factors which influence on an individual’s decision to participate in development activities at work. These factors are perceptions related to the working environment, beliefs regarding the benefits of development, values and judgements and personality factors, such as identification with work and self-efficacy, which means how confident the individual is of her or his ability to learn new skills. Also Ruohotie (1994; 1996) and Ruohotie and Nokelainen (2001) have studied self-efficacy and professional development. They emphasise the motivational basis for professional learning: both self-efficacy and personal effectiveness of the learner, as well as expectations of success, have a positive impact on achievement.

Also, according to Russell (2003), the personality factors are important as they are related to technological changes in working practices. Some variables, which have positive impacts on learning new technology-supported working practices, have already been found. They are an individual’s self-efficacy (Ruohotie, 1996; Raghuram, Wiesenfeld & Garud, 2003; Williamson, Lepak & King, 2003) cognitive style (Workman, Bommer & Kahnweiler, 2003) and self-confidence (Hall, 2004). Bereiter & Scardamalia (1987) have studied new technologies, especially web-based learning environments, in the context of collaborative learning and also they emphasise the meaning of deliberate personal devotion and motivational aspects in the process of constructing new knowledge.

### *Organizations supporting individuals*

On the other hand, the organizational environment affects individual factors too, such as growth motivation, perceptions and expectations. A growth-oriented environment encourages risk-taking, allows for mistakes and encourages professional development and innovativeness. The incentive value of the job depends on the opportunities it offers for learning, especially collaborative learning. (Ruohotie & Nokelainen, 2001.)

There are also other requirements for organizations and working communities which support the individual's professional development. Hierarchical structures should be replaced by decentralized networks emphasising equality and democracy, because in the flat organization the flow of information is open and the personnel can be utilized to their full potential. This, however, requires a process in which complex and difficult problems are reflected and discussed openly. This is especially true when tasks are redefined within change processes. In these situations conflicts are inevitable and must be debated openly if progress to creating new forms of knowledge and practice is to happen. When conflicts are handled successfully, the organizational culture offers such security and safety to an individual that she or he can work in the emotional Zone of Proximal Development, in other words, at the edge of his or her competence, without being afraid of unavoidable failures and mistakes. (Ruohotie 1994; 1996; Engeström, 1999; Mahn & John-Stainer, 2002 referring Vygotsky, 1962.)

### *Professional development in interaction*

Leithwood (1999) noticed that also teachers learn through quite informal means from their colleagues and from the opportunities to socially process new information. Ruohotie (1999) has introduced a concept, usable also in teachers' professional development: relationship-based learning. It emphasises horizontal growth and interactive relations in working life. A career is defined in terms of increasing competence, resulting from both developing expertise and expanding personal networks. Relationship-based learning is related to the concept of the protean career (Hall, 1976), which means that a person's working career is characterized by continual professional development, diversification of competence and work-connected relations. The main source of professional development in working life is relational: the peers and other relationships at work play a crucial role in supporting change. (Hall & Mirvis, 1996; Hall, 2004.)

Fletcher (1996) also has listed types of practices that promote professional development through interaction. For instance, it is important that information in an organization is genuinely available to its teams and members. The information distributed should concentrate on the needs of the recipient and respect an individual's intelligence. In addition, a sense of collaboration is required in the work setting. This means recognizing and respecting others and their work, finding the positive aspects in others' ideas, possibly arranging work schedules, exchanging assignments or parts of them, and basing all this on reciprocity and the furthering of collective goals.

However, individual growth does not automatically occur in all kinds of relations. Fletcher (1996) clarifies growth-fostering interaction with the support of following three concepts: at first, they are characterized by *interdependence* and commitment rather than autonomy. Secondly, one prerequisite for growth-fostering relations is *mutuality*, which means that both parties genuinely benefit from the relationship. Thirdly, the growth-fostering relational interactions need *reciprocity*. Reciprocity grows out of the fact that both parties have skills that can be used and that both are willing to flexibly cross boundaries that, for example, one's position and role in an organization impose. In addition to independence, mutuality and reciprocity, development requires the individual to be ready and able to consider relationships as the source of his or her own learning and development (Ruohotie, 1999).

### *Sociocultural turn in studying professional development*

The debate on learning and knowledge creation in organizations and communities has been empowered by many contributors over the last decade in the frame of reference of *sociocultural tradition* (e.g., Senge, 1993; Nonaka & Takeuchi, 1995; Starkey 1996, Beirsto & Ruohotie, 2003). Based on the same theoretical approach, the theories on organizational learning (Argote, 1999; Gardiner, 1999; Nonaka & Takeuchi, 1995) and organizational intelligence (Blanning & King, 1995) also emphasize that it is essential to consider teams, communities, organizations and even larger networks as agents of intelligent activity. Creating knowledge cannot be explained only as an individual's achievement. It is a process that is distributed across organization's participants, social space and over time.

In educational research generally there is a wider changing paradigm towards sociocultural approaches going on. Instead of studying the content of individual minds, the approaches generated

within this theoretical framework focus on interaction, discourse and participation processes among members of organizations or communities. Knowledge does not exist either in a world on its own or in individual minds but is an aspect of participation in cultural practices (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991). These approaches are leading the sociocultural turn also in the research of careers, and professional development in working life, from studying individual competencies to studying collective interaction and participation.

Also, following theories on learning are based on assumptions that learning is intentional, active, conscious, constructive and reciprocal activity embedded in social and cultural environments: cultural-historical psychology (Vygotsky, 1978), activity theory (Leont'ev, 1976; Engeström, 1999), socially shared cognition (Resnick, Levine & Teasley, 1991), situated learning or situated cognition (Brown, Collins & Duguid, 1989; Clancey, 1997) everyday cognition and reasoning (Nunes, 1992; Carraher & Schliemann, 2000), ecological psychology (Gibson, 1986) and distributed cognition (Hutchins, 1995; Norman, 1993; Oatley, 1990; Perkins, 1993; Salomon, 1993). (See also in Palonen, 2003.)

The idea of learning in an organizational context has its basis in the principles of learning through joint activities and interaction with others; the central importance of sociocultural theorists. For Vygotsky (1981) the source of knowledge, and the “higher psychological processes that are involved in the construction of knowledge, is to be found in the cultural activities in which the learner engages with others, and in the interaction that accompanies, directs and reflects on their shared endeavours” (see Wells, 1994). As Vygotsky emphasises, it is not simply a matter of cultural reproduction, but also transformation. As the learner appropriates the knowledge and procedures encountered in interaction with others, she or he transforms them, constructing her or his personal version. Finally, the learner externalizes this inner transformation in action. By bringing the newly constructed knowledge to bear on problem situations, the learner generates new knowledge. In this way, education functions not only as a means of transmitting the achievements of the past, but it is also the site of cultural renewal and development.

Distributed cognition refers to a process in which cognitive resources are shared socially in order to extend individual cognitive resources or to accomplish something that an individual could not achieve alone (Oatley, 1990). It is related to the concepts of distributed mind (Fisher & Fisher, 1997) or collective mind (Weick & Roberts, 1993). Cognitive processes can be distributed by between humans and tools, the concept for this is physically distributed cognition (Hutchins, 1991;

Norman, 1993; Perkins, 1993) or between cognitive actors: socially distributed and shared cognition (Resnick et al., 1991; see also in Palonen, 2003). So, when investigating learning, it is important to consider not only the performances of the learners but also the sociocultural and sociohistorical context in which the learning occurs as well as the tools and mediation systems that learners use to make meaning (Jonassen & Land, 2000). From these aspects, it is important to consider also teachers' professional development as an interaction and participation process in their particular communities: in their networks of relationships and daily working practices in schools.

Although the idea of *collaborative learning* has been strongly emerging in educational literature with the sociocultural turn in past two decades, is not, however, new in educational tradition. It relies on dialogue (e.g., Platon; Freire, 1970; Senge, 1990), which attempts to encourage people's active involvement in questioning and in creation of knowledge instead of passive receiving of information. Dialogue, at its best, enables people to find new insights which they would not have achieved on their own, creates richer understanding of the matters of problems at hand and involves free flow of new ideas. According to Bereiter and Scardamalia (1987) collaborative learning entails that new knowledge is not simply assimilated but actively constructed through joint problem-solving. Through intensive collaboration resources of the all participants may be used to facilitate advancement of learning.

### **Form communities of practice to innovative knowledge communities**

Engeström (1999; 2001; Ahonen, Engeström & Virkkunen, 2000) has designed the expansive learning model, in which the communities or teams in the workplace come together with different knowledge, expertise and histories to pursue a common goal. The basic unit of the model is culturally (through material and conceptual tools and practices) mediated activity in a specific environment of activity. Engeström has found that in order to effect change, communities must work through processes of articulating differences, exploring alternatives, modelling solutions, examining an agreed model and implementing activities. Sääntti (2003) has stressed that culture cannot be directly managed or controlled, but it is subject to change and these changes can be influenced in intentional ways. Cultural change occurs through a reflective interpretation and re-interpretation process based on dialogue amongst the actors involved. During this kind of expansive cycle the participants are reconceptualizing their activity system in relation to shared objects of activity. The process of reconceptualizing requires also that the tacit knowledge of an organization (Nonaka & Takeuchi, 1995) is made explicit. Tacit knowledge is highly personal and hard to

formalise, making it difficult to communicate or share with others. It is also deeply rooted in an individual's action and experience and it is difficult to process or transmit in any systematic manner. To be communicated and shared within the organisation, it has to be demonstrated then converted into words or numbers that anyone can understand.

#### *Transactive memory and collective consciousness*

Like tacit knowledge, also transactive memory (Wegner, 1986) is developed through experience and over a long period of time within working communities. The transactive memory is a shared system for encoding, storing and retrieving information; knowledge of one another's memory areas, who knows what. The transactive memory system in a group involves the operation of the memory systems of the individuals and the processes of communication that occur within the group. Therefore, it is not traceable to any of the individuals alone, nor can it be found somewhere between individuals: it is the property of the group. It implies that beyond instruments or external memory aids, members of a group are using each other to support their memory. This can happen when the members learn to know each other's domains of expertise. This kind of communal metaknowledge helps members in their information search, in storage, retrieval and management of knowledge. Research drawn mostly from laboratory experiments on the recognition of expertise in decision-making groups suggests that groups do perform better in cases when they have metaknowledge of the members' knowledge (Moreland, Argote & Krisman, 1996; Palonen, 2003).

Bowden and Marton (1998) write about collective consciousness which can be considered as related to the concept of transactive memory. The collective consciousness embraces both what are common; insights, perspectives and ways of seeing; and that which is different and therefore complementary. The collective consciousness feeds on individual competences, but also individual competences feed on the collective consciousness. The richer and more interconnected the collective consciousness is in an organization, the more likely it is that the variation both between and within individual competences increases. Again, the collective competence is a function of the level and mix of individual competences within the organization and of the extent to which the organization manages to draw and further develop individual competences by organizing itself in such a way as to enhance the development of collective consciousness.

### *Interaction in innovative knowledge communities*

According to Wenger (1998), knowledge creation and learning take place in communities of practice through complementary processes of participation, which means the daily, situated interactions and shared experiences of members of the community working towards common goals. Wenger introduces the concept of communities of practice (COP) and emphasises the meaning of practices in the process of knowledge creation. A fundamental challenge from the point of view of professional development is how the practice of the community comes to be known and shared. From this perspective, a teacher community may be understood as consisting of a group of teachers with particular skills or expertise who routinely interact across formal and informal situations, in order to achieve their shared professional goals. Teachers taking active part in using ICT are likely to belong to networks-of-practice that connect practitioners across the boundaries of their schools.

However, the intellectual development of individuals is not the only thing to benefit their working lives. There is also a need to build actively new knowledge in the working organizations and communities. Bereiter (2002) writes about the knowledge-building community and describes knowledge building as collaborative working for developing conceptual creations, practices and theories. An essential aspect in knowledge building is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. According to Bereiter (2002) benefits of knowledge building are that it makes thinking of the participants with different expertise open and perceptible. In addition, it is easier for the community to discuss and adopt written than spoken thoughts. In this purpose the new technologies, such as computer-supported learning environments can offer valuable support for the process. (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989.)

In order to cope with these challenges, teachers, schools and school administrators are developing novel practices of professional development and deliberate mastery of organizational transformation. Consequently, educational institutions are searching for ways to transform stable communities of practice with individually-oriented craft workers toward becoming *innovative knowledge communities* (Hakkarainen, Paavola & Lipponen, 2004). Innovative knowledge communities do not have such strict hierarchical relationships concerning knowledge and competencies as traditional expert communities and continuously face problems that no one within the community has ever solved. As a consequence, many newcomers have knowledge relevant to

solving significant problems that the “old-timers” could not have had access to. In innovative knowledge communities the achievements of communities, and the competence and expertise of individuals, are in interaction, and they co-evolve so that individual achievements and competencies are used as a support for collective activity. In further, the changing collective practices are used as stepping stones to surpass previous achievements of the individuals. Again, Hakkarainen and his colleagues (2004C) remind that there is a profound “epistemification” characterizing modern work, which is associated with increasing dependency on various instruments and material artefacts. Moreover, the integration and fusion (hybridization) of conceptual and material aspects of human activity results in *tools* and *instruments* becoming more and more knowledge-laden and autonomous.

People who work in innovative knowledge communities are “forced” to create new forms of acting, working and learning in order to deal with the challenges of turbulent work environments. One new form of acting is the intensional (sic) network (Nardi, Whittaker & Schwarz, 2000). Intensional networks are egocentric networks that arise from individuals, their communication, and workplace activity. By “intensionality” Nardi and his colleagues (2000) refer to the effort and deliberateness with which people construct and manage personal networks and the tension and stress involved in the network. There are networks that individuals intentionally create and foster. This perspective goes close to relationship-based learning (Ruohotie, 1999) and the protean career (Hall, 1974), which emphasise the meaning of expanding, personal networks for an individual’s professional development. Personal social networks are not stable in nature, but always in an ongoing process of transformation through acts of remembering and communicating.

#### *Networked intelligence and networked expertise*

Building on different theories generated from the basis of sociocultural tradition a paradigm for investigating human intelligent activity is also emerging. Characteristic of these approaches is an emphasis on the role of cultural-historically developed tools and artefacts in human intelligent activity. (Cole, 1996.) Latour (1993; 1999) examined heterogeneous networks that consist of human and non-human actors in the frame of actor-network theory. These actors form clusters, associations of humans and nonhumans that can be called collectives. Scardamalia’s and her colleagues’ (1989) innovation of using computers to support collaborative knowledge building is one practical example.

Basing on the same theoretical principles, Hakkarainen and his colleagues (2004A) have represented the concept of *networked intelligence*, which means that intelligence cannot be located inside the participating agents but is embedded in their mutual relations and relation to supporting artefacts and the task-environment. Networked intelligence refers also to those individual and collective knowledge structures, practices and reasoning processes that allow the individual or community to function intelligently in its environment. This kind of collective intelligence can arise from three sources: the structure of the social systems, its formal and informal relationships (Blanning & King, 1995). However, the notion of networked intelligence should not be understood to mean that intelligence embedded in artefacts or environment somehow automatically produces significant gains in individual cognitive competence.

Further, the concept of networked intelligence is closely linked to the concept of *networked expertise* (Hakkarainen et al., 2004C), which means expertise that arises from social interaction, knowledge sharing and collective learning within a community of professionals. Since the utilization of the experiences of others is an important learning resource, it is reasonable to examine how members of (working) communities share their experiences and knowledge and how knowledge flows and innovation and ideas get distributed within a community. However, the development of networked expertise and innovations are empowered rather in innovative knowledge communities than in traditional communities of practice. (Hakkarainen et al., 2004B.)

#### *The use of media in networks of relations*

One of the interests of this study is the question of what kind of media teachers use in their social interaction in a teacher community? Haythornthwaite, Wellman and Mantei (1995) have studied the alternative means of communication in the work relationships of a group which were available to them: unscheduled face-to-face encounters, scheduled face-to-face meetings, electronic mail, telephone, fax, and desktop videoconferencing. Their research revealed that most communication was done through a combination of media, but predominately through unscheduled encounters, electronic mail, and scheduled meetings; people rarely videoconferenced, telephoned, or faxed. The work relationships included six dimensions: receiving work, giving work, collaborative writing, major emotional support, sociability, and computer programming. The proportion in which the three main media were used varied according to the nature of the work. Haythornthwaite and her

colleagues (1995) concluded that a multivariate perspective that considers group norms and practices, social networks, and work dimensions is necessary to analyze media use.

Haythornthwaite (2005) studied also the impact of communication media and the Internet on connectivity between people by implementing social network studies and exploring the use of all available media among members of an academic research group. The research revealed that members, who were more strongly tied, used more media to communicate with each other than members with weak ties. Hakkarainen and his colleagues (2004C) distinguish strong and weak ties thus: links between participants who engage in intensive interaction or mutual collaboration are typically strong. These kinds of links tend to occur among small groups of actors where everyone knows what the others know. Consequently; the participants are likely to understand each other from hearing half a sentence. Strong links are essential in transmitting “*sticky*” (Brown & Duguid, 1999) knowledge, such as information regarding educational use of ICT, which may require sustained interaction before becoming absorbed. Strong links allow sharing of expertise within a community but do not always provide new information for the most experienced participants. In contrast, weak links support knowledge exchange by transmitting information to and from the organization. Weak links that reach beyond the boundaries of the organization assist in searching for new information. Yet, many studies relying on social network analysis have reported that weak ties do not provide the same kind of socio-emotional support or trust needed for solving complex professional problems as the strong ties (e.g., Haythornthwaite, 2005).

Wellman, Salaff, Dimitrova, Garton, Gulia and Haythornthwaite (1996) have presented the concepts of *computer-mediated communication* and *computer-supported social networks* when studying the interactive relationships, use of collaborative technologies and different media. When computer networks link people as well as machines, they become social networks. Computer-mediated communication, such as electronic mail and computerized conferencing, is usually text-based and asynchronous. It has limited social presence, and online communications are often more uninhibited, creative, and blunt than in-person communication. The nature of the medium both constrains and facilitates social control.

If computer-supported social networks were solely a means of information exchange, then they would mostly contain narrow, specialized relationships. However, information is only one of many social resources exchanged online. Despite the limited social presence of computer-mediated communication, people find social support, companionship, and a sense of belonging through the

normal course of computer-supported social networks of work and community, even when they are composed of persons they hardly know. Although providing such types of support often does not require major investments of time, money, or energy, people in social networks have also mobilized goods, services, and long-term emotional support to help each other. (Rice & Love, 1987; McCormick & McCormick, 1992; Walther, 1996; Haythornthwaite et al., 1995; Wellman & Giulia, 1996; see in Wellman et al., 1996.)

### **Collaborative technologies as tools for learning**

In this study, teachers' professional development is reflected in relation to implementing collaborative learning technologies, such as web-based learning environments, and new pedagogical practices supported by those technologies, such as technology-supported inquiry learning.

*Collaborative technology* refers to groupware and network environments, as well as associated teamwork methods, that allow the participants to produce knowledge in a shared working space (Coleman, 1999). Researchers of computer-supported collaborative learning (CSCL) have developed technical tools embedded in collaborative environments that help the participants manage various aspects of their collaborative activities (Lehtinen, Hakkarainen, Lipponen, Rahikainen & Muukkonen, 1999; Lehtinen, 2003). Technical applications typically include possibilities for sharing documents and other tools for network-mediated communication. Computers can provide mediating tools that help learners to focus their attention on mutually shared objects in order to support reciprocal understanding among learners. (Järvelä, Bonk, Lehtinen & Lehti, 1999.) Computer environments facilitate thinking processes by making them visible. The combination of written communication and face-to-face communication seems to be an effective tool for extensive thinking processes (Lehtinen, 2003).

### *Principles of learning and design of learning environments*

Over the past few decades, research in collaborative learning technologies has focused increasingly on problem-based learning (Hmelo, 1999; Koschmann, Kelson, Feltovich & Barrows, 1996) project-based learning (Blumenfeld, Soloway, Marx, Krajcik, Guzdial & Palincsar, 1999), inquiry-oriented pedagogies in the form of open-ended learning environments (Hannafin, Land & Oliver, 1999; Hakkarainen, 2003), constructivist learning environments (Jonassen, 1999), goal-based

scenarios (Schank, 1992), anchored instruction (Cognition & Technology Group at Vanderbilt, 1992) and social-mediated communication (Jonassen & Land, 2000).

Technological advances have stimulated researchers and educators to expand their conceptions of learning as well as design of learning environments. Though there is variety in their scope, technology and methods, student-centred approaches include similar assumptions about the nature of understanding and the methods best suited to facilitate learning. Such student-centred, learner-centred environments provide interactive, complementary activities that enable individuals to address unique learning interests, study multiple levels of complexity and deepen understanding (Hannafin & Land, 1997; Jonassen & Land, 2000).

Many open learning environments rely heavily on technology to support student experimentation. Problems and contexts are often externally generated, and learners manipulate variables to solve problems such as determining the conditions under which insulation materials retain or lose heat (Lewis, Stern & Linn, 1993). Others, such as reciprocal teaching and cognitive apprenticeships, capitalize on social interactions to scaffold and negotiate problem-solving and self-regulatory procedures. Hence, although diverse approaches may differ in function, they share common assumptions and values about the importance of student-centred learning (Land & Hannafin, 2000). Unlike traditional instruction, no unifying theory seems to guide the design of student-centred learning goals and requirements. Rather, researchers need to identify frameworks for analyzing, designing and implementing learning environment that embody particular foundations, assumptions and practices. Learning environment is rooted in five core foundations: psychological, pedagogical, technological, cultural and pragmatic (Hannafin & Land, 1997).

### *Technological and cultural foundations*

Land and Hannafin (2000) suggest considering technological and cultural foundations in defining how media can support, constrain or enhance the learning environment. Technology can control the pacing and chunking of information where cognitive load limitations are assumed; in contrast, it can support user-directed access to www-resources and support the manipulation of ideas when the importance of individual negotiation is assumed. Technology foundations determine what is technologically possible, but grounded practice requires determination of how capabilities should be exploited. Cultural foundations reflect the prevailing values of a learning community, such as “back

to basics”, “interdisciplinary learning” or “global society”. Finally, pragmatic foundations emphasize the reconciling of available resources and constraints with the actual design of any given learning environment. Many schools perceive the benefits of connecting teachers, students, and administrators to others across the world. Limitations in connectivity and hardware, however, often limit what can be accomplished pedagogically and technologically. Pragmatic foundations represent the reality check of learning environment design and implementation, frequently causing a reassessment of alignment among one or more foundations.

### *Challenges in pedagogical use of collaborative technologies*

Land and Hannafin (2000) outline certain problems dominating the use of learning environments. Although educators support student-centred approaches in teaching and learning, they continue to rely on familiar pedagogical approaches such as lectures and worksheets. At the moment, educators perceive such approaches as more compatible with traditional expectations and methods of student assessment and better supported by existing infrastructures. It is easier and more efficient to maintain current practices than to implement new pedagogical models for which significant changes are required. Learning environments are very often repurposed to fit traditional classroom practices, mismatched theoretical foundations, assumptions, or methods may result. Methods are often added to or taken away from original designs to make them more compatible with existing classroom practices.

Ideally, when implementing learning environments and student-centred pedagogical practices, students establish learning goals and needs, navigate through and evaluate a variety of potentially relevant resources, generate and test hypotheses and so forth and teachers clarify rather than tell, guide rather than direct and facilitate student effort rather than impose. (Holland, Holyoak, Nisbett & Thargard, 1986.) However, despite numerous and varied features and opportunities for learners to hypothesize, manipulate and test predictions, many learners fail to either connect key concepts well or internalize their understanding (Tobin & Dawson, 1992). Also Lakkala, Lallimo and Hakkarainen (2004) found that that guiding technology-supported inquiry learning is very demanding for teachers, especially facilitating genuine collaboration among pupils. Students are easily dependent on external agents to tell them what, when and in what order to respond, as well as to judge the quality, accuracy and completion of their efforts, skills essential to constructivist learning environment.

Balancing student self-orientation and teachers' active guidance is not easy when implementing technology-supported progressive inquiry (Hakkarainen, Lipponen & Järvelä, 2002; Veermans, Lallimo & Hakkarainen, in press). In addition, although most teachers accept key learning theories that underline student-centred and inquiry methods, they have few possibilities to induce this kind of learning in practice (Hakkarainen, Muukkonen, Lipponen, Ilomäki, Rahikainen & Lehtinen, 2001). Many researchers have then emphasised the importance of scaffolding learner self-regulation and strategic processes to help learners manage the complexity of the environment (Scardamalia et al., 1989). On the other hand, Lipponen and Lallimo (2004) stated that it has been very hard to find evidence that a particular application for collaborative learning is better than another, or better than some traditional classroom uses of the computer. Koschmann and his colleagues (1996) argue that computer-supported collaborative learning research is established on varying concepts of learning. Also the developers and promoters of web-based learning environments should explicate further the theories of learning and instruction that motivate development work and are embedded within application designs.

#### *Web-based learning environments implemented in this study*

In this study the collaborative technology refers to the three *web-based learning environment software* that were used in supporting collaborative, student-centred and problem-based learning practices in schools. However, the focus of the research is not on the development and implementation of web-based learning environment or the pedagogical practices, but on the collaborative process and support, that web-based learning environment may offer for teachers' collaboration and professional development.

In the study reported in the Articles I and II the web-based learning environments implemented in schools are called FLE3 (<http://fle3.uiah.fi>) and Synergeia (<http://bscl.fit.fraunhofer.de/en/about.html>). The web-based learning environment implemented in the research reported in the Articles III and IV is called Opit ([www.opit.wsoy.fi](http://www.opit.wsoy.fi)). FLE3 and Synergeia were developed within the ITCOLE project ([www.euro-cscl.org/site/itcole](http://www.euro-cscl.org/site/itcole)). The project was coordinated by University of Art and Design of Helsinki. It was carried out in 2001-2003 and it had three scientific and technical goals: to develop new pedagogical practices for technology-supported collaborative learning and *progressive inquiry learning* (Hakkarainen, 2003), to design web-based

learning environments that support the pedagogical models and to disseminate good pedagogical practices in European schools. The design process of the web-based learning environments of the ITCOLE project are still continuing and open source software is freely available on the Internet. The Opit learning environment is software developed by one of the main Finnish commercial learning material producers. It aims also to support collaborative pedagogical practices in schools and includes several tools for the purpose, for instance, a discussion forum, personal and shared (group) portfolio files, project management tools and learning materials related to the subjects and content areas of the Finnish comprehensive and secondary school ([www.oph.fi](http://www.oph.fi)) curricula.

In FLE3 and Synergeia environments the desired collaborative problem-solving situations are supported in the so-called Knowledge Building forum of the web-based learning environment by Thinking Types, which guide students to categorize the computer entries that correspond to the stage of the knowledge-seeking or interrogative process (Scardamalia & Bereiter 1992; 1994). In other words, the Thinking Types label the thinking mode of each discussion note and are named according to the elements of interaction that are typical for a problem solving process. Thinking Types are earlier developed and used for example in CSILE-system (Scardamalia & Bereiter 1992; 1994; Lipponen & Hakkarainen, 1997). In Synergeia and FLE3 environments the Thinking Types were named after the process of progressive inquiry, for example: “Problem”, “Own explanation”, “Comment”, “Deepening knowledge”, “Evaluation of the process”, “Summary” and “Organising work” (Rubens, Emans, Leinonen, Skarmeta, & Simons, in press).

Within the ITCOLE project the Thinking Types were tested and developed in several phases together with teachers. The goal was to find the most coherent and reliable set of Knowledge Types for flowing problem-solving process. Teachers were not only testing the Types but also developing their labels and defining their meanings. In the latest version of the web-based learning environment, users can also define labels for Thinking Types themselves or choose the Thinking Types set from several different options.

In Opit environment, the tool for supporting collaborative discussion is called, “Discussion Forum”. There are also labels for messages offered. They are not called Thinking Types but Message Types. The Message Types available in Opit environment’s Discussion Forum were ”Question”, ”Answer”, ”Comment”, ”Own idea”, ”Detailing” and “Summary”. The labels do not refer more to the collaborative interaction in general than to the process of problem-based learning and

knowledge building. The labels were also stable and were not under development or critical debate within the implementation project.

*The concepts related to the use of collaborative learning technologies in this study*

*Technology-supported inquiry learning*

In the study reported in the Article I teachers report the possibilities, challenges and problems they face when participating in the development project of technology-supported inquiry learning. Inquiry learning, or in more detail, *progressive inquiry learning* (Hakkarainen, 2003) means a sustained process of advancing and building knowledge characteristic of scientific inquiry. An essential aspect of this kind of inquiry is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. In progressive inquiry learning, the role of technology is to create a learning environment that enables collaborative knowledge building; it supports building, articulating, exploring and structuring knowledge. (Scardamalia & Bereiter, 1994.) The collaborative technology, which was used in study contexts of the Articles I and II, and which created the learning environment needed, were FLE3 and Synergeia software. The nomenclature used for such programs in general in this study is “web-based learning environment”.

The concept technology-supported inquiry learning refers to the use of FLE3- and Synergeia learning environments in supporting the pedagogical principles of inquiry learning. In these web-based learning environments there are specific tools developed to structure and scaffold students’ collaborative learning process, such as discussion forums, document sharing, group-based portfolios and evaluation tools for student participation. The concept “technology-supported” has been actively used in the latest research concerning pedagogical principles of progressive inquiry and collaborative technologies (e.g., in Lakkala et al., 2004). The concept “technology-supported” is the modernized version of the earlier “computer-supported” (e.g., in Koschmann et al., 1996). It refers also to the rapid and ongoing development of collaborative technologies in education. Technologies include more than “just a computer”; there will be, for instance, an immersion of mobile phones, TV and Internet in future learning environments.

### *Web-based knowledge building*

The study reported in Article II concentrates on describing teachers' experiences in implementing synchronous, web-based knowledge building in their in-service training. In this research, the concept *web-based knowledge building* means a facilitated, collaborative process which takes place in a Knowledge Building tool of a web-based learning environment, as described earlier. Online discussion refers usually to synchronous or asynchronous virtual conversations supported in general by the Internet; web-based knowledge building has a more specific meaning. The software described in this study is designed for a particular social activity system, which emphasises participants as subjects and knowledge as an object that is handled and processed by the participants (Leinonen, Ryymin & Korhonen, 2005). In the Knowledge Building tool of the web-based learning environment, groups may carry out knowledge building dialogues and debates by storing their thoughts into a shared database. Knowledge building differs from other online discussions or chats in that its purpose is to achieve something more than just "information exchange". Also, knowledge building has its basis in the pedagogical approach called *progressive inquiry learning* (Hakkarainen, 2003).

Knowledge building can be described as collaborative working for developing conceptual creations, for example practices and theories. (Hakkarainen, Lonka & Lipponen 2000, 274; Scardamalia & Bereiter 1992; 1994.) Benefits of knowledge building include making the thinking of participants with different expertise open and perceptible. According to Scardamalia and her colleagues (1989) it is easier for the community to discuss and adopt written rather than spoken thoughts. In this way the members of the community are able to learn developed cognitive practices to solve intricate problems. The synchronous, web-based knowledge building events are referred to as "virtual workshops" within the study reported in Article II. This practical model of teachers' training was a part of Teachers' in-service training and consulting model (Haatainen & Korhonen, 2002; Ryymin & Korhonen, 2003) which was created within the EU Commission's ITCOLE-project.

### *Web-based learning*

Also, the studies described in Articles III and IV relate to the use of web-based environments among teachers. *Web-based learning* refers in these study contexts to the implementation of pedagogical practices supported by web-based learning environment. These practices were also student-centred and problem-based but did not follow the pedagogical model of progressive inquiry learning as

intensively as the learning projects that were described in Articles I and II were aiming. The web-based learning environment used in these studies was Opit and teachers carried out in practice so-called blended courses; the learning environment was used alongside more traditional forms of teaching and in supporting face-to-face studying. For instance, pupils had problem-solving discussions about their learning tasks in the discussion forum, created group work in the shared files or made learning material rehearsals with peers (or independently) in the web-based learning environment.

## **Teachers' professional development and collaborative technologies**

### *Information and communication technology (ICT) and teacher collaboration*

Information and communication technology (ICT) transform a human's intelligent activity by providing powerful and flexible tools for individual and collaborative creation, elaboration, and sharing of digitalized and dynamic representations. Computers provide tools for mastering, organizing and sharing cognitive tools and, thereby amplify individual and collective learning, thinking and problem solving (Hakkarainen et al. 2004A; Perkins, 1993). When promoting new, technology-supported pedagogical practices in schools, it has been found that *teacher collaboration* and *teacher communities* have a crucial role. Previous research has indicated that an important factor in establishing and scaling up technology-supported pedagogical innovations is the enhancement of teacher networks and collaboration as well as to strengthen teacher communities

(e.g., Granger, Morbey, Lotherington, Owston & Wideman 2002; Ilomäki, Lakkala, & Lehtinen 2004; Slegers, Van Den Berg & Geijsel 2000; Spillane 1999).

### *Challenges in changing educational culture*

The development of teacher collaboration and communities, for the purpose of generating educational change and teachers' professional development, is very challenging in schools. Moreover, the public school system does not generally include the range of tasks and environments necessary to coordinate learning with implementation of new skills. The autonomy of teaching means that a highly motivated and self-regulated educator can find ways to apply new learning, but in the absence of such unique self-discipline, it is much more likely that the individual will quickly

lapse into familiar patterns (Ruohotie, 1999). When the development activities are concentrated on highly-motivated teachers only, it may lead to the situation, where new knowledge related to the transformation of teaching practices with ICT accumulates in the same central actors within the teacher community. As in many other more traditional communities of practice, conventional tasks can be handled by most of the workers as the newest techniques and know-how are in the hands of only a few workers. (Palonen, Hakkarainen, Talvitie & Lehtinen, 2004.)

On the surface schools appear to have come a long way, with emphasis on efficiency, restructuring and systemic reform. However, many reforms have changed the governance procedures of schools but have had little effect on the teaching-learning core (Fullan, 1996). According to Hakkarainen and his colleagues (2001), ICT facilitates meaningful learning and instruction only through transformed social practices. In order to incorporate ICT with their instructional practices, teachers need to change their everyday practices of working with knowledge. Yet, transforming social practices is difficult: according to some studies, it takes several years of effort before teachers start using ICT intensively in preparation and conduct of their instructional activities (Hakkarainen et al., 2001). In the situation of educational change, expertise and new knowledge is not sufficiently shared among the members of school system so as to obtain the best collaborative results. It is important, therefore, to imagine how this reality might be changed to create a more nurturing learning environment and how the entire school system might be more hospitable to change resulting from the learning and development of individual teachers and administrators. (Ruohotie, 1999.)

Promotion of ICT and web-based learning in schools means restructuring and recreating the established pedagogical practices in teachers' work. Hargreaves, Earl, Moore and Manning (2001) have noticed that it is cognitively and emotionally very stressing and challenging for teachers to learn to teach differently than they have been taught themselves. Teachers need scaffolding and guiding from a supportive mentor when turning new pedagogical models into meaningful practices. In the web-based learning development project, teachers need continuous pedagogical support, also after finishing the development project (Ryymän, Lakkala & Veermans, 2004). The creation of collaboration and the redesigning of the teaching profession need non-hierarchical structures and decentralized networks which require new cultures of collaboration which have to come first and foremost from educational authorities.

### *Administrators and collective cultures*

In the context of educational change, school administrators are expected to help teachers, but according to Leithwood, Janzi and Dart (1996), neither their working practices nor, according to Klein (2003), their own professional training support or reflect teachers' professional development sufficiently. Hargreaves (1996) offers new perspectives to the prevailing culture in educational administrators' work. He presents the concept of "contrived collegiality", which means a set of formal, specific bureaucratic procedures designed to increase the attention given to joint teacher work. It is the preferred way of operating for administrators because it reconstitutes teacher relations in the administrator's own image in order to support the implementation of administrative plans and purposes. Such action is also distinctly "masculine", with its emphasis on control and predictability, whereas collaborative cultures are decidedly "feminine" in style. Educational change is more likely to come about when administrators act with humility and respect teachers as persons with purpose than when they act in a contrived manner. Genuine collaborative cultures in schools can, in turn, be described as "moving mosaics", where ideas and communication flows freely. In practice, according to Hargreaves (1996), a culture of collaboration is present only in a small number of schools where, within a broad agreement on educational values, there is tolerance and active encouragement of debate and disagreement.

In the research of Ford and Fisher (1996), computer-based training changed the distribution of technical knowledge between employees and management so that employees acquired information that management did not have. As a result, the management felt that they were incapable of supervising and giving feedback and they also felt that they had lost credibility in the eyes of the employees. This hardly creates favourable conditions for the implementation of new ICT-related skills and it is not uncommon that such authors deny employees the opportunity to use their skills. It would be interesting in future to research how much change-resistance there is among school authorities when it comes to educational change, and how much it is related to the implementation of new technologies and working procedures of decentralized networks.

### *Creation of communities of inquiry*

According to Grimmet (1996) educational authorities could foster teachers' professional development and school development by deliberately attempting to build a culture of inquiry, by

exposing teachers to alternative views and practices, and by providing organizational support for teachers engaging in teacher research as a form of professional development. Also Wells (1994) has concluded that schools, which are communities of inquiry, foster development and educational change: “If the climate for learning in the classroom could be transformed through the creation of a community of collaborative inquiry and conversation why not in the staffroom as well? Since the same principles apply to all learners, teachers, too, might welcome the opportunity to become inquirers into their own practice in collaboration with other members of the community of their peers and colleagues. And if this were true for teachers why not administrators too? And, finally, might these various communities of inquiry not benefit from collaborative links between, as well as within, them?” (Wells, 1994, 10). Development in a community of collaboration requires from individuals the capacity to consider other individuals as source of learning and development (Ruohotie, 1996). This often demands administrators and teachers to review or even change their conceptions of collegiality and professional development.

In line with previous researchers, Nespor (1997) also has underlined the need to understand educational change in wider networks of collaboration. He writes that the key to understanding education is not to be found in what happens in classrooms or schools but in the relations that bind them to networks of practice extending beyond. Instead of looking at the school as a container, its walls should be peeled back and the strings and rhizomes linking it to the outside world inspected. Also Bransford, Brown and Cooking (1999) stress that in the pedagogical use of new technologies, teachers should become partners in innovation which means that there is a need to establish supporting networks between teachers, administrators, universities and the ICT industry. Elementary strategy in enhancing pedagogical development projects in a school should be the building of the community, which aims to link different cultures of expertise for supporting the learning projects. (Hakkarainen & Järvelä, 1999.)

On the other hand, the learning projects themselves can link schools to different cultures of expertise. The development projects of ICT offer an opportunity for schools to be connected to the expanded communities and networks of learning. Triggs and John (2004) found that in a development project of new technologies, new knowledge flowed freely among participants, university and school partners, not from trainers and researchers to teachers as has been the traditional way. Within the development project, teachers’ professional development was fostered in various smaller communities, where new knowledge, ideas and practices, extend upwards, downwards, across and around. In the context of collaborative communities and free knowledge

sharing several features that underpinned teachers' professional development process occurred, most important of them being a reduction of the sense of isolation, interaction that involves knowledge exchange as the basis for knowledge transformation and encouragement to take risks combined with support in open analysing how things might improve.

Bowden and Marton (1998) have researched the learning cultures in university and their conclusions have relevance in other pedagogical communities as well. They write that the acts of knowledge formation, at least some of them, go across professional boundaries as well as across widely differing levels of sophistication, even if the actual knowledge formed varies vastly. Being aware of and focusing on the acts of knowledge formation have the potential to link people across those boundaries, thereby dramatically increasing the collective consciousness and releasing the power inherent in differing views, perspectives, experiences and insights of all the people in teacher community.

### **Synthesis of the framework and key concepts of the study**

Although previous research has found that teacher collaboration fosters pedagogical use of ICT in schools, there are still several challenges related to educational change, for instance, contrived collegiality, lack of pedagogical support and prevailing school culture, which sustains traditional administrative culture and hierarchy. However, there have been suggestions that the transformation of established, bureaucratic school cultures towards the decentralized networks and expanded learning communities over traditional school borders, from communities of practice towards innovative knowledge communities, would support the educational change, implementation of innovative learning technologies and professional development of teachers. External pressures for change, as well as new metacognitive insights into learning and professional development, create powerful influences to move traditional teaching towards a new networked professionalism. The active role required of teachers in creating this new future is emphasised. The basic and further education of teachers, as well as school administrative procedures, should support collaboration and responsibility for widening opportunities for growth and learning on the part of teachers. A teacher can be a social force only if the teacher herself or himself is expected to act in accordance with a new professionalism and if the conditions for this are provided (Niemi, 1996).

The role of a teacher is more than a curriculum implementer or more than just a trainee in ICT development projects and training programs. Teachers can be seen as generators and creators of new knowledge and new pedagogical practices, the central actors in pedagogical communities, who intentionally network with their colleagues and other partners for educational change. For redesigning teachers' profession in this context, the latest research of professional development, knowledge sharing, and collaborative technologies can be utilized. Teachers' personal life, formal and informal relations and accumulating experience are all affecting work behaviours. Teachers' development is connected to the development of practices of their working communities and it has a collective nature; the relationships with others have a role in an individuals' development. Teachers have tacit knowledge, which should be made explicit when building new knowledge and practices in educational interventions. Teachers could benefit better the intelligent networks in which they interact, the transactive memory and collective consciousness of their working communities, and the supporting artefacts and task-environment they use in their daily work.

Collaborative learning technologies may offer new tools to make the tacit knowledge explicit, to make the thinking of teachers with different expertise open and perceptible. Teachers can be considered as actors in intelligent networks, which consist not only of humans, but also technologies, media and other artefacts and information sources. In today's knowledge intensive pedagogical communities teachers may develop, more or less consciously, networked expertise and benefit their personal, intentional networks as sources of professional development. The convenient communities of practice, traditional schools, have all possibilities for evolution into innovative knowledge communities, where innovations flow freely in intelligent, technology-supported networks and challenges of change are faced in genuine, supportive cultures of collaboration.

To sum up, elements of teachers' professional development are in social groups and communities and in their different roles in working communities. They are in decentralized networks, which include besides humans also collaborative technologies and artefacts, as well as procedures and working practices. They are also in the legacy of historical cultural traditions and in collective perceptions and ideas of schools. Furthermore, elements of teachers' professional development are in the continuous process of change, where new knowledge is shared, created and re-created, in open dialogue, and where a teacher is a central actor in knowledge creation and sharing; not an objective, nor a trainee.

### *Key concepts of the study*

Instead of using a few unified concepts for professional development or learning in interaction, there are several key concepts and terms in this study. When studying teachers' professional development in the context of implementing collaborative learning technologies several terms have been named and defined, such as technology-supported inquiry learning (Hakkarainen, 2003) and web-based knowledge building (Scardamalia & Bereiter, 1992; 1994). When the emphasis has been, in addition, on studying teachers' social interaction (see in Articles II-IV), such terms as professional development (Beairsto, 1996) and relationship-based learning (Ruohotie, 1996) have supported the approaching and offered framework for studying the phenomena under examination. In the studies, where the focus has been on schools, (see in Articles III-IV), the teacher community has been analysed in the frame of reference of such concepts as innovative knowledge community (Hakkarainen et al., 2004B), intensional networks (Nardi, Whittaker & Schwarz, 2000) and transactive memory (Wegner, 1986). The key concepts of the study are presented in more detail in Tables 1 and 2.

<b>Concept</b>	<b>Definition</b>	<b>Reference / Based on</b>	<b>Framework in this study for</b>
professional development	the process of extending into qualitatively new areas of knowledge or ability	Beairsto, 1996	teachers' development process when implementing collaborative learning technologies
relationship-based learning	learning process in which employee's competence is increasing as result of developing expertise and expanding personal networks	Ruohotie, 1999	teachers' learning process in their social relations
growth-fostering interaction	interdependent, mutual and reciprocal interaction based on information genuinely available for individuals in the working community	Fletcher, 1996	teachers' interaction contributing their professional development
knowledge sharing	a fundamental challenge to organize work with knowledge in a way that facilitates continuous knowledge advancement and supports the sharing of intellectual achievements	Hakkarainen, Palonen, Paavola & Lehtinen, 2004	knowledge that teachers share regarding the use of ICT and collaborative learning technologies
knowledge building	collaborative working for developing conceptual creations	Scardamalia & Bereiter, 1992; 1994	the process where teachers generate new knowledge in collaboration e.g. web-based knowledge building sessions
community of practice	knowledge creation and learning take place in communities of practice through complementary processes of participation, which means daily, situated interactions and shared experiences of members of the community working towards common goals.	Wenger, 1998	daily interactions of a pedagogical community, in which new knowledge is created
innovative knowledge communities	a non-hierarchical expert community where individual achievements and competencies are used as a support for collective activity and which continuously faces problems that no-one within the community has ever solved	Bereiter, 2002; Hakkarainen, Paavola & Lipponen, 2004	pedagogical community, where new knowledge in educational change process is created and disseminated freely (ideal)
networked intelligence	intelligence which is not located inside the participating agents but which is embedded in their mutual relations, and related to supporting artefacts and the task-environment.	Hakkarainen, Lonka & Paavola, 2004	teachers' networks, which include people, collaborative learning technologies, media and information sources
pedagogical community	the personnel of a school or other educational institution in charge of organizing teaching and learning		the personnel of an upper secondary comprehensive school including teachers, school assistants, principal and school secretary

Table 1. Key concepts of the study, part I.

<b>Concept</b>	<b>Definition</b>	<b>Reference / Based on</b>	<b>Framework in this study for</b>
intensional networks	networks that individuals intensionally create and foster	Nardi, Whittaker & Schwarz, 2000	teachers personal networks that they utilize in their professional development
networked expertise	expertise that arises from social interaction, knowledge sharing and collective learning within a community of professionals	Hakkarainen, Palonen, Paavola & Lehtinen, 2004	the expertise that arises from the interaction of networked teachers
transactive memory	a shared system for encoding, storing and retrieving information, knowledge of one another's memory areas, who knows what	Wegner, 1986	memory developed within a pedagogical community
technology-supported inquiry learning	a sustained process of advancing and building knowledge characteristic of scientific inquiry supported by technologies	Hakkarainen, 2003	inquiry learning process, which is supported by modern learning technologies, such as web-based learning environments
web-based knowledge building	knowledge building (KB)carried out in the Knowledge Building tool of a web-based learning environment	Scardamalia & Bereiter, 1994	teachers' collaborative KB process, which is supported by a KB tool of a web-based learning environment
genuine cultures of collaboration (in schools)	cultures which foster and build upon qualities of openness, trust and support between teachers and their colleagues and which capitalize on the collective expertise and endeavours of the teaching community (opposite: collegiality which reconstitutes teacher relations in the administrators' own image)	Hargreaves, 1996	teachers' and administrators' non-hierarchical, decentralized, networked and new generative culture, which exceeds over school borders (ideal)
social network analysis	a collection of techniques that are focused on uncovering the patterning of people's interaction and relational information on participation, patterned sets of connections	Scott, 1991; Wasserman & Faust, 1994	studying communication structures of ICT in a pedagogical community
phenomenography	research method for mapping the qualitatively different ways in which people experience, conceptualize, perceive and understand various aspects of, and phenomena in, the world	Marton, 1981	studying teachers' experiences and conceptions related to the implementation of collaborative learning technologies
media use in social interaction	impact of media on connectivity between people	Haythornthwaite, 2005	studying teachers' media use in their social relations

Table 2. Key concepts of the study, part II.

## **2. The Methods of the Study**

My purpose in this study is to present new perspectives on teachers' professional development related to the implementation of collaborative learning technologies in working life. The approach of the work is focussed on teachers' experiences and conceptions and on teachers' social interaction relations.

One important contribution of the work is also to offer a new set of methodologies in understanding teachers' professional development; there has been implemented a set of research methods which are getting their concrete form in phenomenography (Marton, 1988) and social network analysis (Scott, 1991) in this study. However, I consider it important to remind here, that by applying these methods in the research of teachers' professional development, my purpose is not criticize or replace the more traditional research practices, but to offer new and complementary perspectives. Also more traditional, basic statistical tools were utilized in one study (see in Article I).

I have carried out a series of case studies on teachers' professional development and the use of collaborative technologies in this research process. I presented the relevance for the studies in the first chapter, in the theoretical framework for the "intelligent networks" including approaches contributing teachers' professional development in networking perspective and collaborative learning technologies.

The studies are reported as original articles and they form the empirical part of the dissertation. They focus on teachers' experiences on implementing new pedagogical practices supported by collaborative learning technologies (see Article I), on teachers' experiences in implementing web-based knowledge building in their problem-solving process (see Article II), on a teacher community's central actors in the development process of web-based learning (see Article III), and on network structure of a teacher community in using information and communication technology (see Article IV). In addition, the teachers' media use in their social relations has been analysed (see Articles III-IV). These studies offer multiple data of teachers' experiences, conceptions and networking relations related to collaborative learning technologies and their professional development.

In the next chapter, I describe the research methods and their benefits and limitations in more detail. In addition, I reflect upon the interviewing, especially the group interviewing, as a data gathering technique and highlight some aspects related to the research ethics of the study.

### **Phenomenographical approach**

Phenomenography is a research method for mapping the qualitatively different ways in which people experience, conceptualize, perceive and understand various aspects of, and phenomena in, the world around us (Marton, 1988). It is a research approach designed to answer certain questions about thinking and learning and originally developed by a research group in the Department of Education, University of Gothenburg, Sweden. The word “phenomenography” was coined in 1979 and appeared in print for the first time two years later (Marton, 1981). Phenomenographic research has been carried out especially in the Nordic Countries, Great Britain, and Australia (Webb 1997, 1996). Huusko and Paloniemi (2006) have listed that in Finland, the approach has been especially used by Järvinen (1985), Engeström (1990) and Gröhn (1991) and Tynjälä (1997, 1998), Goman and Perttula (1999) and Niikko (2002) who have implemented this method particularly in researching the perceptions of people who are working or studying in the field of education. In addition, Collin (2002) and Paloniemi (2004) have used phenomenography in studying work and learning in Finland.

Phenomenography is not concerned solely with the phenomena that are experienced and thought about, or with the human beings who are experiencing or thinking about the phenomena. Nor is phenomenography concerned with perception and thought as abstract phenomena, wholly separate from the subject matter of thought and perception: phenomenography is concerned with the relations that exist between human beings and the world around them (Marton, 1988). Phenomenography is more interested in the content of thinking than it is in traditional psychology. Psychologists are interested in studying how people perceive and conceptualize the world. Their focus is usually on the act of perception and thought in general terms. With phenomenography, thinking is described in terms of what is perceived and thought about: the research is never separated from the object of perception or the content of thought. Phenomenographers do not make statements about the world as such but about peoples’ conceptions of the world. (Marton, 1988.)

The point of departure in phenomenography is always relational. The approach deals with the relation between the individual and some specified aspect of the world, or, to state it differently,

with phenomenography the researcher tries to describe an aspect of the world as it appears to the individual. This means that the researcher adopts an experimental, “a second-order” perspective (Marton, 1981; 1988). Human beings do not simply perceive and experience, they perceive and experience things and therefore, descriptions of perception and experience have to be made in terms of their content. To characterize how something is apprehended, thought about, or perceived is, by definition, a qualitative question. Phenomenography provides descriptions that are relational, experiential, content-oriented and qualitative. (Marton, 1981; 1988; Marton, Dall’Alba & Beaty, 1993; Bowden & Marton, 1998.)

### *Data gathering*

In this study, one of my main purposes was to “hear teachers’ voices” in the development projects of collaborative learning technologies and to describe their relational, experiential and content-oriented conceptions of implementing collaborative learning technologies in their authentic working environments. The phenomenographic approach offers a relevant tool for the purpose to find the qualitative different ways how the teachers experience and perceive their challenging and changing educational reality and what kind of different meanings they give to their experiences.

Interviewing has been the primary method of phenomenographic data collection and I have also implemented this data gathering method in all studies (see Articles I - IV), however, with a different emphasis and structure. What questions are asked and how the questions are asked, are highly important aspects of the method. In this study, the questions were open-ended in order to let the subjects choose the dimensions of the question they want to answer. The dimensions that interviewed teachers chose are an important source of data because they reveal an aspect of the individual’s relevance structure.

In the first study (see Article I), I adopted the phenomenographic approach in analysing teachers’ group interviews on how they experienced the development project of collaborative learning technologies and new pedagogical practices. The method was complementing the more traditional data gathering technique of questionnaire, which consisted of both structured and semi-structured questions and were analysed and described by basic statistical methods. The role of the phenomenography was to provide context for the research results and offer the triangulation (Stake, 2005) for the study. In the second study (see in Article II), I formed the categories of descriptions

on teachers' descriptions on their experiences on participating into the web-based knowledge building sessions. I gathered the data from teachers' interviews, writings to the web-based learning environment's data base and from a questionnaire, which consisted of open-ended questions concerning web-based knowledge building.

The phases of data gathering offered also one valuable perspective on the development of the concepts that teachers used when they described their experiences. In this study (see in Article II), then, the phenomenographic approach highlighted two dimensions: the most distinctive that appeared in teachers' descriptions and the significant differences and changes in teachers' descriptions in time. In the third study (see in Article III) phenomenography offered a technique to find the most significant elements concerning teachers professional development related to the use of ICT and collaborative learning technologies (web-based learning) in a teacher community. In this study, I gathered the data by searching the central actors of the community (by social network analysis) and by interviewing these key actors individually. Then, I analysed teachers' answers to the most essential questions concerning teachers' professional development and learning technologies with the phenomenographical approach. The most significant expressions of the central actors are also represented in the study (see in Article III), whereas another article concentrates on the network structure of ICT in a same teacher community (see in Article IV). I transcribed all interviews and analyzed the transcripts with the phenomenographic approach. Also, the data gathered by a questionnaire and data base (see in Article II) were analysed with similar techniques.

#### *Categories of descriptions as research findings*

When applying the phenomenographic approach, a researcher categorizes study subjects' descriptions, and these categorizations are the primary outcomes of phenomenographic research. In other words, the results of phenomenographic research are the categorization of descriptions.

When reading and classifying descriptions of a phenomenon, a researcher is not merely sorting data, but looking for the most distinctive characteristics that appear in those data, this means: looking for structurally significant differences that clarify how people define some specific portion of the world. The researcher is focusing on both of the particular problem at hand of the particular subjects participating in the study.

Within this framework, the most essential and distinctive structural aspects of the relation between the individual and the phenomenon are paid attention. Leaving other aspects aside, researcher ends up with categories of description which, though originating from a contextual understanding, are decontextualized and may prove useful in contexts other than the one being studied. (Marton, 1988.) Above all, each category is a potential part of a larger structure in which the category is related to other categories of description. It is a goal of phenomenography to discover the structural framework within which various categories of understanding exist. Such structures (a complex of categories of description) should prove useful in understanding other people's understandings. Just as the botanist finds and classifies previously undiscovered species of plants, the phenomenographer must discover and classify previously unspecified ways in which people think about certain aspects of reality (Marton, 1988, 147-148).

The first phase of my analysis was a kind of selection procedure based on criteria of relevance. I defined the relevance by following the content, the significant characteristics for the problem-setting and the theoretical framework of the study. In the analysis process, there were different aspects of conceptions emerging from the data and I characterised and presented the categories of description for the grouped conceptions. The utterances that I found to be interesting for the problems under investigation were selected.

Marton (1988; Marton et al., 1993, 283) makes a distinction between conception and categories of description. The conception refers to actual experiences, understandings and conceptualisations that people have of various phenomena. Categories of description are abstract tools used to characterise the conceptions. According to my interpretation the categories of description which emerged from the data analysis, are meaningful in understanding the characteristics and contribution of collaborative learning technologies in teachers' professional development in social relations in a teacher community. Marton (1988) writes also that the meaning of an utterance occasionally lies in the utterance itself, but in general the interpretation must be made in relation to the context from which the utterance was taken. The phenomenon in question is narrowed down to and interpreted in terms of selected quotes from all the interviews (or data gathered). The quotes themselves are interpreted and classified in terms of the contexts from which they are taken; they are abstracted from the data gathered.

When analysing the data I identified and grouped teachers' expressions on the basis of similarities, differences and complementarities and identified the meaning embedded in quotes. Each quote has

the “pool of meanings” to which it belongs. This interpretation process was an interactive procedure, where, finally, I brought the utterances together into categories on the basis of their similarities. I illustrated each category by quotes that were found from the data gathered, such as “Developing thinking through shared writing process” (see Table 4 in Article II) and “Learning from advanced colleagues” (see page 27 in Article III). Like Marton (1988) stresses, in the phenomenographic content analysis, the process is dialectical in the sense that meanings are developed in the process of bringing quotes together and comparing them.

As the meanings of categories begin to form, those meanings determine which quotes should be included and which should be excluded from specific categories. It entails the continual sorting and re-sorting of data, where a researcher has an active, interpretative and sorting role. Marton and his colleagues (1993, 282) found that expressions often represent different fragments of the same conception. In order to see expressions as representing different fragments of the same whole, the researcher has to have an idea of what the whole is like. To be able to decide whether or not two expressions reflect the same conception, the researcher must have an idea as well what the conception is; the conception is abstracted from the expressions that are considered to reflect it.

Hence, it is important to test the definitions for categories against the data, adjust, retest and adjusted again. There is, however, a decreasing rate of change and eventually the whole system of meanings is stabilized.

In the phenomenographic approach, the categories of descriptions can be classified hierarchically (conceptions are classified e.g., by their quality), vertically (conceptions are organized e.g., by their frequency) or horizontally (conceptions are equal) (Uljens, 1989, 46-51; Järvinen & Järvinen, 2004). In this study, I classified the categories of descriptions horizontally; this means that the conceptions found from the data are considered to be equal (see in Articles I–III). There is no such category of description or a teacher’s conception, which is more valuable than others.

#### *Aspects on interviewing and group interviewing*

As mentioned above, one of the main methods for data gathering used in the current study was interviewing. In the first study (see Article I) a semi-structured group interview of teachers was carried out, in the second study (see Article II) free interviews of a few teachers were used as complementary data gathering techniques for reaching all the teachers participating in web-based knowledge building. In this study, the interviewing was unstructured to some degree: there was a

setting and identified informants, but there were several options offered and interviews were conducted very freely on some general topics which the researcher wanted to know about their experiences. In the third and fourth studies (see Articles III and IV) the semi-structured in-depth interviews (where questions were open, supplementary questions were asked, and the responses were taped and transcribed) were carried out with the central actors of a teacher community. (See more about the definition of semi-structured in-depth interviewing e.g., from the University of Hertfordshire.)

Asking questions and getting answers is a much harder task than it may at first seem. The spoken or written word always has a residue of ambiguity, no matter how carefully the questions are worded and how carefully the answers are coded and reported. Yet interviewing is one of the most common and powerful ways in which to try understand fellow humans. Interviewing includes a wide variety of forms and a multiplicity of uses. The most common form of interviewing involves individual, face-to-face verbal interchange. Malinowski (1989) captures the difference in structured versus unstructured interviewing: the former aims at capturing precise data that can be coded so as to explain behaviour within pre-established categories, whereas the latter attempts to understand the complex behaviour of members of society without imposing any a priori categorization that may limit the field of inquiry. In this study, when studying teachers' experiences, the unstructured interviewing technique has been found most relevant. "Semi-structured" refers in this study to the setting, that there has been the same open questions for all interviews and, for instance, the order of the questions has not been changed. This supported the phenomenographical analysis of the interviews; sorting the quotes appeared in individual interviews to "the pools of meanings".

In the first study (see Article I) the interview was carried out as a formal group interview. The group interview is a qualitative data-gathering technique that relies on the systematic questioning of several individuals simultaneously in formal or informal settings. In this study, there were two groups of teachers interviewed with the same set of open questions, however, the interviewers allowed the groups to concentrate on the topics they found most important and interesting. Other interview session was audio- and other videotaped, then both of them were transcribed.

In a group interview, the interviewer directs the inquiry and the interaction among respondents. Group interviews can be used successfully to aid respondents' recall or to stimulate detailed descriptions of specific events or experiences shared by members of the group. Group interviews can also be used for triangulation purposes or used in conjunction with other data-gathering

techniques (Fontana & Frey, 2005). Triangulation has been generally considered a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation (Stake, 2005). In this study, I applied the group-interview for both purposes. For example, group interviews were helpful in the process of “indefinite triangulation” by putting teachers’ responses into the context of a particular development project of collaborative learning technologies. It also served the triangulation of the research methods within the study by enriching the results acquired by more traditional methods.

### *Phenomenography and phenomenology*

Phenomenography is a qualitative research method. According to Lincoln (2005, 178) the current challenge for qualitative researchers is to work toward legal and policy changes that reflect the reconfigured relationships of qualitative research. These new relationships are cooperative, mutual, democratic, open-ended, communitarian. They are highly incompatible with the asymmetrical power, informed consent, risk-beneficence models of research ethics currently in force.

Many times phenomenography is related to phenomenology. However, phenomenography is not an offspring of phenomenology. Phenomenology, based on the Husserlian imperative (<http://www.phenomenologycenter.org/phenom.htm>) to return to “the things themselves”, offered a philosophical explanation for what we were doing. According to the basic tenets of phenomenology, all knowledge is rooted in our immediate experience of the world. All four features of phenomenography referred to earlier (the relational, experiential, contextual and qualitative) are characteristic features of phenomenological research as well. In what way then does the phenomenographic approach differ from the phenomenological tradition?

Marton (1988) describes three areas of disagreement. First, phenomenology is an alternative to empirical research and can be described as a first-person enterprise. Researchers “bracket” their preconceived notions and depict their immediate experience of the studied phenomenon through a reflective turn, bending consciousness back upon itself. Second, phenomenology is focused on the essence of experience. For phenomenologists the essence of the experience is usually interpreted as that which is common to different forms of experience, while phenomenographers try to characterize the variations of experience. Third, Edmund Husserl, the father of phenomenology, was anxious to find experience unaffected by scientific thinking. He emphasised the distinction

between immediate experience and conceptual thought.  
(<http://www.phenomenologycenter.org/phenom.htm>.)

In a phenomenological investigation, one should “bracket” the latter and search for the former. Phenomenographers do not make use of this distinction, at least not as a starting point in research. They try instead to describe relations between the individual and various aspects of the world around them, regardless of whether those relationships are manifested in the forms of immediate experience, conceptual thought, or physical behaviour. Although it does make a difference on the psychological level in which form the relationship is manifested, the assumption is that there is a structural level which is not affected by these psychological differences (Marton, 1982). In the last decade, phenomenographers have been more and more interested in experiences (Marton & Fai, 1999), when the object of the research is a way of experiencing something or the difference between two ways of experiencing the same thing.

#### *Reliability in phenomenography*

When qualitative research, like phenomenography, is based on a researcher’s subjective interpretation, it is essential to assess how “faithful” the interpretation is to the data. The categories of description in the phenomenographic approach can be considered adequate and sufficient, if every single interview is possible to place into the categories. From the point of view of reliability, it is important that a researcher’s interpretation is faithful to the differences of categories. This means that a researcher is aware of different conceptions of the research subjects’ and different conceptions are also represented in research results. It is also important that the categories of descriptions include different conceptions when comparing them to each other (Larsson, 1986, 37-38).

Phenomenographic studies have often been criticised for not having the analysing process sufficiently reported; a reader may have difficulties to understand how the researcher has created the categories. In addition, Ashwort and Lucas (1998, 426) have criticised Marton’s (1994) presumption, that there is a certain, limited amount of different conceptions that can be found from research data. Because a researcher creates the categories, she or he also decides how many categories there are. Huusko and Paloniemi (2006) ask: Do the conceptions remain the same and

constant also in different historical times? It is important to realize, that in a community or in a culture there are limited amount of different ways to consist certain phenomena at any given time.

In qualitative research, like in phenomenography, the researcher has an impact on the research. According to Laine (2001) a researcher's awareness of her or his own values and presumptions support her or him to assess their impacts on the interpretation process. The presumptions involve, first of all, the researcher's theoretical and subjective framework in perceiving the world. The theoretical framework consists of the previous research concerning the phenomena. In this research process, I have carried out conscious introspection and open discussion about my presumptions and interpretations with research subjects (the teachers participating in the study), my theoretical and methodological guides and with the other postgraduate students. From this basis, it can be assumed, that the categories of descriptions that emerged from the data have been analysed being aware of the researchers' impacts on the process. Because qualitative research combines researcher's and participants' values, also the reader of the research should have the possibility to make her or his own interpretations. When a researcher has openly reported the different phases of research, the reader has better possibilities to assess researcher's notices. (Ashwort & Lucas, 1998, 429.)

Another challenge of phenomenography is related to the generalization of research results. As Marton (1988, 148) writes: "When phenomenographers present their findings, someone usually asks, would another researcher working independently arrive at the same set of categories if she or he were studying the same data?" And continues: "The original finding of the categories of description is a form of discovery, and discoveries do not have to be replicable. On the other hand, once the categories have been found, it must be possible to reach a high degree of intersubjective agreement concerning their presence or absence if other researchers are to be able to use them".

### **Social Network Analysis**

Social network analysis (SNA) is a collection of techniques that are focused on uncovering the patterns of people's interaction and relational information on participation, patterned sets of connections (Scott, 1991; Wasserman & Faust, 1994). Haythornthwaite (1996) describes applying SNA in studying information exchange and how it is an approach and set of techniques used to study the exchange of resources among actors (individuals, groups, or organizations). One such resource is information. Regular patterns of information exchange reveal themselves as social

networks, with actors as nodes in the network and information exchange relationships as connectors between nodes. Just as roads structure the flow of resources among cities, information exchange relationships structure the flow of information among actors. Social network analysis (SNA) assesses information opportunities for individuals or groups of individuals in terms of exposure to and control of information. By gaining awareness of existing information exchange routes, information providers can act on information opportunities and make changes to information routes to improve the delivery of information services.

In this study (see Articles III and IV) I applied SNA in studying the network structure of a teacher community related to the use of information and communication technology (ICT). I gathered the data for SNA through networking questionnaire which consisted of a list of names in rows which represented the names of each of the 33 members of the teacher community and columns for five types of networking relations. In the case of each colleague, the member of the community was guided to think about the following questions, which are also described as network dimensions within this study: 1) to whom they go to with technical questions related to ICT, 2) to whom they go to with pedagogical questions related to ICT, 3) with whom they carry out collaboration on web-based learning, 4) from whom do they receive new knowledge and ideas on web-based learning and 5) with whom they interact informally. In addition, the members detailed what media they use in each of their relations from the following six categories: 1) e-mail, 2) Internet: web sites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else? What? The respondents were guided to think their interaction with their colleagues during the last six (6) months.

The dimensions of questionnaire were formed on the basis of earlier research and experiences on adopting technologies in schools (Hakkarainen, Järvelä, Lipponen & Lehtinen, 1998; Ilomäki, 2002; Ryymin & Korhonen, 2003). These previous studies have indicated that some teachers specialize on technical questions whereas others are merely pedagogical actors in their communities in the process of adopting new technologies, and that there are usually early adopters, who disseminate their knowledge to the other community members. In addition, in the first phase of adoption of new technologies, teachers usually start with e-mails, but may use variety of media when they have more knowledge, experience and skills on new technologies. I tested the questionnaire by a group of teachers from other schools for verifying that teachers genuinely understand the questions and the structure of the questionnaire.

The data consisted of the links between members, indicating what kind of interaction they engaged in and with whom. All the dimensions were computed on the matrix. The tie between the members was present if the member of the community had reported it in the matrix. The matrix cell can only get values 1 (the tie is observed) or 0 (there is no tie). In this study, I studied the interaction and information exchange between the members of the community for its density, centrality, centralization and egocentric networks of the individual members of the community and performed social network analyses with the Ucinet 6 program (Borgatti, Everett & Freeman, 2002).

In addition, the members of the community reported their networking relations outside of the community. The questions consisted of open rows, where the members filled in the names and organizations of their contacts, and columns of the same five types of networking relations. The members also detailed in each contact, the media they used in interaction. The members of the community reported also other sources where they acquired information about 1) technical questions related to the information and communication technologies, 2) pedagogical use of information and communication technologies and 3) new knowledge and ideas related to web-based learning.

#### *Centrality, centralization and density*

The idea of centrality of individuals and organizations in their social networks has its origins in the sociometric concept of the star; a person who is the most popular in his or her group or who stands at the centre of attention (Scott, 1991, 85). What unites the majority of the approaches to centrality is a concern for the relative centrality of the various points in the graph, the question of so-called “point centrality”. A point is locally central if it has a large number of connections with the other points in its immediate environment. A point is globally central, on the other hand, when it has a position of strategic significance in the overall structure of the network. Related to the measurement of point centrality is the idea of the overall centralization of a graph, and these two ideas have sometimes been confused. The term “centrality” is restricted to the idea of point centrality, while the term “centralization” is used to refer to particular properties of the graph structure as a whole. Centralization refers to the overall cohesion or integration of the graph (Scott, 1991).

In this study, I measured the network centrality of individual members of the community by Freeman's Degree function (Scott, 1991, 88), which means the amount of information and knowledge the participant provides for or receives from the other participants (see in Articles III and IV). The

measure is based on indegree, which means the number of incoming networking linkages, and outdegree, which means the number of outgoing linkages. Every individual's centrality related to the information exchange was measured within the all five dimensions: technical and pedagogical questions, collaboration of web-based learning, acquiring new knowledge or ideas of web-based learning and informal interaction. I examined also the extent to which a whole community had a centralized structure within the dimension. Centralization of a whole network thus accounts for the variation in outdegrees or indegrees of the members in a network.

Centralization means whether there is a member who is more important than the others; the extent to which the cohesion of the network is organised around particular points. Density, in turn, measures how often information flows between members. The more actors have relationships with one another, the denser will the network be. The density of a network is the total number of ties divided by the number of possible ties. It describes the general level of cohesion in a graph. Because centralisation and density are important complementary measures (Scott, 1991, 92-93), I also measured the density of the networks of the teacher community within the five dimensions in this study. The centralization and density values were analysed related to the network structure of ICT (see Article IV).

In addition to examining the density of the overall network, it can be analysed concerning with the density of links surrounding particular agents, the personal networks of the members of the community. This approach is called *egocentric networks* (Scott, 1991, 75). In this study, I analysed the egocentric networks of the individual members of the community within the five dimensions by their size and density (see Article IV). In this context, measuring the egocentric networks, the size of the egocentric network means the number of actors that an individual, "an ego", is directly connected to, while the density of the egocentric network means the number of ties (total number of ties in the ego network) divided by the number of pairs multiplied by 100 (Borgatti et al., 2002). My goal in analysing egocentric networks within this study was to find out whether the same actors are central in different networks? For instance, are the central actors of the network of pedagogical knowledge sharing central also in the network for technical knowledge sharing? Further, in Article IV, I used the QAP-correlation to analyse whether the five dimensions examined (technical and pedagogical questions, collaboration of web-based learning, acquiring new knowledge or ideas of web-based learning and informal interaction) could have be combined or summed up (Pearson's correlation coefficient between data matrices) for further analysis. (Borgatti et al., 2002.)

### *Multidimensional scaling*

In this study, I presented the results of analysis of the fifth dimension, informal interaction, by multidimensional scaling (MDS) map (see Article IV) also. It shows the distances between the members and the structure of the network of the community. The basic idea behind MDS is that of using the concepts of space and distance to map relational data. As a configuration of points and lines can be made into a metric map, it is also possible to measure distances and directions in ways which differ from the path distances, where the distance between two actors is the length is the length of the shortest path that connects them (a geodesic path). Contrary to the path distance, the metric concept of distance is close to the everyday understanding of physical distance. MDS is an attempt to convert graph measures into metric measures (Wasserman & Faust, 1994, 287-289; Scott, 1991, 151-156, see also in Palonen & Lehtinen, 2001, 505-506). The validity of each map can be measured by a value of stress, where the greater the value the worse the model. The value is dependent on the data: the number of actors and the scale of measures. The stress value of the MDS figure of the study presented in the Article IV is 0.114, which is reasonably good.

Additionally, I examined the media used in teachers' interaction by focusing on the egocentric networks of the four different types of actors (see Articles III and IV). I chose these teachers because of the specific qualitative characters of their egocentric networks and media use when comparing them to their colleagues' networks and media choices. Further, I used the data gathered by the teacher interviews as validation for the network classifications. Because the media use appeared to be very complex phenomenon, which was related to the quality and content of a tie and to the individual's personal ways to interact, I found it important to illustrate and visualize the egocentric networks of the four case examples. I examined also what contacts these four types of actors have outside of the community and what other sources, besides their colleagues and outer-community contacts, they utilize when acquiring information concerning ICT. The drawings referring to the egocentric networks of the four types of actors are represented in Figures 2-5 in Article IV.

### *The benefits and limitations of the social network analysis*

The benefits of social network analysis are that it makes explicit the network structures that other techniques cannot highlight. In this study context, the social network analysis opened new

perspectives on teachers' interaction and its structures in networks. However, only limited tools and methods were presented within this study, and there are several other methods that would be useful in educational research, for instance, approaches to study subgroups in teacher communities.

In the studies reported in Articles III and IV, the SNA required that the participants made retrospective generalizations regarding their networking relations (Reis & Gable, 2000). In this sense it would have been important to study dynamically evolving networks also. However, it may have been cognitively rather demanding to determine the nature of networking relations across all members of one's workplace community. A more optimal, but much more labour-intensive method would have been to ask the participants to keep a record of their networking interaction on a day-to-day basis.

Further, in the researches reported in Articles III and IV, the size of the present community (N=33), which was chosen to be manageable, may have been a limitation. It is difficult to judge the effects in the present case, but it is possible that some of the less frequent interactions would have appeared differently for a larger sample. In the case of two or three of the respondents, she or he reported informal networking relations with all of their colleagues. These participants had possibly different interpretations of the concept "informal interaction" than the others. In most cases, incoming ties indicated that these were really the most central actors regarding the network of informal interaction.

In future research, it would be important to study the co-evolution of teachers' pedagogical practices and their social networks: how the knowledge of pedagogical innovations is shared, and how this process could be supported, in networks which consist of people, artefacts and mediative tools? One needs to look at how the different cultures of expertise can help schools to widen their pedagogical communities of practice towards the principles of innovative knowledge communities? There are some open-source computer programs, such as TECFLOW and SONIA, that can be used to examine dynamically changing social networks (Bender-deMoll & McFarland, 2005).

The co-use of phenomenography and social network analysis offered reliable triangulation for this study. By using both qualitative and quantitative approaches, the network structures of the networks were revealed, but also the experiences and conceptions of the actors of the networks were heard.

One of the limitations of this study derives from the research design based on single teacher groups and communities with no possibilities to compare network settings, for instance, with control groups. This leaves the generalizations at the level of examples, descriptive explanations and ideas for further studies. Moreover, although the co-use of phenomenography and social network study offers a robust combination of research techniques for understanding teachers' professional development in its social context, it is important to remember, that school and teacher communities are complex phenomena with formal and subcultures and would benefit multi-sided, longitudinal approaches.

### **Aspects to the internal validity of the study**

In the last section, "the control groups" refers to the questions of external validity of the research process. However, the more accurate challenge is of internal validity, which is the approximate truth about inferences regarding cause-effect or causal relationships. Thus, internal validity is relevant for studies that assess the effects of interventions (Trochim, 2006). In these contexts, a researcher would like to be able to conclude that the program or intervention made a difference. But there may be lots of reasons, other than the intervention itself, why the research results may improve. For instance, the alternative explanations for the outcome may arise from "the Hawthorne effect"(Landsberger, 1958), where people's behaviour and performance change following any new or increased attention.

In many cases, the assessment of the results of educational implementations take many years and need supporting elements after intervention. In this research, these supportive aspects have been described more in detail in the research results of the first article; they are organisational, pedagogical and technical in nature. Unfortunately, in this research process, it was not possible to follow the development processes over several years; the question how constant and scalable the new pedagogical practices are, is definitely the important duty of the future research. However, there are several answers to the challenges of internal validity in this research such as 1) the post-measurement 1,5 years of the intervention in the first article, 2) attention to theory-driven intervention implementation, 3) self-observation and open debate of the intervention statement and researcher's role with the participants and other researchers, 4) quality control, for instance, debate with participants and other researchers about the research process and research results and, 5) the use of multiple perspectives and triangulation in data gathering and research methods (single and

group interviews, open and structured questionnaires, writing in virtual database, social network analysis and phenomenographic approach).

The complicated relationship between technology and pedagogy bring one aspect more to the questions of the internal validity of this research. For instance Söderlund (2000) has found, that although there has been several technological interventions in schools, the pedagogical breakthrough has not happened. The challenges of implementation of technologies in schools is one of the key themes of this research and it is reflected both in theoretical background and in research results. This study aims to offer some new elements in meaningful technology dissemination, for instance, strengthening teacher networks and collaboration. One of the main conclusions in the in the introductory chapter ( see the 4<sup>th</sup> chapter “Results and General Discussion”) is that technology must be developed seamlessly together with teachers’ professional development and pedagogical practices in authentic learning contexts. This may possibly be one element to support pedagogical change in the near future.

### **Codes of ethics in this study**

I have followed the principles and codes of research ethics defined by Christians (2005, 144-145) within this study. The research subjects, teachers, have been informed about the nature and consequences of experiments in which they have been involved (the principle of informed consent). Teachers have agreed voluntarily to participate and their agreement has been based on full and open information. As a researcher I have explained them the duration, methods and the purpose of the research. In collaboration with teachers, it has been agreed that there are no possible risks within these studies, merely the challenges related to the practicalities, such as finding time for interviews during the busy school day. These practical issues were solved through cooperation.

I have designed the studies free of active deception (the principle of deception) and protected teachers’ privacy and confidentiality. All personal data had been secured or concealed and made public only behind a shield of anonymity. Professional etiquette uniformly concurs that no one deserves harm or embarrassment as a result of insensitive research practices. For instance, the teacher community (see Articles III and IV) is anonymous. However, with the teachers and a principal profiled in more detail as central actors in these studies I have negotiated together how they feel in the case that they would be identified from the descriptions. The participants have allowed me to publish the studies taking into account this eventuality. Finally, accuracy of the data

is a cardinal principle. The data is internally and externally valid; and this has been confirmed by the teachers, the subjects of the study, as well as co-researchers of the study (see Article I) and the guides of my dissertation (see Articles III and IV).

Further, it is important to write a few words about the ethics of the implementation of the research results. From the basis of the research results, one may suggest new educational policies, training programs etc. However, it is ethically meaningful that both the research results and the suggestions for new policies are always critically debated and weighed in the society of educational researchers. This is especially true when talking about school reforms; we need constant, open and critical dialogue between researchers, developers and politicians.

### 3. An Overview of the Empirical Studies

#### Article I

**Ryymän, E., Veermans, M. & Lakkala, M. (2005). Dissemination practices of technology-supported inquiry learning. *Learning the Skills, Special Edition of The Finnish Journal of Vocational and Professional Education*, 65-85.**

The aim of this article was to explore how pedagogical innovations of technology-supported inquiry learning should be disseminated and consolidated in the long-term practice of schools. The goal was to learn what possibilities, challenges and problems teachers confront when implementing technology-supported inquiry learning. Empirical data for the study were gathered during a two-year international project (ITCOLE). The article focused on experiences and results gathered in Finland, and, in particular, on the results of an end phase questionnaire, a delayed post-measurement questionnaire, and group interviews of teachers. The findings of the study indicated that experiences and practices of technology-supported inquiry learning can be transferred to everyday school life when pedagogical, technical and organizational factors support teachers in the implementation. Especially true is that teachers required pedagogical guidance and support not only during, but, if needed, after development projects. It is suggested that one important means for dissemination is the establishment and fostering of a teacher community and the promotion of teacher-based networks.

## Article II

**Ryymin, E. (In press). Web-based knowledge building and teachers' professional development. In T. Varis (Eds.) *Online Education and Professional Development*. Saarijärven Offset-paino: Saarijärvi.**

The goal of this article is to open new perspectives on teachers' technology-supported professional development and offer advice, ideas and meta-policies, for educational policy makers for planning innovative, effective and cost-efficient models for teacher training. The goal is to learn what possibilities, challenges and problems teachers confront when implementing synchronous, web-based knowledge building in their in-service training and to find out what kind of advantages a web-based learning environment offers to teachers' collaboration.

Empirical data for the study were gathered during a two-year international project (ITCOLE).

The focuses here are on experiences and results in Finland, and, in particular, on the results of an end phase questionnaires and interviews of teachers.

The findings of the study indicate that synchronous web-based knowledge building, which is based on clear, authentic, real-life problem statements, supports teachers' collaborative problem-solving and professional development in a meaningful way. The findings also indicate that a web-based learning environment provides, as a collective memory and a platform for shared writing, a unique possibility for the development of teacher communities. It is suggested that for supporting teachers' professional development better in the future, educational policy makers should implement web-based knowledge building as an innovative model for teacher (in-service) training and foster genuine collaborative cultures in teacher communities.

### Article III

**Ryymän, E., Lallimo, J. & Hakkarainen, K. (In press.) Teachers' professional development in a community: a study of the central actors, their networks and web-based learning. *E-learning and education (eleed)*.**

The goal of this article was to study teachers' professional development related to web-based learning in the context of the teacher community. The object was to learn in what kind of networks teachers share the knowledge of web-based learning and what are the factors in the community that support or challenge teachers professional development of web-based learning.

In the study, all 33 members of the school's teacher community took part, including 29 teachers, the principal, 2 school assistants and the school secretary. The participants were asked to respond to a Social Network Analysis (SNA) questionnaire designed to assesses networking relations among the participants according to the following five dimensions: 1) providing technical advice regarding ICT, 2) providing pedagogical advice for using ICT, 3) collaboration regarding web-based learning, 4) acquiring new knowledge or ideas of web-based learning, 5) informal interaction between the members of the community. In addition, the use of different kinds of media and teachers' other information sources were analysed. In further, the data for the study were gathered by interviews of teachers.

The findings of the study revealed that there are teachers who are especially active, whom we shall call the central actors, in the teacher community who collaborate and share knowledge of web-based learning. These central actors share both technical and pedagogical knowledge of web-based learning in networks that include both internal and external relations in the community and involve people, artefacts and a variety of media. Furthermore, the central actors appear to bridge different fields of teaching expertise in their community.

According to the central actors' experiences the important factors that support teachers' professional development of web-based learning in the community are; the possibility to learn from colleagues and from everyday working practices, an emotionally safe atmosphere, the leader's personal support and community-level commitment. Also, the flexibility in work planning, challenging pupils, shared lessons with colleagues, training

events in an authentic work environment and colleagues' professionalism are considered meaningful for professional development. As challenges, the knowledge sharing of web-based learning in the community needs mutual interests, transactive memory, time and facilities, peer support, a safe atmosphere and meaningful pedagogical practices.

On the basis of the findings of the study it is suggested that by intensive collaboration related to web-based learning it may be possible to break the boundaries of individual teachership and create such sociocultural activities which support collaborative professional development in the teacher community. Teachers' in-service training programs should be more sensitive to the culture of teacher communities and teachers' reciprocal relations. Further, teacher trainers should design teachers' in-service training of web-based learning in co-evolution with supporting networks which include the media and artefacts as well as people.

## Article IV

**Ryymin, E., Palonen, T. & Hakkarainen, K. (2008). Networking relations of using ICTs within a teacher community. *Computers & Education*, 51(3), 1264-1282.**

The purpose of the present study is to examine the network structure of a teacher community related to the use of information and communication technologies (ICTs). The study was carried out in an upper comprehensive school in a suburban area of Helsinki, Finland. In the study, all 33 members of the school's teacher community took part, including 29 teachers, the principal, 2 school assistants and the school secretary. The participants were asked to respond to a Social Network Analysis (SNA) questionnaire designed to assesses networking relations among the participants according to the following five dimensions: 1) providing technical advice regarding ICT, 2) providing pedagogical advice for using ICT, 3) collaboration regarding web-based learning, 4) acquiring new knowledge or ideas of web-based learning, 5) informal interaction between the members of the community. In addition, the use of different kinds of media and teachers' other information sources were analysed. The results of the study indicated that the members of the community differed in terms of their use of ICT-related networks and informal interaction. There were a few central actors in the community, who dominated technical and pedagogical information exchange and to whom their colleagues actively turned when seeking advice. Two of the cognitively central actors represented hybrid expertise, a characteristic of which was to merge technological and pedagogical expertise in using ICT in education. These actors tended also to have their own external networking relations that helped them to keep up their high level of competence. The participants' ICT-related egocentric network differed in size and density. There were some actors central to the network of informal interaction that were, simultaneously, peripheral in ICT-related networking activities. On the other hand, the central actors of ICT were not necessarily the socially central persons in the community. In the analysis, investigators identified four distinct personal patterns of networking, represented by four teachers; The Counsellor offers advice actively without herself seeking information from colleagues; The Inquirer is an active seeker of ICT-related information capitalizing on her social relations; The Collaborator engages in collaboration efforts of web-based learning by using several media; and The Weakly Social prefers media rather than face-to-face contacts in his information seeking. Other members of the teacher community were more or less mixtures of these four types. The use of media in ICT information exchange relationships was a complex phenomenon and was strongly related to the actors' personal egocentric networks and the

quality and content of a tie. The use of media explained members' individual ways of interacting with others and the different kinds of actors appeared to have their own unique personal media profiles. The results of the study indicate that SNA can productively be applied to examine networking relations within a teacher community.

#### **4. Results and General Discussion**

My purpose in this study was to find new knowledge on teachers' professional development related to the implementation of collaborative learning technologies in working life. The approach of the work was focused on teachers' experiences and conceptions and on their social interaction relations.

Moreover, I aimed to find new perspectives to the challenges of how to support teachers to transfer development projects to everyday school life, how to benefit collaborative learning technologies professional development and how the networks of teachers may contribute professional development? One of my interests was also to research, what kind of network structure exists in a teacher community related to the use of ICT and to reflect, how this network structure contributes to teachers' professional development? I examined also what kind of media teachers use in their social interaction in a teacher community.

I carried out the actual analysis in the form of phenomenography (Marton, 1988) and social network analysis (Scott, 1991). The empirical studies have their basis in teachers' professional development, social interaction, networking and collaborative learning technologies. The fields, in which the empirical studies were carried out, did not comprise of a set of unitary or coherent phenomena. Instead, the studies cover quite a wide range of different targets from teacher groups participating in development projects of learning technologies (see in Articles I and II) to studying school communities and their actors (see Articles III and IV). However, some general results can be reported in order to describe the experimental and relational perspectives on teachers' professional development and use of collaborative learning technologies.

#### **I Teachers need pedagogical, technical and organizational support when implementing collaborative learning technologies**

The findings of the study indicated that experiences and practices of technology-supported inquiry learning can be transferred to everyday school life when pedagogical, technical and organizational factors support teachers in the implementation (see in Article I). Especially true is that teachers require pedagogical guidance and support not only during, but, if needed, after development projects.

For implementing technology-supported inquiry learning successfully, teachers have to resolve first the technical challenges. Successful scaling-up requires a usable technical application, which is easy to access and implement in natural settings. However, results of this study indicated that this is not enough for supporting educational change (see in Article I). Teachers need, in addition to reliable technical infrastructure and their personal commitment to the development process, also longitudinal pedagogical support after the official intervention.

Further, supporting teachers pedagogically is not sufficient if the organizational structures of the school resist the process of change. These restrictive structures may include, for example, insufficient physical facilities for teaching. Successful scaling-up of the pedagogical model of the technology-supported inquiry learning requires, in addition to long-term technical and pedagogical support, a new approach to organizational challenges. Professional development of teachers should be linked to the teacher community.

## **II Collaborative technologies contribute to teachers' professional development when carried out in careful design**

The findings of the study indicated that an application of collaborative learning technologies, called synchronous web-based knowledge building, supports teachers' collaborative problem-solving and professional development in a meaningful way when it is guided and based on clear and authentic, real-life problem statements (see Article II). The synchronous web-based knowledge building may support teachers to create new knowledge, which they found usable when implementing new, technology-supported pedagogical practices in everyday schooling. Further, a web-based learning environment, which includes the Knowledge Building forum, supports teachers' collaboration by offering the possibility to save the collaborative knowledge building process of a teacher community as a collective memory and by developing thinking by shared writing. Web-based knowledge building can be used for reaching more qualitative goals than just information change: it can, in the best case, support individuals to create new knowledge.

## **III Teachers' networks are meaningful in their professional development**

The findings of the study indicated that the networks of teachers, who are cognitively central in their community related to the development of web-based learning involve people, artefacts and variety of mediative tools (see Article III). The central actors have internal and external relations in the

community and they mediate knowledge related to web-based learning not only in face-to-face occasions but also by phone, e-mail and web-based learning environments. They acquire new knowledge and ideas about web-based learning not only from people but also from different sources of information, such as the Internet, books and magazines. The important factors in developing teachers' skills of web-based learning in a teacher community are; the possibility to learn from colleagues, safe atmosphere, leader's personal support and community-level commitment. The challenges related to knowledge sharing of web-based learning are facilities, a need for training in an authentic working environment, importance of mutual interest in peer learning occasions and safe and supportive atmosphere among colleagues.

In their networks, central actors mediate both pedagogical and technical knowledge. They seem to have meta-knowledge about the locus and availability of community members' knowledge capital and they benefit that knowledge in their own professional development (see Article III). The central actors play also a crucial role in implementing and further developing technology-supported pedagogical practices, for example, web-based learning in a teacher community (see Article III). They bridge different areas of expertise in the community, for instance, they use innovatively web-based learning in different subjects and learning tasks. They also translate knowledge from one area of expertise to others, for instance by bringing new ideas on web-based learning to immigrant teaching.

#### **IV The central actors play key roles in teacher communities**

In the study on the network structure of the teacher community the notion of central network actors was obvious (see Articles III and IV). The cognitive networks related to the use of ICT are concentrated on some important and influential persons: the central actors have key roles in their communities.

The study revealed that the central actors of ICT were not necessarily the socially central persons in the community. In many in-service training programs, which emphasise peer tutoring in ICT implementation, the trainers and principals are encouraged to recruit the socially most active teachers to the task. The present evidence, however, indicates that the advice-seekers do not necessarily turn to the most sociable colleagues in their domain-specific advice seeking.

The central actors are both women and men representing different ages, subject domains and work experience. In the subject domain of ICT, being in a central position in this teacher community was not connected to a teachers' gender, teaching subject, experience or age. In this study, I didn't examine what exactly made central informants central, however, in interviews they emphasized that they found ICT genuinely meaningful in their teaching. They also have strong, personal growth-orientation, for instance, they are all seeking more in-service training related to ICT.

## **V The information of ICT is not equally exchanged among teachers in a teacher community**

The study on the network structure of the teacher community showed that the relations among community members are divided quite unequally within the different dimensions; some of the members reported more outgoing ties, some incoming ties. There are certain central actors found, as reported above, related to the technical and pedagogical information exchange, to who their colleagues actively turn to in their advice-seeking. The network of providing technical advice correlates with that of providing pedagogical advice on using ICT; these networking dimensions had substantial correlation and the same persons were asked both technical and pedagogical advice. The network technical advice did not correlate very much with other networking dimensions, whereas the network of providing pedagogical advice, collaborating in web-based learning and acquiring new knowledge or ideas of web-based learning correlated, and they can be seen as the properties of the same, coefficient factor of "pedagogical support network" of ICT. The network of informal interaction did not correlate with any other networks.

The network of informal interaction is denser than that of ICT-related networking interaction or collaboration. In further, advice asking networks are denser than the dimension of collaboration. This result may reflect the fact that it is likely to be more demanding to maintain collaborative activity than just exchange the information related to ICT. It may also reflect the situation that the collaboration of web-based learning is a quite a new activity in the community, whereas the other pedagogical practices have more established routines.

## **VI The members of the community interact and build networks in personal ways**

The study revealed that the egocentric networks of the community members are qualitatively different across the networks measured. Teachers interact in qualitatively different ways in their

networks. The four different types of actors and their egocentric networks were identified in more detail. For instance, The Counsellor offers advices actively, but does not turn so much for her colleagues in advice seeking. The Inquirer is an active information seeker, who utilizes her social relations in ICT information exchange as well. The Collaborator concentrates on concrete collaboration in web-based learning, and The Weakly Social prefers media instead of face-to-face occasions in information seeking.

## **VII The use of media in interaction is a personal and complex phenomenon**

The use of media in relations of information exchange of ICT is a complex phenomenon, which is strongly related to the actors' personal egocentric networks. The use of media explains members' individual ways of carrying out interaction with others and the different kinds of actors appear to have "personal media profiles". The use of media may also be considered as a property of a tie; the quality and the content of a tie between individuals appear to have an impact on the media choices.

## **Teachers' Intelligent Networks: Relationship-based Professional Development supported by Collaborative Learning Technologies**

### *Conclusions on study results*

This study revealed that teachers need technical, pedagogical and organizational support in the process of implementing collaborative learning technologies in their teaching (see Article I). The collaborative learning technologies can be benefited as innovative tools in contributing to teachers' professional development with careful planning (see Article II). Teachers in schools are members of the teacher community; they belong to the social network of relations, where information of ICT is exchanged and media is used in personal ways (see Articles III and IV). The relations among community members are divided quite unequally within the flow of information. There are cognitively central actors of ICT in pedagogical communities, who offer support to their colleagues and establish networks also with outer-community contacts through a combination of media (see Articles III and IV). These central actors not only exchange information, but also bridge different areas of expertise in their community and innovate new ways using it (see Article III). The central actors also play a crucial role in implementing and further developing technology-supported pedagogical practices, for example, web-based learning in a teacher community (see Article III). There are several factors in the teacher community, which both support ("leader's personal support") and challenge ("need for training at authentic working environment") teachers' professional development (see Article III).

This study revealed many factors we seem to be rather unaware of when carrying out teachers' professional development in the context of work. There are several ICT development projects in schools, but teachers are usually not offered enough pedagogical, technical, organizational and collegial support after closing the projects in order to transfer and maintain new practices in everyday schooling. There is a need for accurate, everyday problem-solving and creation of new knowledge in schools in the processes of educational change. Yet, the teachers rarely are involved in the change process as knowledge-generative subjects, nor are the possibilities of collaborative technologies cultivated efficiently for this purpose. In many cases teachers participate in out of school development activities in teams, but teachers' everyday relationships are not considered as a source of or a resource for professional development. In many development projects or educational reforms the training partners, administrators and even teacher communities themselves are unaware

of the networks of information exchange in- and outside of the school. The role and the purpose of the central actors are not found and mediative tools utilized in interaction are not paid any specific attention. It is also very common that people are not aware of those factors in their community which support or challenge their professional development, or they are not debated openly.

Teachers are still considered as working alone in their classrooms and meeting colleagues only in staffrooms and meetings instead of interacting in cross-boundary networks. The use of modern media is not perceived as part of teachers' personal profile of interaction; it is merely associated as tools in teaching, or as learning objects. Further, the development of collaborative learning technologies is mainly concentrated on the agents outside pedagogical communities, although, teachers' role in assessing and further developing learning technologies in real-life is essential. For instance, this study revealed that cognitively central teachers of the teacher community may generate innovative ways in using technologies in their working environment and mediate this knowledge to their colleagues (see Articles III and IV). Currently, there are some interest groups, where producers, researchers and teachers work together in order to collaboratively develop modern learning technologies (see for example, ITCOLE-project, [www.euro-cscl.org/site/itcole](http://www.euro-cscl.org/site/itcole)); this model of participatory design has not, so far, been disseminated widely in formal education.

The resources and limitations that pedagogical communities and teachers' social networks offer to teachers' professional development and implementation of collaborative technologies should be made more explicit and debated openly. However, I find it important to underline here, that this process may be very sensitive and should be conducted discreetly, wisely and professionally in schools, where change is not only cognitively, but often also emotionally stressful.

#### *The new concepts developed in the study and the dimensions of co-evolution*

On the basis of the findings of this study, I suggest that teachers' professional development could be seen innovatively as *relationship-based professional development*. This development cannot be considered separate from *teachers' social networks* and the *development of collaborative learning technologies*. Instead, these three fields should be seen as the overlapping elements of *teachers' intelligent networks* (see in Figure 1). By this concept "teachers' intelligent networks" I mean the networks, which include members of pedagogical communities, learning technologies, media (mediative tools), artefacts and information sources, and in which teachers intensionally exchange information and create new knowledge in order to develop their profession ( see also Table 3).

In this context, *pedagogical communities* should be understood in their wider meaning; not only certain school, but all the border-crossing networked communities, where a teacher acts and interacts. By developing teachers' intelligent networks it may be possible to deliberately cultivate traditional, hierarchical schools towards genuine collaborative cultures more efficiently and strengthen schools as non-hierarchical, innovative knowledge communities. By fostering teachers' intelligent networks, it is possible to establish and maintain networked pedagogical communities of expertise for supporting the educational change in schools.

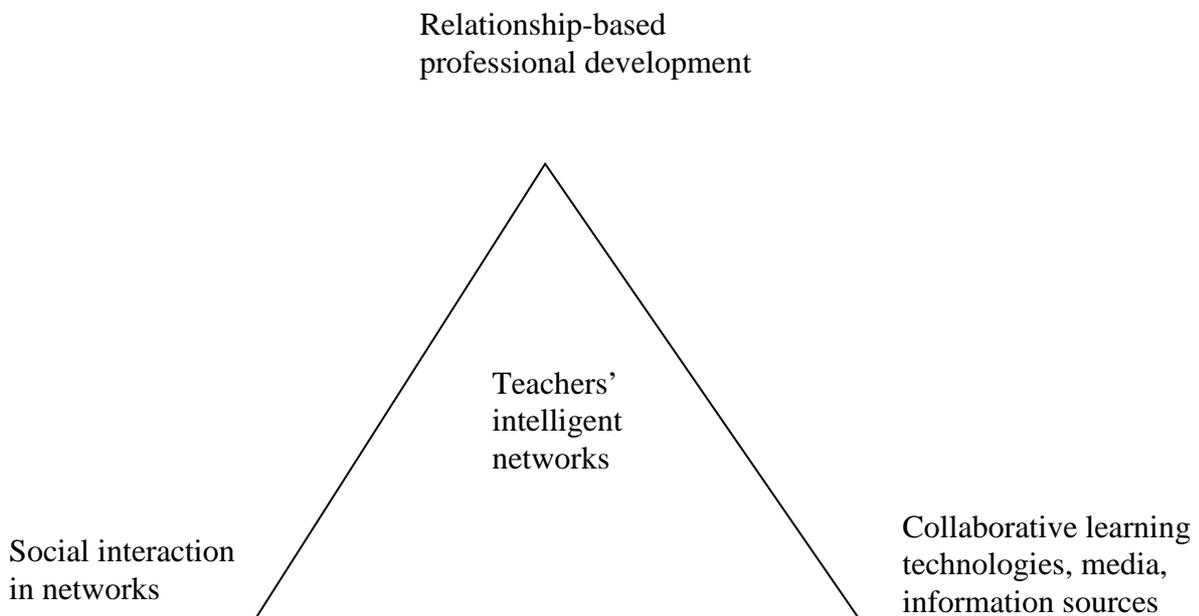


Figure 1. Elements of teachers' intelligent networks.

<b>Concept</b>	<b>Definition</b>	<b>Inspired by</b>	<b>Suggestions for implementation in practice</b>
relationship-based professional development	the process where an individual's professional knowledge is extended into qualitatively new areas of knowledge or ability as a result of interaction in personal networks and relationships	relationship-based learning (Ruohotie, 1999), professional development (Beairsto, 1996)	community-based teacher in-service training programs
teachers' intelligent networks	the networks which include people, learning technologies, media (meditative tools), artefacts and transactive memory of a teachers' working community and in which a teacher exchanges information and creates new knowledge in order to develop her / his profession intensionally	distributed cognition (Salomon, 1993) networked intelligence (Hakkarainen et al., 2004), intensional networks (Nardi et al., 2000), transactive memory (Wegner, 1986)	community-based teacher in-service training programs consultation of teachers and teacher communities to find and maintain support and sources for educational change
co-evolution of teachers' intelligent networks and professional development of teachers	an innovative approach to school development which emphasises the co-evolution and development of dimensions of teachers professional development, networks and collaborative learning technologies		community-based teacher in-service training programs consultation of teachers and teacher communities to find and maintain support and sources for educational change development of collaborative learning technologies development of network cultures of pedagogical expertise for supporting educational change

Table 3. New concepts developed in the study.

In Figure 2, I have illustrated this complex process of development as “the dimensions of co-evolution”. This approach includes the aspects of deliberate development activities of teachers’ profession, collaborative learning technologies and their coefficient on the evolution of school culture and on the use of technologies in school. Teachers’ professional development is reflected within two fields: development of in-service training and development of social networks. Also the development activities concerning collaborative learning technologies are seen from two perspectives: development of collaborative technologies in pedagogical context and development of collaborative technologies as agents in networks (see Figure 2). In addition, the evolution of school culture is observed from two aspects: evolution of pedagogical cultures of networked expertise and evolution of teachers’ intelligent networks. Also the evolution of the use of learning technologies in a pedagogical context is examined from two aspects: evolution of technology-supported pedagogical practices and evolution of collaborative technologies as pedagogical tools.

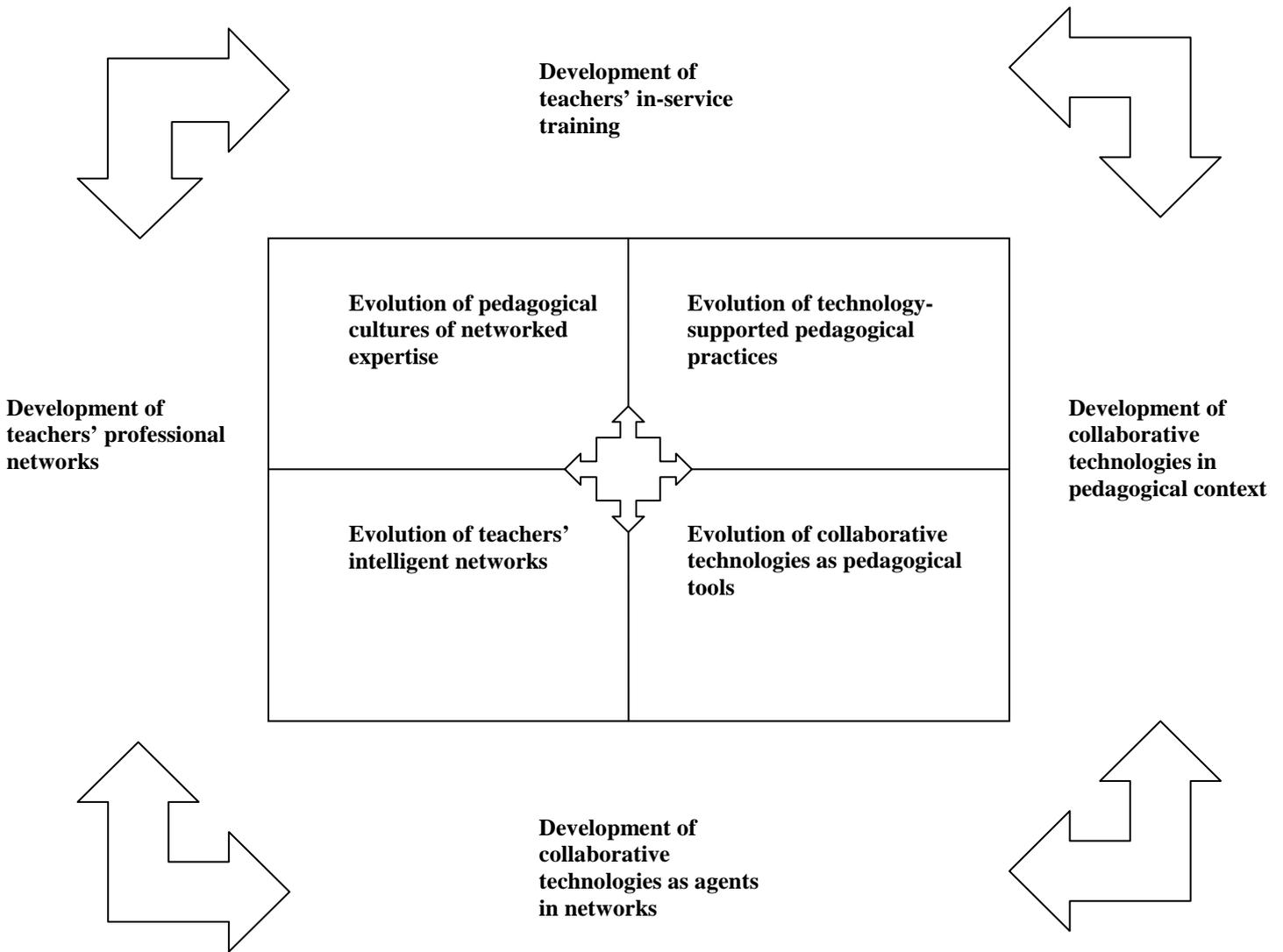


Figure 2. The dimensions of co-evolution of teachers' intelligent networks and professional development.

As shown in Figure 2, it is important that the collaborative learning technologies are developed in authentic pedagogical contexts and within the programs of teachers' in-service training. This way, teachers can establish such technology-supported pedagogical practices, which they find genuinely usable and meaningful both in their teaching and in their own professional development. For instance, in this study teachers participated in developing web-based knowledge building which, according to their experiences, contributed to their professional development uniquely (see Article II) and supported them to implement technology-supported pedagogical practices (see Article I) in teaching. However, formal teacher in-service training is needed to confirm the quality, goals and financing of the training, together with the committed administrators and university partners.

The open, explicit and deliberate development activities in an authentic school context support teachers to utilize more efficiently the resources of the community and its' social networks in the change process. The pedagogical, technical and organizational support that teachers need in the process could be better based on the already existing structures of knowledge of the community. For instance, the cognitively central actors and their meta-knowledge about the locus and availability of community members' knowledge capital could be sensitively used and cultivated. If we do not turn these hidden resources from shadow to explicit, these resources will stay unconscious and unavailable.

The development of the collaborative technologies as tools in a pedagogical context, and also as agents in networks, supports the evolution of pedagogical tools. This means that technology plays a more intelligent role than "just a technical tool" for organizing the teaching (see Figure 2). As revealed in this study (see Articles III and IV) teachers utilized, for instance, the web-based learning environment not only as a support for pedagogical practices, but also as a personal medium in information exchange and in their reciprocal planning of teaching. This innovative way of using a web-based learning environment had been generated by teachers themselves in their authentic working context. Hence, when developing technologies for teachers' use, teachers should be respected as participatory co-developers of the learning technologies.

This study revealed that teachers use different media in their networks in personal and complex ways (see Article IV). The development of teachers' social networks by paying attention to the agents used in their networks enable the evolution of *teachers' intelligent networks* (see Figure 2). This means such networks which consist of people, the collaborative learning technologies

developed within the pedagogical context to fit the professional needs of teachers, media and other information sources, and which teachers find personally meaningful in order to develop themselves professionally. By developing consciously teachers' intelligent professional networks within the in-service training programs and other interventions, it is possible to foster and maintain the evolution of the pedagogical culture of networked expertise. This means establishing such expanded networks and cultures of collaboration that cross the borders of traditional school organizations and involve several outer-school agents, for instance pedagogical experts from universities, to support the development of schools. By deliberate development of networks of expertise, schools could better find, benefit from and maintain resources outside of the school when organizing the continuous pedagogical, technical and organizational support that teachers need in the process of educational change (see in Article I).

The evolution of teachers' intelligent networks strengthens the cultures of networked expertise, which support schools to implement and further develop technology-supported pedagogical practices. The evolution of technology-supported pedagogical practices, in turn, enables more creative and new-generative use of technologies in schools, for instance, in planning teaching and mediating new knowledge created in that process. And then, again, this has an effect on teacher networks, in which the new technologies are utilized as agents in networking and information exchange.

In the dimensions of development activities, the emphasis is on purposeful, planned activities, which aim to strengthen the evolution described above. By developing teachers' in-service training to consider teacher communities as social networks including also collaborative technologies, media and other information sources, it is possible to cultivate teachers' networks more professionally. This means that teachers' social networks can be used more efficiently and purposefully as a support and source of professional development. When the use of collaborative technologies becomes more explicit as the agents in networks, they can be critically evaluated and further developed. This again supports teachers' professional networks in acting and reacting (e.g., to disseminate accurate information, create new, topical knowledge) more meaningfully and efficiently. When teachers find new technologies meaningful in their interaction, they are also encouraged to adopt the collaborative technologies in their teaching too (see Article II), where, in turn, collaborative technologies can be further developed within the authentic pedagogical context. The main principle is that the teachers' professional development is seamlessly linked to the

development of teachers' social networks and to the development of collaborative learning technologies.

### *Teachers' role in development activities*

I would like to emphasise that it is important to involve teachers themselves in the processes of developing new activities and models for professional development. Teachers should take, like any professionals today, more personal responsibility on renewing and reviewing their profession and working practices. Educational policy makers should respect teachers' dignity and autonomy in this re-creation process. The traditional and hierarchical models of school reforms including "contrived collegiality" (Hargreaves, 1994; 1996) are not sustainable in practice. Teachers should participate equally in creating new knowledge in the process of educational change, which is, admittedly, said than done. However, proper balance should be created in between teacher-generated and authority-guided educational interventions. In teachers' professional development there is a need for a genuine collaborative culture of different agencies, where the knowledge of networking, adult education and new technologies are united with political and administrative will. The realization that teachers can very concretely contribute to each others professional development in their daily circumstances and act as active knowledge creators within the development projects, could be better utilized in in-service training.

In future research, it would be interesting to study collaborative knowledge creation in pedagogical communities in more detail, for instance the different groups and their coherences, the reciprocity of knowledge change and the gaps and blocks in knowledge flow. Also the leadership of modern, networked pedagogical communities should be examined deeper. In addition, it is always important to hear teachers' voices in the process of educational change: what are the meanings that they give to the new technologies in teaching and learning? Do these meanings change in time? A variety of new media and technological tools will be innovated and offered for teachers' professional development in near future, and they open new possibilities for networking, widening and researching learning communities.

At the end, I find it crucial to state, that in researching and supporting teachers' professional development related to the collaborative learning technologies, it is basically a question of advancing the democracy of pupils. All pupils should have equal rights and possibilities to learn together with a highly educated, motivated teacher. It is not a privilege of lucky pupils only.

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Running head: DISSEMINATION PRACTICES OF TECHNOLOGY-SUPPORTED INQUIRY  
LEARNING

Dissemination practices of technology-supported inquiry learning

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**Abstract**

The aim of this article is to explore how pedagogical innovations of technology-supported inquiry learning should be disseminated and consolidated in the long-term practice of schools. The goal is to learn what possibilities, challenges and problems teachers confront when implementing technology-supported inquiry learning. Empirical data for the study were gathered during a two-year international project (ITCOLE). The focuses here are on experiences and results in Finland, and, in particular, on the results of an end phase questionnaire, a delayed post-measurement questionnaire, and group interviews of teachers. The findings of the study indicate that experiences and practices of technology-supported inquiry learning can be transferred to everyday school life when pedagogical, technical and organizational factors support teachers in the implementation. Especially true is that teachers require pedagogical guidance and support not only during, but, if needed, after development projects. It is suggested that one important means for dissemination is the establishment and fostering of a teacher community and the promotion of teacher-based networks.

Keywords: technology-supported inquiry learning, in-service teacher training

## 1. Introduction

There have been lots of projects carried out in many countries that introduce pupils and teachers to new pedagogical models, such as inquiry learning, and new learning technologies. Most of the projects have also attempted to transfer new ideas and practices developed in the project to the natural, every day learning settings after finishing the official intervention. Some of the projects manage to reform pedagogical practices in schools, but many of them fail. This so called scaling up–problem has been realized among school developers: what is the best way to ensure that the innovations created within educational intervention projects will be adopted, maintained and further disseminated?

According to Slegers, Van Den Berg and Geijsel (2000) most system-level school reforms have been leading to unsatisfactory outcomes. Researchers claim that educational innovations have not been sufficiently sensitive to the problems arising from the school context and organizational culture. This leads to the result that reforms are modified into existing practices or rejected. Usually some supporting activities are still needed after the development project when continuing implementing new pedagogical models and technological tools.

Hargreaves, Earl, Moore and Manning (2001) stated that it is cognitively and emotionally challenging to learn to teach in a different way than one has been taught himself / herself. The change of the learning culture requires support for teachers in practical details; teachers need mentoring when implementing new teaching methods. Other researchers (Jongmans, Biemans, Slegers & De Jong, 1998; Beijaard, Verloop & Vermunt, 2000) support the contention indicating that there is a strong link between educational innovations and a teachers' professional development.

Penuel and Means (2004) studied the scaling-up of scientific research practices in science teaching of schools. According to their results, new practices were adopted if there was concrete support available at school after the teachers' in-service training, such as mentoring or supportive material. Spillane (1999) believes that there are three distinct approaches of teachers in this regard. The first is the teacher who successfully implements pedagogical innovations in teaching; the second is the teachers who collaborate with colleagues and experts outside of the school; and the third is the

teacher who discusses both the principles and practical procedures of the pedagogical innovation with others, and who possess concrete materials and tools that supported the implementation. Also Slegers and colleagues (2000) found collaboration among teachers to be necessary for the successful implementation of educational innovations.

Blumenfeld, Fishman, Krajcik, Marx and Soloway (2000) studied implementation of inquiry and technology science innovation in a systemic urban school reform setting. They emphasized the importance of collaboration between teachers and administrators in innovation adoption. In addition, it turned out to be crucial to achieve common understanding and strategic coordination of administrative and organizational rearrangements required by an innovation. Systemic reform needs several components taken into account: school curriculum and pedagogy, software tools and professional development of teachers. Also the research community involved in educational reform needs lobby agencies to fund work for collaboration and strategic planning to enhance the likelihood of successful enactment. (Blumenfeld et al., 2000.)

Duart and Kiselyova (2003) discusses reform of university pedagogy through intensive use of information technologies, changing the traditional “teachers and library-university” to a global network of content, teachers, researchers, students and service. They found as determinants for the innovation implementation the ability to combine the three factors of web-based learning practices: pedagogy, technology and organization. Organization provides strategic, managerial and functional aspects that make possible the new learning-teaching process. Management and strategic planning are key factors in the successful use of information and communication technologies in higher education (Duart & Kiselyova, 2003). Also Butler and Sellbom (2002) as well as Chizmar and Williams (2001) researched adoption of technologies in higher education. Chizmar and Williams concluded that lack of institutional and financial support and, most importantly, lack of time to learn new technologies imposed barriers to adoption. Butler and Sellbom identified the biggest problem with using the technology is its unreliability, even among most proficient teachers in higher education.

As Blumenfeld and colleagues (2000) stated there is a need for further research on successful scaling-up, on school reform and on implementation of pedagogical innovations in the complex context of formal education. It is important to systematically study the components that enhance the dissemination of pedagogical innovations as well as the aspect which challenge the process. There

are, in any event, few empirical studies published on the matter of scaling-up, although many of the school reforms and development projects have been reported.

The objective of the present study is to determine what kind of possibilities, challenges and problems teachers report when they participate in the development project of technology-supported inquiry learning. We are searching for answers to the question of how one can enhance the scaling up of the pedagogical model of the technology-supported inquiry progressive inquiry and to consolidate it in the long-term practices in schools.

## **2. The context of the research**

This paper describes a study that belongs to a series of reports conducted in the context of the ITCOLE-project (<http://www.euro-cscl.org/site/itcole>), which was funded by European Commission. The main objectives of the ITCOLE-project were to develop pedagogical models of collaborative knowledge building for European education, to develop a modular knowledge-building environment, to support collaborative learning, and to evaluate, test and disseminate the environment in European schools, for the purpose of building meaningful pedagogical practices and to advance the use of collaborative learning technologies. An important aspect of the project was to organize professional development training for participating teachers concerning inquiry learning and collaborative knowledge building.

### 2.1 Pedagogical approach

The initial pedagogical approach in the project was *progressive inquiry learning* (Hakkarainen, 2003). Progressive inquiry means a sustained process of advancing and building knowledge characteristic of scientific inquiry. It entails that new knowledge is not simply assimilated but constructed through solving problems of understanding. An essential aspect of this kind of inquiry is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. Through intensive collaboration and knowledge building, resources of the whole learning community may be used to facilitate advancement of inquiry. Facilitation of progressive inquiry at school appears to require changing in the traditional division of cognitive labour between the teachers and students and to encourage students to take responsibility for their cognitive (e.g., questioning, explaining) and metacognitive (e.g., goal-setting, monitoring, evaluating) aspects of inquiry (Bereiter & Scardamalia, 1987). However, proper balance should be

pursued in each pedagogical situation between teacher-controlled and student-controlled aspects of inquiry. Teachers should not rely too much on students' creativity, but should provide intervention with careful pedagogical guidance and expert-model when student is not able to make progress (Hakkarainen, Lipponen & Järvelä, 2002; Veermans, Lallimo & Hakkarainen, in press).

## 2.2 Web-based learning environment

Several software and web-based applications have been developed to enrich collaborative processes. See for instance CSILE (<http://www.ed.gov/pubs/EdReformStudies/EdTech/csile.html>), Knowledge Forum (<http://www.knowledgeforum.com>) and Moodle (<http://moodle.org>). In progressive inquiry learning, the role of technology is to create a learning environment, which enables collaborative knowledge building; it supports building, articulating, exploring and structuring knowledge. (Scardamalia & Bereiter, 1994.) The nomenclature for such programs used in this study is “web-based learning environment” and for progressive inquiry learning supported by web-based applications is “technology-supported inquiry learning.” In a web-based learning environment there are usually specific tools developed to structure and scaffold students' collaborative learning process, such as discussion forums, document sharing, group-based portfolios and evaluation tools for student participation. Lipponen and Lallimo (2004) stated that it has been very hard to find evidence that some particular application for collaborative learning is better than another, or better than some traditional classroom uses of computer. Koschmann (1996) argues that computer-supported collaborative learning research is grounded in varying concepts of learning. Also the developers and promoters of web-based learning environments should better explicate the theories of learning and instruction that motivate the development work and are embedded within application designs.

Two web-based learning environments were developed within the ITCOLE project: Synergeia (<http://bscl.fit.fraunhofer.de/>) and FLE3 (<http://fle3.uiah.fi/>). Both learning environments are based on the pedagogical principles of progressive inquiry learning. The desired collaborative problem-solving situations are supported in the so called Knowledge Building forum of the web-based learning environment by Thinking Types, which guide students to categorize the computer entries that correspond to the stage of the knowledge-seeking or interrogative process (Scardamalia & Bereiter, 1992; 1994). In Synergeia and FLE3 environments the Thinking Types were named after the process of progressive inquiry, for instance such as: “Research question,” “Own explanation,” and “Deepening information” (Rubens, Emans, Leinonen, Skarmeta, & Simons, in press).

### 2.3 Phases and participants of the project

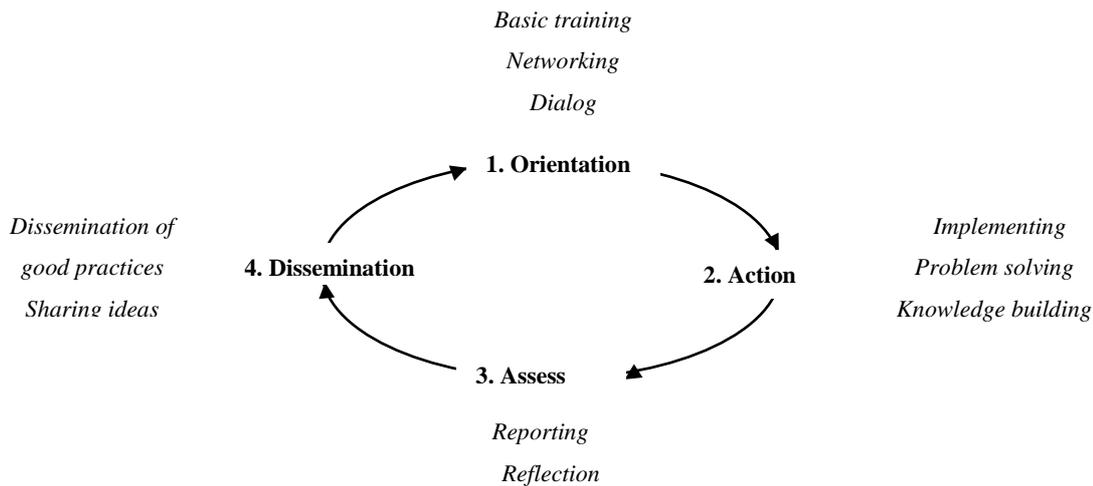
The amount of teachers and student interaction increased phase by phase in the ITCOLE-project. In four participating countries there were 80 school projects implemented, in which 100 teachers and 2000 students participated. Here we are primarily concerned with the implementation experiences in Finland. Participants were teachers and students from different schools in Helsinki. The ITCOLE-project consisted of three development and research phases. In the first phase, teachers studied the pedagogical principles of progressive inquiry and the first version of the Synergeia web-based learning environment. In this phase there were 10 pilot teachers and 235 students (19.6 students per group on average). In the second phase teachers carried out progressive inquiry projects supported by Synergeia (hereafter “technology-supported progressive inquiry,” as described earlier) in their classrooms or with their teaching groups. In the third phase there were 27 teachers, seven of whom had also participated in the second phase and 504 students (21.0 students per group, on average). Participants came from 14 schools. At the beginning of the third phase, all teachers studied FLE3 web-based learning environment and, at the end of it, carried out inquiry learning projects using the FLE3 web-based learning environment.

### 2.4 Teacher in-service training

The teachers’ training during the project was organized according to an in-service training and consulting model (Ryymän & Korhonen, 2003), which was developed within the projects. The goal of the training model was to enact meaningful pedagogical use of technology in common schools. The contents of the training included the following topics: the model of progressive inquiry, web-based learning environments and principles of change management. The training lasted about four months, and it was carried out two times during the three phases of the project. The training was organized as face-to-face meetings, school consulting occasions, and in web-based environments.

The training was divided in four stages typical for a development process: orientation-, action-, assessment- and dissemination phases (Figure 1). The orientation phase consisted of introduction to the technology-supported inquiry learning. In the action phase, the teachers implemented the inquiry learning projects and were supported, in addition to school consulting, by workshops and virtual workshops. In virtual workshops, the teachers collaborated in the Knowledge Building forum on the topical problems appeared in the implementation process (Ryymän & Korhonen,

2004a; 2004b). In the assessment phase, the process was evaluated in guided discussions and then, in dissemination phase, teachers participated into the distribution of the project results by presenting their outcomes in their schools and in international ITCOLE teacher conference in Athens.



**FIGURE 1. The teacher training and consulting model.**

## 2.5 The classroom projects

The Finnish teachers implemented technology-supported inquiry learning projects on several school levels and in various subjects (Table 1). The projects varied from one-classroom projects to international networks and from mainstream education to special needs education. In the second development and research phase, there were 8 different project plans. Two of them were guided by two teachers in collaboration with two mixed student groups, and two other projects were also guided by two teachers, but now in separate groups. In the third phase there were 23 different project plans, one of them implemented in two different groups. In the Table 1 is presented a summary of the implemented projects: topics of the projects, subjects included, amount of the students and projects' duration. Brief descriptions of all projects carried out within the project are available in the final report (Emans & Sligte, 2003) of the ITCOLE-project.

**TABLE 1. The Finnish progressive inquiry projects realized in the project.**

(MO=mother tongue, EN=English, SP=special education, FI=philosophy, HI=history, DO=domestic science, AR=arts, ME=media education, SC=student counselling, GE=German, FI=Finnish as second language, RE=religion, EC= economics, AH=art history, SS=social science, SCI=science )

Topic, class level and subjects included	Teachers (N)	Students (N)	Duration (weeks* hours per week)
<b>Phase II (Synergeia-learning environment)</b>			
Globe, 4. class, SCI <sup>a)</sup>	2	28+27	14 w * 3 h
“All roads lead to Rome”, 6. class, HI <sup>b)</sup>	1	28	14 w * 3 h
Culture, 9. Class, several subjects <sup>c)</sup>	1(+2)	15	10 w
Kalevala, 9. class, MO, SP <sup>d) e)</sup>	2	10+20	14 w * 1-2 h
”Human is what he eats –youth in media”, secondary school 1.1 class, ME	1	23	12 w * 2-3 h
Sources of finance and Finland’s financial markets, secondary school 1. class, EC	1	14 ja 19	6 w * 6 h
Matrix, secondary school 1. class, FI	1	32	6 w * 5 h
Reading and Writing (in Special education), secondary school 1-1 3 class, SP <sup>f)</sup>	1	6 ja 13	8 w * 5 h
<b>Phase III (FLE3-learning environment)</b>			
Phenomenal Baltic Sea, 3. class, SCI	1	23	7 w * 4 h
Ten secrets, 5. Class, HI, MO <sup>a)</sup>	2	27+29	8 w * 4-8 h
Peculiar seas, 6. Class, YPI, MO	1	29	9 w * 2-4 h
Studying sea coast organisms, 3. class, SCI, MO <sup>b)</sup>	1	18	11 w * 2 h
German festivities, 6. Class, GE	1	14	7 w * 1 h
Tirlittan – nattirliT, book by Oiva Paloheimo 3 class, MO, RE, AR	1	26	8 w * 3 h
Children book writers in the Scandinavian countries, 4. class, MO	1	29	7 w * 3-4 h
Children book writers in the Scandinavian countries, 6. class, MO	1	23	10 w * 1-2 h
Finnish and English schools –similarities and dissimilarities, 6.1 class., EN	1	27	8 w * 1-2 h
Finnish and English schools –similarities and dissimilarities 6.1 class, EN	1	29	6 w * 1-2 h
Comparison between Finnish. & English school, 6. class, EN	1	12	4 w * 1-2 h
The iron age, 6. class, HI	1	24	8 w * 2-10 h
Mathematics briefcase, 8. class, MA	1	18	11 w * 1 h
Culture-course, 9. class, several subjects <sup>c)</sup>	2(+1)	15	10 w
The art of living, 9. class, MO, DO, RE, SC <sup>d)</sup>	2	13	12 w * 3 h
Housing markets, 9. class, SS, SP <sup>e)</sup>	2	28	3 w * 6 h
Monday means nothing, 9. class, SS	2	18	9 w * 2-3 h
The art of the ancient Greece and Rome, secondary school 1.1 class, AH	1	20	3 (6) w * 5 h
Neue Formen des Zusammenlebens, secondary school 2. class, GE	1	25	6 w * 1,5 h
Issues on career counselling, secondary school 1.-3. class, SC	1	30	6 w * 5 h
A right for language-the comprehension and production of text (Finnish as a second language), secondary school 1.-3. class, FI	1	9	6 w * 1,5 h
Improving the quality of learning., secondary school 1.-3. class, SP	1	6	6 w * 5 h
Read2: Learning foreign languages 1.-3. class, SP <sup>f)</sup>	1	12	8 w * 5 h

a), b), c), d), e), f) The same teachers in II and III phase.

One can conclude on the basis of the data introduced in the table 1, that the projects were very different from each other by their nature, and planned according to different learning objects. In this sense it is irrelevant to compare projects with each other in this study. However, when comparing Finnish projects to the projects carried out in other participating countries (the Netherlands, Italy, Greece) one learns that the Finnish projects were, firstly, longer and, secondly, aimed more clearly towards the principles of progressive inquiry, such as collaborative knowledge-building and pursuing students' own explanations. (Emans & Sligte, 2003.)

Rahikainen (2002) analyzed two of the elementary project to examine the extent to which participation in technology-supported inquiry learning can be democratized in terms of their motivational orientation. The results of the study indicated that that the systematic guiding of teachers and students in the principles of progressive inquiry and technology-supported learning elicited active participation of groups of students. Lakkala, Lallimo and Hakkarainen (2004) analyzed the pedagogical practices implemented in the second phase of the project. Their results indicate that it was most challenging for teachers to find meaningful practices for guiding the process of progressive inquiry in its different stages, and to enhance the students' genuine, purposeful collaboration.

### **3. Methods**

In every development and research phase of the ITCOLE-project the teachers responded to a questionnaire, the objective of which was to acquire knowledge on teachers' thoughts and conceptions related to the model of progressive inquiry and the web-based learning environment implemented in the project. At the end of the third phase, the teachers were also interviewed in groups. In addition to the questionnaires and group interviews, the teachers also completed in a delayed post-measurement questionnaire about one and half years (1.5) after the project had been closed. This questionnaire made it possible to gain valuable information on how technology-supported inquiry learning had been further applied after the official intervention. In this article we present the results of the questionnaires of the third phase of the ITCOLE-project, delayed post-measurement (hereafter "delayed questionnaire") and the teacher group interviews.

### 3.1 Questionnaires

The third phase and delayed questionnaire included two parts. The first part was different in each questionnaire. *In the first part of the third phase questionnaire* teachers evaluated the pedagogical usability of the FLE3 web-based learning environment by scale with a range of six ordered categories (from “very bad” to “very good”). In addition, there were questions on the general functions of the FLE3 that teachers assessed by scale of three ordered categories (difficult/little, neutral, easy/much). There was also one open question for technical problems.

In the first part of the delayed questionnaire there were six open questions and one multiple-response question in which teachers were asked to describe how they will continue with technology-supported inquiry learning after completing the project. Teachers were also asked to report on technical problems and ideas for further development of the application. In addition, teachers assessed the benefits and problems of the pedagogical model of the progressive inquiry learning in general. They assessed also their own working and guiding procedures in regard to progressive inquiry learning.

In both questionnaires teachers responded to 28 Likert-scale statements of five ordered categories (from fully disagree to fully agree) according to how the statements described their beliefs on progressive inquiry and web-based learning environment used in the project. Altogether 27 of 31 teachers responded to the third phase questionnaire (87 % of all teachers). 19 of the respondents (70%) were women and 8 (30%) were men. 13 were from lower level comprehensive school (elementary) teachers, five (5) upper level comprehensive school (junior high) teachers and five (5) upper secondary school (high school) teachers. In addition, there were two (2) teachers from the schools for special educational needs and two (2) special educational needs teachers from upper secondary schools.

The delayed questionnaire was sent to 33 teachers, 31 of whom were teachers participating in the ITCOLE-project and two of whom were colleagues who were committed to the project and were from the same school. 24 teachers from 33 responded to the questionnaire (73% of all teachers). One teacher answered by e-mail and reported, that he could not continue to implement technology-supported learning in his new school which was situated in other community. Sixteen (67%) of the respondents were women and eight (33%) men. Most of the teachers, who completed the questionnaire (11), were from lower level comprehensive schools. There were four (4) teachers

from upper level comprehensive school, five teachers (5) from upper secondary school (high school), two teachers (2) from special schools and two special educational needs teachers (2) from upper secondary school.

### 3.2 Group interviews

Altogether 21 teachers were interviewed in groups in the closing seminar, which was organized at the end of the third research phase. Teachers were interviewed in four separated groups. There were five teachers in each group (except six in one group) and the groups were representative of every school level. Two of the interviews were recorded in full, other on audio and another on videotape, and the tapes were transcribed and analyzed. There were 10 teachers in the analysis groups: four (4) from lower level and three (3) from upper level comprehensive school and two (2) from upper secondary school. One (1) teacher was special educational needs teacher from upper secondary school.

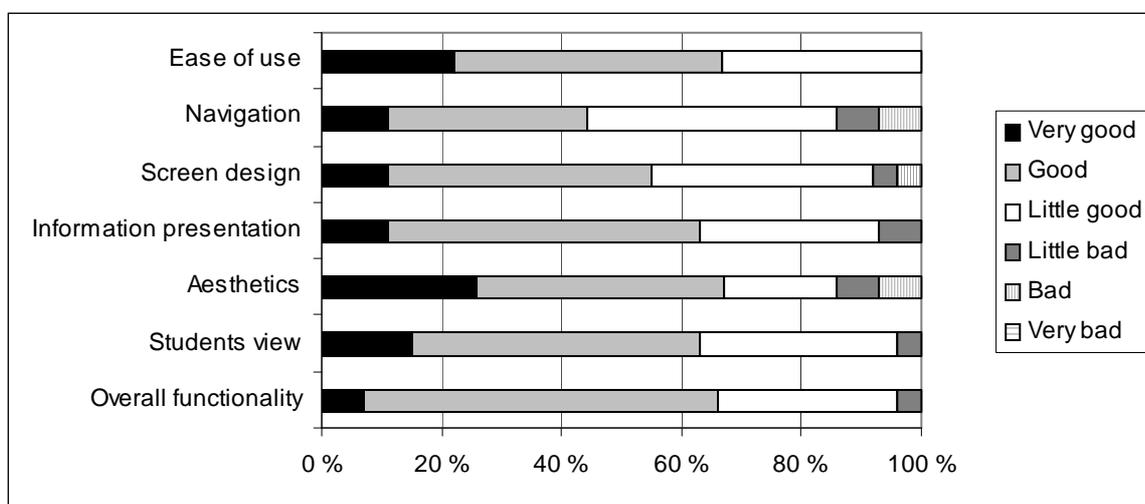
The interviews were semi-structured in-depth interviews. There were no fixed questions, but a list of topics that were assumed to be important was available. The topics included teachers' experiences and conceptions of implementing technology-supported inquiry learning. Teachers were encouraged to freely recall the benefits, challenges and problems they had met during the classroom projects. Also Fontana & Frey (2000) concluded that group interview can be successfully used to aid respondents' recall of specific events or to stimulate embellished descriptions of events or experiences shared by the members of a group.

The analysis of group interviews was carried out within the framework of a phenomenographic approach, which is a qualitative method emphasising subject's experience and conceptualisation of phenomena (Marton, 1988). Conceptions of teachers' expressions were identified and grouped according to categories on the basis of similarities, differences and complementarities. According to Marton, Dall'Alba and Beaty (1993) in a phenomenographic approach conception is abstracted from expressions that are considered to reflect it, thus there is an important linguistic component. To decide whether or not two expressions reflect the same conception, one must have an idea what the conception is. In this sense, the role of researcher is significant when interpreting the data and forming the categories of descriptions. (Marton et al., 1993.) The categories of descriptions for the group conceptions of the interviewed teachers are introduced in the next section.

## 4. Results

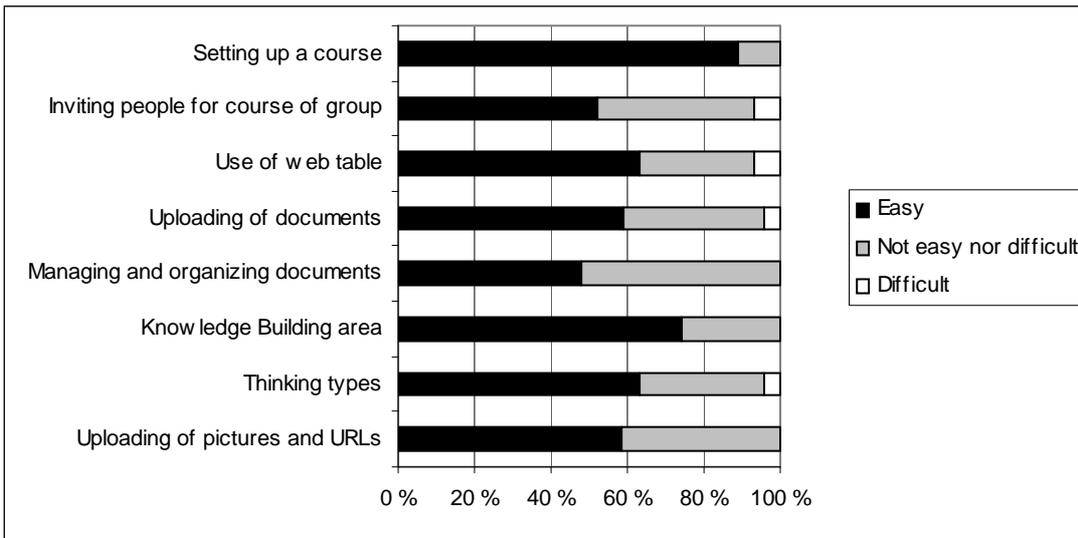
### 4.1 Teachers' opinions of the web-based learning environment after the classroom projects

Teachers, who completed in the questionnaire in the third phase of the project, assessed the usability of FLE3 to be good (see Figure 2). In all sectors at least half of the respondents, in many cases over 60 %, assessed the usability at least good. Only the navigation in the FLE3 received less positive assessment, but even that feature was assessed to be at least easy to use by 44% of the respondents.



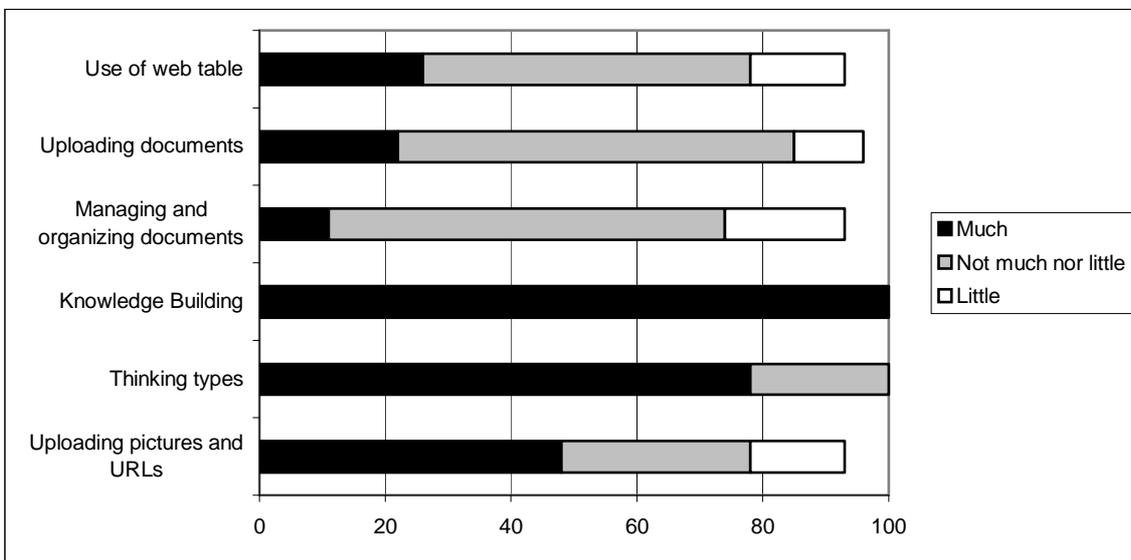
**FIGURE 2. Teachers' answers of the usability of FLE3.**

In the questionnaire a table about the separate functions of the FLE3 was presented and teachers were asked how easy it to use the functions is. As can be seen from Figure 3, according to teachers the functions of FLE3 were easy to use. Only 1-2 respondents considered that four functions were difficult.



**FIGURE 3. The ease of use of FLE3 according to teachers' answers.**

Teachers were also asked how the functions of FLE3 supported collaboration among students. The central functions of the FLE3, the Knowledge Building forum and the Thinking Types, were the functions, which were evaluated by the teachers to support student collaboration best (Figure 4).



**FIGURE 4. FLE3's functions support for student collaboration according teachers' conceptions.**

There were no statistically significant differences in a teacher's conceptions of the usability of FLE3 in regard to gender, school level or a teacher's working experience. There were no differences of opinion of teachers who participated in the project in the first phase, or who joined in later, in the second phase.

#### 4.2 How did the teachers apply technology-supported progressive inquiry after the project?

Most of the respondents, 67 % (n = 16), applied inquiry learning in their teaching after the ITCOLE-project. Those who had not used it reported reasons, mainly associated with starting new work or development project. The inquiry learning was implemented in very different subjects and projects, and the duration varied a lot. Almost the same amount of the respondents, 71 % (n= 17), continued to implement the web-based learning environment in their teaching. Some respondents reported that they integrated web-based learning environment to a wider extent in their teaching while others used it occasionally. Some of the teachers who implemented inquiry learning did not mention that they also used a web-based learning environment, and the teachers who used the environment did not mention that they used it according to the principles of the progressive inquiry. This indicates that inquiry learning practices do not always need the support of technology. On the other hand, some teachers used the web-based learning environment without implementing principles of progressive inquiry. This indicates that teachers assimilated flexible ways to apply the pedagogical and technical resources developed within the project.

The most often used web-based learning-environment was FLE3, which was mentioned by 10 teachers. Five teachers offered the opinion that they used the Opit-learning environment (<http://www.opit.wsoy.fi>), a web-based learning environment developed by a central Finnish commercial learning material producer. Three teachers mentioned other environments. Of importance is that FLE3 was used and developed in the third and last phase of the project and so it was natural that the most of the teachers continued working with this application owing to recent use. As reported in the results of the third phase questionnaire, teachers also assessed the usability of FLE3 to be good, which may well lead them to continue to use this environment.

Altogether 42% (n=10) of the respondents faced technical problems in classroom projects in which they used a web-based learning environment. The most frequently reported problems were the slowness of the web and problems in logging in. However, there was also immediate technical support available, according to the teachers' reports. Teachers did not typically develop new

strategies for further development of the learning environment applications— most of the teachers experienced the environment as developed in its original state.

Teachers were also asked to name the benefits and problems of progressive inquiry learning in open questions. Altogether 20 respondents reported several benefits, which were divided into the following categories: development of thinking, learning and working skills (7 reports), deepening learning and knowledge processing (6 reports), emphasizing the active role and work of students (5 reports), students generating their own research problems and explanations (3 reports), changing the conception of learning and knowledge (2 reports) and democratic participation of all students, also the introverts (2 reports). Altogether 16 respondents described problems of progressive inquiry. The most often reported hazard was the lack of time (13 reports). Respondents mentioned that implementing progressive inquiry took too much time. In addition, three teachers proclaimed problems in student motivation. One teacher reported that there is too much assumed personal responsibility for students in progressive inquiry, and one teacher maintained that he did not reach the cognitive goals set in his inquiry learning project.

Results received from phase I and III in the ITCOLE-project indicate that teachers find the guiding of progressive inquiry challenging or difficult (Rahikainen, Emans & Lakkala, 2002). Also in the delayed questionnaire, teachers were asked to complete in what they need to better guide their students in progressive inquiry. There were five answer formats structured in the questionnaire and, in addition, one open-ended question.

In Table 2 we introduce the categorized answers of teachers. Most of the teachers assessed that they would need more time and pedagogical guiding. These two categories were most frequently mentioned in the teachers' answers in the earlier research phases as well (Rahikainen et al., 2002) and they were still considered to be the most central challenges after the project. Teachers experienced that teaching organized according to the principles of progressive inquiry was time-consuming; especially guiding the process took a lot of teachers' time resources. Other wishes expressed by the teachers were experience sharing and collaborative planning on the working community level. There were three hits in this category, for instance: *"The changing ideas and experiences with others make my own thinking clearer."* One teacher wished to have more *"adult resources"* and one teacher reported that he *"just needed more practice."*

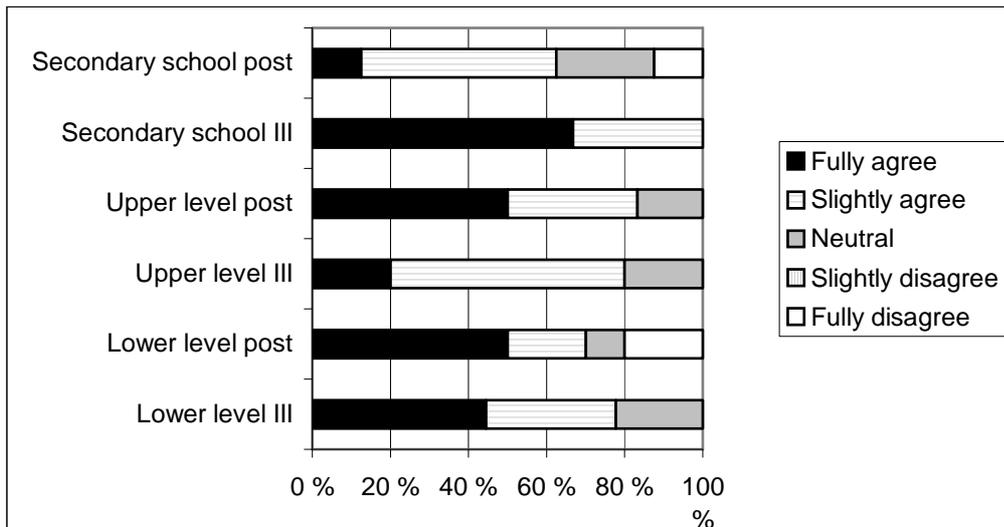
**TABLE 2. Teachers' answers to the question: "What you would need more for guiding students in progressive inquiry learning better?"**

Time	17
Pedagogical guiding	10
More time for using computer class	5
Something else (for example discussion, experience sharing, skills for collaborative work in working community, more practising)	5
Technical support	3
Nothing	1

The written answers to the final open questions ("How you would develop your own contribution in the project of the progressive inquiry? How could you work better yourself?") stressed the importance of guidance. Altogether 12 teachers wrote answers associated with guiding, structuring or planning. For example, "*I have tried to comment more, this means, guide more in the web, which is time-consuming*" and "*I could develop my guiding process to support deepening knowledge further.*" Five (5) of the respondents reported that they will apply progressive inquiry in versatile purposes and to a larger extent. For example, "*I can manage the method so well that I'm thinking about widening and opening new areas for progressive inquiry.*" Six teachers did not answer the question.

#### 4.3 Teachers reports regarding time and computers

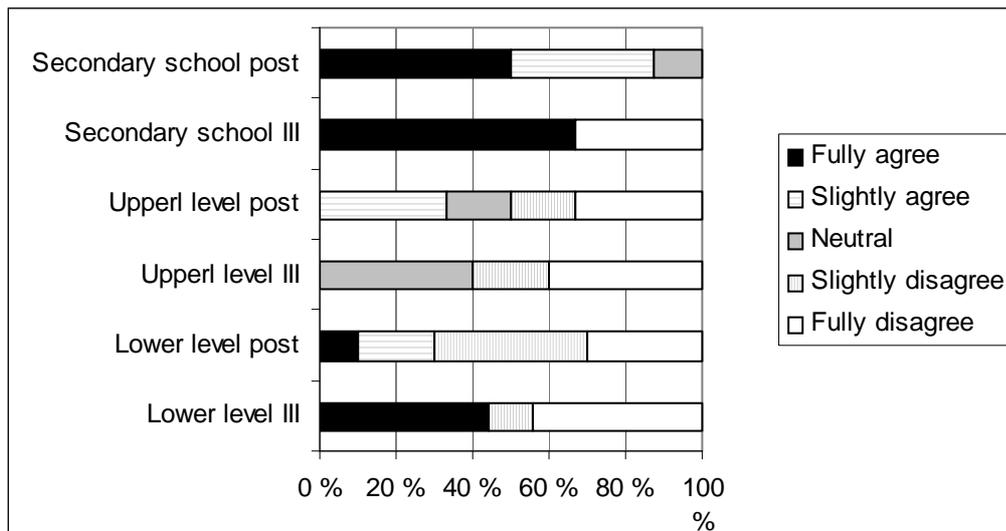
The second part in both questionnaires was similar. In the delayed questionnaire, teachers from lower and upper level comprehensive school expressed their willingness to use even more time for working in web-based learning environment than they expressed in the third phase questionnaire. Eighty percent of the comprehensive school teachers agreed with this statement (Figure 5).



**FIGURE 5. Lower and upper level comprehensive school teachers' and secondary school teachers' answers to the claim: "I would like to use more time for working with web-based learning environment" in third phase (III) and in delayed questionnaire (post).**

The surprising result was that teachers from upper secondary schools reported that there are not enough computers in schools. Four teachers from the upper secondary teachers fully agreed that they had no computers enough to implement computer-supported progressive inquiry. None of the upper level comprehensive school teachers and only four from the lower level teachers agreed fully with this statement (Figure 6).

According to results of the delayed questionnaire the situation has not changed significantly, though the opinions of the upper secondary school teachers differed from the opinions of the lower level ( $p < .010$ ) and upper level comprehensive school teachers ( $p < .050$ ). This difference was not apparent in third phase. Because there were only small number of respondents, and because the responses varied so little, we draw the conclusion that the differences between schools and individuals explain different experiences on problematic time resources in this study.



**Figure 6. Lower and upper level comprehensive school teachers' and secondary school teachers' answers to the claim: "We should have had more computers for working with web-based learning environment" in third phase (III) and in delayed questionnaire (post).**

#### 4.4 Benefits and problems teachers described in group interviews

The following categories were formed from the teachers' descriptions about the benefits of the technology-supported inquiry learning: 1) students were more motivated (9 descriptions), 2) students collaborated more than usually (8 descriptions), 3) students achieved cognitive goals of the learning projects fine (6 descriptions) and 4) the role of the teacher changed in a positive way (5 descriptions). The following categories of descriptions were formed regarding teachers' conceptions of the challenges and problems of the technology-supported inquiry learning: 1) lack of time disturbs implementing new practices (10 descriptions), 2) guiding the inquiry learning process is very demanding in general (7 descriptions) and especially in regard to deepening knowledge (7 descriptions), student collaboration (5 descriptions) and assessment of the student-centered learning process (5 descriptions), 3) school tradition resists the pedagogical change (5 descriptions), 4) some schools have insufficient working facilities, such as suitable classrooms and computers for collaborative work (5 descriptions) and 5) technical problems related with computers cause problems for teaching (5 descriptions). There were no significant differences in the descriptions of teachers representing because of subject or level taught. However, all three upper secondary school teachers said their school culture is more traditional and more inflexible than it is at lower levels.

In the following we present statements from teachers that illustrate descriptive categories. When implementing technology-supported inquiry learning, almost all the teachers (9) suggested that their students were more motivated and more active than usual:

*“Though this has been hard for teachers, the students were very enthusiastic and they found it very easy and fascinating to use the web-based learning environment.” (Lower level comprehensive school teacher)*

Although student collaboration was considered a challenge altogether eight (8) teachers expressed that technology-supported inquiry learning enhanced student collaboration and it was one of the least anticipated benefits of this pedagogical practice:

*“Even those boys and girls who previously avoided each other, which is a typical behavior for that age, now concentrate on the work and collaborate with each other in the web-based learning environment” (Lower level comprehensive school teacher)*

Six (6) teachers reflected the cognitive goals of their learning projects as an encouraging achievement:

*“Afterwards I noticed that students remembered these things better than anything else they had studied during the school term.”*  
(Lower level comprehensive school teacher)

Five (5) teachers emphasized that they had a possibility to change to role of teacher from the traditional lecturer towards the facilitator of the student-centered learning process, for example:

*“I told students that now they can investigate something that even I don’t know! You are the researchers and I will guide you!” (Upper secondary school teacher)*

When considering challenges and problems of implementing the technology-supported progressive inquiry, all 10 teachers expressed that, in line with Chizmar and Williams (2001) and the results of the questionnaires of this study, lack of time prevented efficiently implementing technology-supported inquiry learning:

*“I would have needed at least one extra day in the middle of the project just for planning and organizing.” (Upper level comprehensive school teacher)*

The teachers also discussed in their groups how they guided the inquiry learning process in face-to-face occasions and in the web-based learning environment. Seven (7) of them concluded, in line

with previous studies (Lakkala et al., 2004), that guiding the technology-supported inquiry learning was very demanding, in general, and seven (7) found it especially challenging when guiding students to deepen their knowledge and search for new information:

*“We had difficulties in deepening knowledge process, how to find (relevant) information from Internet, for instance, and statistics of unemployment and how to make conclusions of them”.*  
(Upper level comprehensive school)

Five (5) teachers offered that it was demanding to guide students in collaborative work; to study for collaborative goal with genuinely collaborative studying practices. In line with previous research (Hakkarainen et al., 2002; Veermans et al., in press) balancing student self-orientation and teacher active guidance is not easy when implementing progressive inquiry, as one teacher informs us:

*“With this web-based learning environment one could support collaboration, but I felt that I couldn’t guide the collaborative learning of the students yet.”* (Upper secondary school teacher)

Five (5) teachers reflected how the criteria of assessment in a technology-supported progressive inquiry project could affect, for instance, motivation of students. As such, should a teacher share assessment criteria openly with students? For example:

*“I discuss assessment openly with my students, how working in the web-based learning environment effects assessment.”* (Lower level comprehensive school teacher)

Five (5) teachers also discussed the existing school culture and how it delimited pedagogical change:

*“Older teachers have created a certain history and teaching culture in the school, and I must follow that. We must have similar courses, similar contents and ways of teaching. They are maybe a little bit afraid that I will bring something new there which they don’t know and can’t control.”* (Upper secondary school teacher)

Five (5) teachers found their working facilities insufficient for collaborative work, and five (5) teachers felt, that technical problems disturbed their project implementing every so often.

The results of the group interviews were in line with the outcomes of the questionnaires reported earlier but cannot be generalized in wider contexts. However, in this case, the results support the analysis of the questionnaires by contextualizing individual responses. (Fontana & Frey, 2000.)

## 5. Conclusions and discussion

One of our objectives was to determine the possibilities, challenges and problems teachers report when they participate in a development project of technology-supported inquiry learning. Our other objective was to investigate how the scaling up of the pedagogical model of the technology-supported inquiry could be enhanced in schools. The research revealed, in line with Duarte and Kiselyova (2003) three aspects which were significant when disseminating pedagogical innovations: technical, pedagogical and organizational.

### 5.1 Technical aspects

For implementing technology-supported inquiry learning successfully, one has to resolve, at first, the technical challenges. Successful scaling-up requires usable technical application, which is easy enough to access and implement in natural settings. The FLE3 web-based learning environment, which was developed in the ITCOLE-project, can fulfill these criteria. The results of this study indicate that teachers' conceptions of the usability of FLE3 do not vary according to gender, experience or school level. In addition, most of the teachers continued using FLE3 after the project. Nevertheless, the use of learning technology at school should be fluent and non-problematic, which was not fully accomplished for the participating teachers: 42 % of those who answered the delayed questionnaire insisted that they had technical problems when using a web-based learning environment. Technical problems can efficiently prevent the innovation diffusion in pedagogical settings. In line with Butler & Seldom (2002) we conclude that it is very important to convince the staff involved with technology of the importance of equipment, its integration into the classrooms and its continuous maintenance.

### 5.2 Pedagogical aspects

The analyses of the questionnaires and group interviews indicate that, in general, participating teachers considered the pedagogical model of progressive inquiry usable. They also found that the web-based learning environments developed within the ITCOLE-project supported the pedagogical principles of progressive inquiry. For instance, using the Thinking Types in Knowledge Building was considered meaningful for learning.

As Hargreaves and his colleagues (2001) argue educational reforms require training, which support teachers concretely and individually enough in the new working practices. Zech, Gause-Vega, Bray, Secules and Goldman (2000) emphasize how important it is that teachers understand the principles of learning theories behind the new innovations when reforming teaching.

In many teacher in-service training cases, traditional top-down models fail to reform pedagogical practices in schools. (Fullan, 1999.) In the ITCOLE-project, which was the context of this study, teachers received personal guidance, which supported them individually in their own working contexts. Teachers were also committed to the bottom-up development process: they recreated their pedagogical practices themselves and implemented them in natural working environment. However, results of this study indicate that this is not enough for empowering educational change. Teachers need in addition to reliable technical infrastructure and their personal commitment to the development process also longitudinal pedagogical support after the official intervention.

### 5.3 Organizational aspects

Another result of this study was the notion that supporting teachers pedagogically is not sufficient if the organizational structures of the school resist the process of change. These restrictive structures may include, for example, insufficient physical facilities for teaching (*“crowded computer-classes”, “problems in using technology”*), lack of time resources (*“no opportunities for planning and implementing new pedagogical practices”*) and established working practices in school community (*“other teachers resist, “we have to have similar courses”*). Songer, Lee and Kam (2002) found other barriers to inquiry pedagogy, such as crowded classes, continuous change of teachers and students and insufficient pedagogical materials. As well, Hakkarainen, Muukkonen, Lipponen, Ilomäki, Rahikainen and Lehtinen (2001) noticed, that although most teachers accept key learning theories that undergird student-centered and inquiry methods, they have few possibilities to induce this kind of learning in practice.

The framework of collaborative planning and work is missing in teachers' working culture. Usually teachers plan and carry out teaching alone without collaborating with colleagues. In the delayed questionnaire of the present study, some teachers mentioned that they require collaborative work with their colleagues for generating professional development plans. The participating teachers received positive experiences of teacher collaboration during the ITCOLE project, but the teacher community was only temporary, and after the project teachers realized an absence of collegial

collaboration in their school community. Previous research reveals that an important factor in establishing and scaling up pedagogical innovations is the enhancement of teacher networks and collaboration, and stronger teacher communities (Granger, Morbey, Lotherington, Owston & Wideman, 2002; Ilomäki, Lakkala, & Lehtinen, 2004; Sleeper et al., 2000; Spillane, 1999).

We conclude that successful scaling-up of the pedagogical model of the technology-supported inquiry learning requires, except long-term technical and pedagogical support, a new approach to organizational challenges. Professional growth of teachers should be linked to the pedagogical community and with other members of the community. According to Wenger (1998) expertise arises as networked expertise and it is shared and situated in communities of practice. A future challenge for teacher in-service training and development is to support teacher communities inside a school and to establish interschool teacher networks. The challenge for future research is to study professional growth of teachers in the framework of networked expertise as opposed to individually. Data gathered that especially reveals knowledge of new pedagogical practices, such as technology-supported inquiry learning, should be shared and further developed in pedagogical communities.

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Running head: WEB-BASED KNOWLEDGE BUILDING AND TEACHERS' PROFESSIONAL DEVELOPMENT

Web-based knowledge building and teachers' professional development

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**Abstract**

The goal of this article is to open new perspectives on teachers' technology-supported professional development and offer advice, ideas and meta-policies, for educational policy makers for planning innovative, effective and cost-efficient models for teacher training.

The goal is to learn what possibilities, challenges and problems teachers confront when implementing synchronous, web-based knowledge building in their in-service training and to find out what kind of advantages a web-based learning environment offers to teachers' collaboration.

The findings of the study indicate that synchronous web-based knowledge building, which is based on clear, authentic, real-life problem statements, supports teachers' collaborative problem-solving and professional development in a meaningful way. The findings also indicate that a web-based learning environment provides, as a collective memory and a platform for shared writing, a unique possibility for the development of teacher communities. It is suggested that for supporting teachers' professional development better in the future, educational policy makers should implement web-based knowledge building as an innovative model for teacher (in-service) training and foster genuine collaborative cultures in teacher communities.

**Keywords:** synchronous web-based knowledge building, teachers' professional development, in-service teacher training

## 1. Introduction

What is happening in the professional development of teachers? How can we benefit from new technologies to empower teacher development and collaboration in the context of educational change? I believe the potential in using web-based technologies both for supporting teachers' individual development and in fostering communities of teachers is great. The goal of this article is to offer new perspectives on teachers' technology-supported professional development and offer advice and ideas, meta-policies, for educational policy makers when planning innovative, effective and cost-efficient models for teachers' in service training in future.

This article is divided into five chapters. In the introduction, I present the key concepts of this study and the latest findings from educational research which is of most interest in relation to professional development, teacher collaboration and use of new technologies. At the end of the chapter, the objectives of the present research are described in more detail. In the second chapter, I introduce the context of the research and have a closer look to the web-based knowledge building, which is an innovative, technology-supported model for teacher in-service training. Then, in the third chapter, I describe the research process, methods and results. In the fourth chapter I make my conclusions on the results and I offer some new aspects on technology-supported professional development and ideas for planning innovative policies for teachers' in-service training.

### **Collaborative learning, web-based knowledge building and professional development**

The most essential concepts in this study are *collaborative learning*, *web-based knowledge building* and *professional development*. They all offer useful aspects to the dynamic process, in which teachers learn to benefit new technologies meaningfully in their pedagogical practises. In next sections I will introduce these concepts in more detail for encouraging policy makers to critically reflect and assess how teachers' professional learning in collaborative context could be supported by new technologies.

The idea of *collaborative learning* is not new for educators. However, it has been strongly emerging again in educational literature in the past two decades. Collaborative learning entails that new knowledge is not simply assimilated but actively constructed through joint problem-solving. Through intensive collaboration resources of the all participants may be used to facilitate advancement of learning. (Bereiter & Scardamalia, 1987; Hakkarainen, 2003.) Collaborative learning relies on dialogue (see e.g., Freire 1970; Senge, 1990); it attempts to encourage people's active involvement in questioning and in creation of knowledge instead of receiving information passively. Dialogue enables people to find new insights which they would not have achieved on their own; it creates richer understanding of the matter in hand and involves the free flow of new

ideas. Collaborative learning is also closely related to the conception of collaborative knowledge building, but they are not synonymous. Instead, one could say, that in its' best case, collaborative learning can lead to collaborative knowledge building.

In this research, the concept *web-based knowledge building* means the facilitated, collaborative process, which takes place in a Knowledge Building tool of a web-based learning environment, which is software designed for supporting collaborative pedagogical practices. Currently, there are several software *programmes* planned for supporting shared discussions and group work on the market and also freely available on the Internet. One often hears mentioned the term, “online discussion”, which refers usually to synchronous or asynchronous virtual conversations supported by the Internet in general. Web-based knowledge building has a more specific meaning. The software described in this article is designed for a particular social activity, which emphasises participants as subjects and knowledge as object that is handled and processed by the participants (Leinonen, Ryymin & Korhonen, 2005). In the Knowledge Building tool of the web-based learning environment, groups may carry out knowledge building dialogues and debates by storing their thoughts into a shared database. Knowledge building differs from other online discussions or chats in its means to achieve something more than just “information exchange”. Knowledge building has its bases on pedagogical approach called *progressive inquiry learning* (Hakkarainen, 2003) which means a sustained process of advancing and building knowledge characteristic of scientific inquiry. An essential aspect of this kind of inquiry is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. Knowledge building can be described as collaborative working for developing conceptual creations, for example practices and theories. (Hakkarainen, Lonka & Lipponen, 2000, 274; Scardamalia & Bereiter, 1992; 1994.) Benefits of knowledge building are that it makes the thinking of participants with different expertise open and perceptible. According to Scardamalia, Bereiter, McLean, Swallow and Woodruff (1989) it is easier for the community to discuss and adopt written rather than spoken thoughts. In this way the members of the community are able to learn developed cognitive practices to solve intricate problems.

The days when teachers entered their classroom, closed the door and got on with teaching, to be visited only on occasion by inspectors, are gone. There is now an emphasis on self-evaluation, reflective practice and continuing personal and *professional development* in teacher's profession. Teachers are encouraged to take responsibility for their own careers. (Neil & Morgan, 2003.) But what is the difference between professional growth and professional development? According to Beirsto (1996), intellectual growth means the acquisition of more knowledge and skills, basically within already familiar realms. Intellectual development, instead, involves an extension into the unfamiliar and the emergence of new concepts, skills and behaviour. On the other hand, professional growth might be used to describe the broadening of expertise while professional development might be used to describe the process of extending into qualitatively new areas of

knowledge or ability. In this article, teachers' professional development is related to teachers' process to develop new skills and practices when implementing innovative, technology-supported pedagogical practices. The qualitatively new areas of knowledge are aimed for within this process. For this purpose the concept of teachers' professional development has been chosen to clarify the specific nature of the development described here. The context of the research and teachers' in-service training are introduced in more detail in the second chapter. Before we go on, I think it would be useful to have a glance at the findings of latest educational research about professional development, teacher collaboration and use of new technologies. These notes are important to bear on mind when reading this article further and planning school development projects in future.

### **Informal, personal and interpersonal dimensions in professional development**

Many policy makers are aware of the basic principles of professional development, but there are some new aspects, which might be beneficial when planning policy making related new technologies and networking. As we all know, the modern world is characterized by pervasive and rapid change. Professionals can no longer think in terms of being educated but in terms of becoming educated or enhancing our competence. Especially, according to Ruohotie (1997) ongoing learning and self-development by employees is critical to the success of competency-based organizations, such as educational institutions. Ruohotie (1996) introduces Dubin's (1990) findings on phenomena which make continuous professional development essential: rapid creation of knowledge, complexity of knowledge, technological innovation and global competition and concludes, that when external factors create a need for organizational changes to tasks and duties, individuals must respond to these changes in order to retain their competence. However, all authors who are trying to manage with reforms know that uncritical acceptance of every new development leads only to stress and confusion. Also, the role of the educators is far more active and autonomous than just responding to the need of global competition. For instance, here in Finland teachers are quite independent, highly-educated players, who actively participate into curriculum development (not only implementation), creation of new pedagogical practices and public discussion of educational and social values in the society. The critical question is then, as Ruohotie (1996) puts it: "when does a failure to change result in obsolescence and when is it an indication of stability and mature judgement"? An interesting view to teachers' professionalism is offered with the concepts of *competent and obsolete professionals* (Kaufman, 1974; 1990; see in Ruohotie, 1996). Obsolescence of skills and knowledge can be defined, for example, as a lack of the up-to-date skills and knowledge necessary in order to perform in current and future tasks. A competent professional demonstrates innovative solutions to problems, seeks challenging assignments which involve advanced knowledge and have active interaction with colleagues. An obsolete professional, in turn, is no longer inclined or able to solve novel problems, is not familiar with the latest strategies and equipment for his / her work and experiences decreased respect and credibility among colleagues.

Why, then, teachers get involved with professional development, what makes them interested? Maurer and Tarulli (1994) have found some factors, which influence an individual's decision to participate in development activities at work: perceptions related to the working environment, beliefs regarding the benefits of development, values and judgements and personality factors such as identification with work and self-efficacy, which means how confident the individual is of his / her ability to learn new skills. Also, Ruohotie (1994; 1996) and Ruohotie and Nokelainen (2001) emphasise the motivational basis for professional learning: self-efficacy and personal effectiveness in the learner, as well as expectations of success, have a positive impact on achievement. In addition, the motivation to grow, the desire on the part of the learner to develop and experience new things, is one of the key factors in professional development.

Leithwood (1999) writes that teachers learn through quite informal means from their colleagues and from the opportunities to socially process new information. Ruohotie (1999) introduces also another interesting, colleague-related insight for reflection teachers' professional development. He talks about *relationship-based learning*, which emphasises horizontal growth and interactive relations in working life. A career is defined in term of increasing competence, resulting from both developing expertise and *expanding personal networks*. Educational policy makers know well, that the application of career research, which is based on experience in business life, in public school system, requires consideration of the unique circumstances of the school environment. Anyhow, I believe, that career research is relevant to education. For instance, a teacher's personal life, formal and informal relations and accumulating experience are all having an effect on his / her work behaviour. This realization broadens the perspective on professional development of teachers and could have implications on the way in which educational authorities support professional learning in working life.

### **Genuine collaboration and contrived collegiality**

Collaboration is generally seen very positively in the educational field and several researchers have pointed out that teacher collaboration, dialogue in teacher communities or professional sharing and caring empowers teachers to put into practice new teaching skills, adapting new technologies and creating new pedagogical solutions (Coronel, Carrasco, Fernandez & Gonzalez, 2003; Snow-Gerano, 2005; Kohonen, 2001; Butler, Novak Lauscher, Jarvis-Selinger & Beckingham, 2004; see also Boudah, Logam & Greenwood, 2001; Briscoe & Peters, 1997; Rennie, 2001). Also, several educational researchers recommend, that an important factor in future is to establishing stronger teacher networks and communities for scaling up technology-supported pedagogical innovations (Granger, Morbey, Lotherington, Owston & Wideman, 2002; Ilomäki, Lakkala, & Lehtinen, 2004; Slegers, Van Den Berg, & Geijsel, 2000; Spillane, 1999).

Strong partnership in a teacher community is founded on perseverance, empathy, common focus, equity and trust (Hargreaves & Fullan, 1998). Hargreaves (1996) also talks about “moving mosaic”,

the creative, flexible and collaborative culture of teachers, which enables individual community level development. However, research has also noted that collaboration is not easy to establish or maintain. There may be a lack of time and space for collegial interaction during the school day and the need for continuing pedagogical support for teachers after official interventions (Ryymän, Veermans & Lakkala, 2005), may mean that teachers feel unsafe when changing individual practices to work alongside colleagues (Lacey, 1996; see in Neil & Morgan, 2003). There may also be school subcultures, such as isolation, contrived collegiality or balkanization, which means that competitive territorial groups, (Hargreaves, 1994; 1996) may prevent collaboration and professional development.

Hargreaves (1996) presents an interesting point of view for educational authorities: he claims, that the challenge in developing extended cultures of collaboration within teacher culture is, basically, a question of purpose and power. Collaborative cultures foster and build upon qualities of openness, trust and support between teachers and their colleagues. They capitalize on the collective expertise and endeavours of the teaching community. They acknowledge the wider dimensions of teachers' lives outside the classroom and outside the school, blurring the boundaries between in-school and out-of-school, public and private, professional and personal, grounding projects for development and change in a realistic and respectful appreciation of teachers' broader life. In turn, contrived collegiality reconstitutes teacher relations in the administrators' own image - regulating teachers' lives so that they support the predictable implementation of administrative plans, rather than creating the development of teachers' own (Hargreaves, 1996, 283). Contrived collegiality is, as well, meant to assist the successful implementation of new approaches but it is characterized by a set of formal, bureaucratic procedures and, at last hand, does support neither individuals nor communities. In line with Ruohotie's (1996) findings, that personal and interpersonal factors are meaningful in professional development, also Hargreaves (1994; 1996) emphasises the importance of interweaving of the personal and the professional in collaborative cultures that enable teachers' development and educational change.

Many development projects of new technologies are empowered by local educational authorities and university partners of schools. Triggs and John (2004) researched the development and dissemination of professional knowledge as it relates to teaching and learning with ICT. They challenged the linearity embedded in the professional development processes and demonstrated, instead, how “micro”-, “meso”- and “macro-communities” in a development project inter-connected and improved professional development between teachers, teacher educators and researchers. I find it a very important realization that knowledge related to new technologies and professional development flows freely among development project participants, not from trainers to trainees or authorities to teachers. This research result supports, again, Hargreaves' (1996) findings of “moving mosaic”; flexible culture of collaboration.

## Teachers and web-based discussions

This research focuses on in-service teachers' technology-supported collaboration, which is synchronous and situated in web-based learning environment. This is why I find it relevant to introduce some previous findings on using online (web-based) discussions in teacher collaboration, and in adult education in general, in following sections.

Several studies have determined that both synchronous and asynchronous online discussions are useful in educational purposes with adults but under certain critical criteria. Next, I'll refer to a couple of the most frequent findings. At first, as all educators already know, writing (for instance, a response to a question in an on-line discussion forum) requires greater reflection from an individual than face-to-face discussions (Harasim, 1995), and this can, even, in the best case, contribute to the participant's intellectual growth (MacKnight, 2000). Secondly, it has also been shown, that online discussions offer teachers new opportunities to talk and participate (Williams, 1997), share and exchange their knowledge with colleagues (Dillon, 2000; Selwyn, 2000), and once again, interact in day or night with each other about things that matter most to them (Hargreaves & Fullan, 1998). But still it raises the question; are there other benefits that web-based forums can offer to teachers' professional development?

Professional development by web-based interaction can't be considered as a self-evident fact. Many challenges are already well known among policy makers, and some of them are constantly emerging in educational debate. Lets have a quick glance to the challenges and problems next: virtual discussions are not very well structured and can be quite confusing, they can end up as open-ended and interest of participants can collapse before the discussion ends (Shafquat & Salter, 2004), the loss of face-to-face interactions disturbs interpreting the discussion (Winter & McGhie-Richmond, 2005) and too big discussion groups decrease individual contributions (Chidambaram & Lai Lai, 2005) and, in worst case, there's no interaction at all; Selwyn (2000) found that over a third of the requests for information in a teachers' discussion forum remained unanswered.

In this study, I describe especially teachers' synchronous knowledge building in the Knowledge Building tool of the web-based learning environment. Are there some differences then between asynchronous and synchronous virtual interaction then? At least it seems, that synchronous interaction requires even more planning and guidance for resulting coherent and deepening conversation than asynchronous. Recent research has revealed, however, the following encouraging results and advantages in using synchronous interaction in adult education: the participants receive immediate feedback and they have ability to affirm implicit assumptions in conversation. With facilitative design (course design, group dynamics, questioning skills) it offers more coherent and a deeper argumentation process than asynchronous discussion and even more inclusive and intensive learning conversations than in face-to-face interaction. (Dracopoulos, 2003; Cox, Carr & Hall,

2004; McAlister, Revenscroft & Scanlon, 2004; Wang, 2005.) Still, is there something more to offer?

### **The objectives of the study**

In addition to research results reported earlier, it would be interesting to find teachers own experiences on using synchronous interaction. Do they find it meaningful to their professional development themselves? If so, how does it support development? Also, can teachers genuinely gain new knowledge through collaboration, or as Senge (1990) puts it, “gain insights that could not be achieved individually”? Or are the web-based discussions always more or less “artificial” (Selwyn, 2000) with fatal problems and hazards? Also, by inspired by Hargreaves (1994; 1996) I wonder, could the web-based knowledge building, in general, be applied for empowering genuine collaborative cultures of teachers instead of contrived collegiality?

In this article, I introduce a process, which offers some new views to these questions and can help creating such innovative teacher in–service training, were web-based tools are implemented meaningfully. In the development project described within this research, teachers participated in synchronous conversation with more ambitious goals than just knowledge exchange or debate, they participated in “knowledge-building”. They aimed to solve accurate problems in their process of educational change. At the same time, they participated in the critical process of developing synchronous interaction so, that it would better benefit them in future too. From this basis, the new knowledge which is offered in this article, involves above all teachers' own perceptions and experiences on benefits and challenges of using synchronous web-based knowledge building supporting their professional development.

The objective of the present research is to determine what kind of possibilities, challenges and problems teachers report when they participate in the synchronous, web-based knowledge building.

The other objectives are to search for answers to the questions of what kind of synchronous, web-based knowledge building support teachers' collaborative problem-solving meaningfully and, finally, what kind of advantages a web-based learning environment, which includes the Knowledge Building forum, offers to teachers' collaboration that no other media can offer?

## **2. Synchronous, web-based knowledge building in teachers' in-service training**

### **2.1 Context of the development was the ITCOLE-project**

In this chapter I introduce the context of the development and research project, where synchronous web-based knowledge building was developed. The reason I'm describing you this case is because it's important to know the general pedagogical initiative, which was behind the teacher training: development of new technology-supported pedagogical practices in teaching and learning.

Synchronous, web-based knowledge building, which is called “virtual workshop” within the project and also in this article, was a part of teachers' in-service training (Haatainen & Korhonen, 2002; Ryymin & Korhonen, 2003) which was created within the EU Commission's ITCOLE-project ([www.euro-cscl.org/site/itcole](http://www.euro-cscl.org/site/itcole)). The project was coordinated by the University of Art and Design of Helsinki, it was carried out in 2001-2003 and it had three scientific and technical goals: to develop new pedagogical practices for technology-supported collaborative learning and *progressive inquiry learning* (Hakkarainen, 2003), to design web-based learning environments that support the pedagogical models and to disseminate good pedagogical practices in European schools. I find it important to remind the reader, before I go further in the project description, that the design process of the web-based learning environments of the ITCOLE project, Synergeia (<http://bscl.fit.fraunhofer.de/en/about.html>) and FLE3 (<http://fle3.uiah.fi>), are still continuing and the software for both are available in the Internet.

The initial pedagogical approach of the ITCOLE project, *progressive inquiry learning* means a sustained process of advancing and building knowledge characteristic of scientific inquiry. It entails that new knowledge is not simply assimilated but constructed through solving problems of understanding. An essential aspect of this kind of inquiry is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. Through intensive collaboration and knowledge building, resources of the whole learning community may be used to facilitate the advancement of inquiry. Facilitation of progressive inquiry at school appears to require a change in the traditional division of cognitive labour between the teachers and students and to encourage students to take responsibility for their cognitive (e.g., questioning, explaining) and metacognitive (e.g., goal-setting, monitoring, evaluating) aspects of inquiry (Bereiter & Scardamalia, 1987; Hakkarainen, 2003). However, proper balance should be pursued in each pedagogical situation between teacher-controlled and student-controlled aspects of inquiry. Teachers should not rely too much on students' creativity, but should provide intervention with careful pedagogical guidance and expert-model when a student is not able to make progress (Hakkarainen, Lipponen & Järvelä, 2002).

The project was divided in three research stages. In the first stage, the pedagogical models and research made on computer-supported collaborative learning (CSCL) in Europe were surveyed (Lakkala, Rahikainen & Hakkarainen, 2001) and the alpha version of the project's web-based learning environment application was built on the European models of CSCL. Then, teachers' pedagogical and technical training was carried out in participating countries. In the second stage of the project teachers implemented their learning projects with the support of the alpha versions of the web-based learning environments and gave feedback on the usability of the applications. On the basis of the teachers' feedback, the software was developed into the beta versions. In the third stage of the project teachers implemented learning projects in the beta versions and gave again feedback on the usability. The web-based learning environments were developed in to the final versions and

the good practices of computer-supported inquiry learning (hereafter, in this article, “technology-supported inquiry learning”) were disseminated, for instance, through the web site of best practices, Ideabank (<http://www.euro-cscl.org/Ideabank>) and leaflets ([http://www.euro-cscl.org/site/itcole/itcole\\_brochure.pdf](http://www.euro-cscl.org/site/itcole/itcole_brochure.pdf)).

### **Finland's specific efforts in practical implementation**

This article concentrates on describing Finnish teachers' experiences of synchronous web-based knowledge buildings. The teacher in-service training practices, especially virtual workshops, were implemented and further developed in every detail only in Finland, where the participants' goal was also to develop new, applicable strategies for teacher training, which would be maintained and further developed after the project too. The teachers' training during the ITCOLE project was organized according to an in-service training and consulting model (Ryymän & Korhonen, 2003). The goal of the training model was to empower teachers' professional development in the context of new technology and foster educational change. The contents of the training included the following topics: the pedagogical model of progressive inquiry, web-based learning environments and principles of change management. The training lasted about four months, and was carried out two times during the three phases of the project. The training was organized as face-to-face meetings, school consulting occasions, and in web-based environments. The training was divided in four stages typical for a development process: orientation-, action-, assessment- and dissemination phases. The orientation phase consisted of introduction to the technology-supported inquiry learning. In the action phase, the teachers implemented the inquiry learning projects and were supported, in addition to school consulting, by face-to-face workshops and virtual workshops (the synchronous web-based knowledge buildings). In the assessment phase, the process was evaluated and then, in dissemination phase, teachers participated into the distribution of the project results by presenting their outcomes in their schools and in national and international teacher conferences. In the first and second stages of the project there were 10 teachers and 235 students participating in the project from Finland. Teachers who joined in the project's first and second stages are called the pilot teachers. In the third stage of the project there were 21 new teachers and 448 new students participating in the project in Finland.

In this phase, it is good to clarify a bit more Finland's role in the project. Among university partners, there were also local educational authorities participating in the project from Finland; the Media centre of the education department of Helsinki City. The goal of this Finnish partner was then more policy- and practice-oriented; the partner was aiming to empower educational change by embedding new technology-supported pedagogical practices in everyday school and maintain them after official project by new teacher training strategies. The training models were anyhow developed in collaboration with international project partners, the efforts appointed to implementation was decided independently in participating countries. In Helsinki, the project was situated into a wider national and local frame of reference of promoting web-based learning in schools. The national

curriculum reform (in 2003) in Finland involves progressive inquiry learning (problem-based learning) and web-based learning (learning in networks, technology-supported learning) into the national curriculum of nine years comprehensive school and the secondary school. In addition, educational authorities and politicians in the City of Helsinki have empowered special regional emphasis on the development of web-based learning in all educational levels, from preschool to secondary school and vocational learning. Besides the ITCOLE project, there were several other pilot projects going on, different web-based learning environments and training models were evaluated and further developed in teaching.

Finland's specific efforts in practical implementation can be concluded also from the evaluation of learning projects within the ITCOLE project. All teachers from participating countries (the Netherlands, Italy, Greece) implemented progressive inquiry projects supported by a web-based learning environment within the project. When comparing Finnish projects to the projects carried out in other participating countries one learns that the Finnish projects were, firstly, longer and, secondly, aimed more clearly towards the principles of progressive inquiry, such as collaborative knowledge-building and pursuing students' own explanations. Brief descriptions of all projects carried out within the project are available in the final report (Emans & Sligte, 2003) of the ITCOLE-project. The Finnish teachers implemented technology-supported inquiry learning projects on several school levels and in various subjects and projects varied from one-classroom projects to international networks and from mainstream education to special needs education. In the second development stage, there were 8 different project plans and in the third stage 23 plans, one of them implemented in two different groups.

## **2.2 The virtual workshops were organised in a Knowledge Building forum**

The synchronous web-based knowledge buildings were organised in the Knowledge Building forum of the web-based learning environment when in-service teachers were practically implementing technology-supported inquiry learning. The goal of virtual workshops was to support the process of implementing new pedagogical practices by offering teachers opportunity to collaborative solve problems emerged in the process. The goal of organising the virtual workshops was also to research and assess the model of synchronous, web-based knowledge building with teachers and improve it according to teachers' feedback. The knowledge building discussion was scaffolded and structured by Thinking Types, which label the thinking mode of each discussion note and are named according to the elements of interaction that are typical for a problem solving process. Thinking Types used in the virtual workshop were, for example: Problem, Own explanation, Comment, Deepening knowledge, Evaluation of the process, Summary and Organising work. Thinking Types have been developed earlier and used, for example, in CSILE-system (Scardamalia & Bereiter, 1992; 1994; Lipponen & Hakkarainen, 1998). Usually Thinking Types raise many critical questions in aware readers, so let me spend a moment on the topic. Thinking Types are also called Knowledge Types (see Leinonen et al., 2005) and their usability as well as development is under continuous critical

debate. For instance, although their purpose is to support, scaffold and clarify the problem-solving process, in some cases they may also distract participants' contributions in discussion. Within the ITCOLE project the Thinking Types were tested and developed in several phases together with teachers. The goal was to find the most coherent and reliable set of Knowledge Types for flowing problem-solving process. Teachers were not only testing the Types but also developing their labels and defining their meanings. Unfortunately it is not possible to go into this specific process in more detail here. In the latest version of the web-based learning environment, users can also define labels for Thinking Types themselves or choose the Thinking Types set from several different options. I encourage all those interested to look closer at the software's web site mentioned earlier or even to send their own suggestions to the development team.

The synchronous web-based knowledge building sessions within the ITCOLE project were guided by teacher trainers, who represented both the training organization of local educational authority and university partners. There was one facilitator in each session. Before the virtual workshop, facilitator offered user support in general on functions of the web-based learning environment. The facilitator also divided teachers into groups of 6-10 persons so that there were teachers from different schools school levels. During the virtual workshops facilitator guided knowledge building with questions, by encouraging teachers and by acting as an example in using the Thinking Types.

Facilitators also took care of time, for instance, hinting at the need to move on to the conclusion making phase and closing the workshop when time ran out. They also made final summaries on teachers' suggestions at the end of the workshop. During the process, the facilitators paid special attention that their guiding was very careful and balanced between scaffolding and offering space for teachers' expressions. Guiding, but not leading, was very demanding and facilitators developed their practices by collecting feedback from teachers, by monitoring each other's actions and by analysing the saved database of knowledge buildings. It is not possible to discuss the role of facilitator deeper in this article, but some more information and reflection can be found from other publications (Ryymän & Korhonen, 2003; 2004a; 2004b).

### **3. Research and development process**

Next, I will take a closer look at the research and research methods: how the data was gathered from teachers, and how it was analysed and interpreted. The development process of the synchronous web-based knowledge building included three research phases, in which teachers' descriptions on their experiences were analysed. The process followed partly the stages of the ITCOLE project. The third research phase was, anyhow, one and a half years after closing the ITCOLE project.

### 3.1 Phenomenographic approach

The analysis of teachers' reports was carried out within the framework of a research approach called *phenomenography* (Marton, 1988). It aims to reveal the qualitatively different ways in which people experience and conceptualise various phenomena in the world around them. People are considered to be conscious subjects, who can build different conceptions of phenomenon and express these conceptions by language. In this research the empirical data includes 27 teachers' written reports and five interviews in which teachers reflected their experiences on virtual workshops and which were gathered in 2002-2004. From the point of view of the development process, I believe that the use of longitudinal data is an advantage, because it provides greater variation than a research based on only one interview or questionnaires.

By adopting the phenomenographic approach I identified and grouped teachers' expressions describing synchronous, web-based knowledge building on the basis of similarities, differences and complementarities. Marton, Dall'Alba and Beaty (1993, 282) found that expressions often represent different fragments of the same conception. In order to see expressions as representing different fragments of the same whole, researcher has to have an idea what the whole is like. To be able to decide whether or not two expressions reflect the same conception, the researcher must have an idea as well what the conception is; the conception is abstracted from the expressions that are considered to reflect it. These principles underline the participatory and active role of the researcher in the process of interpreting the research data.

There were different aspects of conceptions that emerged from the data in my analysis. In this article, I have characterised and presented the categories of description for the grouped conceptions. Marton (1988; Marton & al., 1993, 283) makes a distinction between conception and categories of description. The conception refers to actual experiences, understandings and conceptualisations that people have of various phenomena. Categories of description are abstract tools used to characterise the conceptions. I consider that the categories of description, which emerged from the data, are meaningful in understanding the characteristics and contribution of synchronous web-based knowledge building in teachers' professional development. The phenomenographic approach is purposeful in this study, because it supported to find out teachers' own experiences and the personal meanings they gave to the knowledge building. By adopting this method I reached the teachers' immediate feedback; their spontaneous, free and genuine perspectives. This method offered teachers also possibility, besides expressing themselves freely, to emphasise those aspects they found most important.

When assessing research, one has to pay special attention to the relationship the researcher has to the research object as well as to the research context. In this study, I was one of the learning partners collaborating with teachers and developing the research context, because I represented the training organisation of the local department of education. This means that both my assumptions

and concrete actions have had an effect on the research process, pedagogical settings and research context. For the phenomenographic approach it is, however, typical that the research is strongly related to the researcher's presumptions and interpretations. According to Laine (2001), researcher's awareness of her / his presumptions and starting points support to assess and monitor their impacts on interpretation of research. The assumptions and starting points involve, first of all, researcher's theoretical (the previous research concerning the phenomena) and subjective framework in perceiving the world. In the process of this research I have needed constant critical reflection, conscious introspection and continuous open discussion about my presumptions and interpretations of research results with teachers and other project partners. Finally, I can conclude, that the analysis of the data has been iterative and interpretative by its nature and the meanings that emerged from the data have been analysed several time under critical evaluation and aware of researchers' partnership within the process.

### **3.2 The three phases of data collection**

#### **The first phase**

The data was collected through e-mail questionnaires, in the web-based learning environment's Knowledge Building forum and by interviews in three phases, from 2002 to 2004. In the first phase, in spring term 2002, there were 10 pilot teachers participating in the two synchronous knowledge buildings, which were organised in the Knowledge Building forums of the alpha version of the Synergeia web-based learning environment (<http://bscl.gmd.de>). Discussion was supported by following Thinking Types: Research problem, Own explanation, Deepening knowledge, Comment, Evaluation of the process, Summary and Help request (Rubens, Emans, Leinonen, Skarmeta, & Simons, in press.). Besides two synchronous knowledge buildings, teachers participated into the long term (two weeks), asynchronous knowledge building. (See more about Synergeia from <http://bscl.fit.fraunhofer.de/download/SynergeiaManual.pdf> ).

There were four (4) teachers from lower level comprehensive school, two (2) teachers from upper level comprehensive school and three (3) teachers from upper secondary school participating in the knowledge-buildings. Teachers were divided into two groups so that there were five teachers and a facilitator in each group. Both workshops had the same problem statement: "How can a teacher guide pupils to start their individual inquiry processes?" and they lasted about two hours. After participating in the knowledge buildings teachers were either interviewed (5 teachers) or answered an open e-mail questionnaire (5 teachers). Additionally, seven (7) teachers evaluated virtual workshops in the semi-structured questionnaire at the end of spring term 2002. Teachers were encouraged to give their descriptions freely but, in addition, were also asked to reflect on do they prefer to participate in the short-term (two-hour), intensive knowledge building or long-term (two weeks) knowledge building.

## **The second phase**

There were 31 teachers participating in the second phase of the process in the autumn term 2002. Teachers were from lower and upper level comprehensive school and from secondary school. Seven (7) of the pilot teachers continued the project and 24 new teachers joined. In this phase, teachers worked mainly in teams. There were all together nine (9) virtual workshops organised for the teachers in this phase. 21 teachers participated in those four (4) virtual workshops, which were evaluated. (There were about 5-6 participants and a facilitator in each group.) Evaluation of the workshops was ended, when it was noticed that the teachers' descriptions didn't bring any new information. According to Eisenhardt (1989) the ideal number of cases in a research cannot be defined in advance and acquisition of the cases can be finished when theoretical saturation is reached. 12 teachers from 21 participants answered the open questionnaire in the Knowledge Building forum of web-based environment right after the virtual workshops.

The synchronous knowledge buildings were one and a half to two hour guided sessions. Compared to the first phase workshops the problem-statements were formulated more clearly and the problems chosen were authentic, real-life problems, initiatives of participating teachers. The first problem statements were, in any case, the same as for the pilot teachers in the first research phase: "How a teacher can guide pupils to start their individual inquiry processes?". The problems of the third and the fourth workshops were: "How can evaluation support achieving the goals of learning?". There was special attention paid to guiding the workshop, for instance, the workshop was divided in phases for helping the collaboration. (See in more detail: Ryymin & Korhonen, 2003.) The knowledge buildings of the second research phase were organised in FLE3 web-based learning environment (<http://fle3.uiah.fi>). Following Thinking Types were used in this time: Problem, Own explanation, Deepening knowledge, Organisation and Summary.

At the end of the knowledge buildings teachers answered the following questions: "How did the virtual workshop work? Did you gain new knowledge? Were you able to present your own thoughts? Did you get answers to the questions that were on your mind? Did the Thinking Types help knowledge building? Is it worth while to organise virtual workshops in the future? Do you have any development ideas for the virtual workshop?". Teachers were, especially, encouraged to give their free description and to highlight perspectives that they perceived most important.

## **The third phase**

In the third phase of the process teachers, who had participated in the ITCOLE project in Finland, answered to the delayed post-measurement about one and a half years (1,5) after finishing the official project. This questionnaire made it possible to acquire valuable data of how teachers were implementing technology-supported progressive inquiry after the project. From the 26 teachers, who responded to this questionnaire, the ten (10) most active were chosen to answer an additional,

more in-depth questionnaire. These teachers had been actively implementing technology-supported inquiry learning in their work and acting also as tutors for other teachers. (In this article this group of teachers is called “advanced teachers” hereafter.) Through an additional questionnaire, it was wanted to discover these teachers' experiences and opinions of web-based knowledge building long after the official project. Secondly, it was interesting to find out how teachers had implemented web-based knowledge building in practice and, thirdly, to acquire information about teachers' actions as promoters of technology-supported inquiry learning. The in-depth questionnaire consisted of 17 open questions which focused on the following four themes: 1) Teachers' actions as tutor for colleagues (dissemination of technology-supported inquiry learning), 2) Teachers' participation in other pedagogical development projects, 3) Teachers' professional networks and collaboration and 4) Knowledge building.

The theme “Knowledge building” included seven (7) open questions: 1) Have you implemented web-based knowledge building with your colleagues after the ITCOLE-project? For what purposes? 2) Can web-based knowledge building support teachers' professional knowledge building according to your experiences?, 3) What kind of advantages or disadvantages have you found when using Thinking Types in knowledge building processes?, 4) What kind of benefits, problems or challenges do you find when participants in the web-based knowledge building are representing different schools and school levels?, 5) What kind of advantages can the web-based learning environment, which includes Knowledge Building forum, offer to teachers' collaboration that no other media can? 6) Would some other media, than the web-based learning environment, support teachers' collaboration? and 7) Have you implemented Knowledge Building forum in the web-based learning environment with your students? It is good to notice that the concept web-based knowledge building involved both synchronous and asynchronous practices in this questionnaire. The three phases of data gathering are described in detail in Table 1.

Phase 1.	Phase 2.	Phase 3.
<p>Spring term 2002</p> <p>10 Pilot teachers participate in two virtual workshops.</p> <p>10/10 Pilot teachers answer the open e-mail questionnaire or were interviewed.</p>	<p>Autumn term 2002</p> <p>21 Teachers participate in four virtual workshops.</p> <p>12/21 Teachers answer the open questionnaire in the web-based learning environment's discussion forum.</p>	<p>Spring term 2004</p> <p>26/31 Teachers answer the delayed post-measurement questionnaire.</p> <p>10/10 Teachers answer the additional open questionnaire.</p>

**Table 1. The three phases of data collection.**

## 4. Research results

### 4.1 Results of the first phase: teachers preferred brief synchronous knowledge building

All Ten (10) pilot teachers preferred the short-term, synchronous knowledge building to the long-term and asynchronous. The following three categories of conceptions emerged from the teachers' descriptions: I) Time management, II) Need for clear problem stating and III) Technical challenges (Table 2). Typical for the teachers' descriptions was that the virtual workshop was reflected only by the conceptions associated with the practical conditions and workshop facilities. Teachers, for instance, didn't use conceptions related to the virtual workshops goals, such as generating new knowledge or solving the problem stated. Teachers didn't reflect their own contributions on the knowledge building process either. Below I present the themes of the categories in more detail and give examples from each category.

#### I) Time management:

*“From the point of view of the teacher the two-hour period is better. Then you really concentrate on the topic.”*

The first category, Time management, means, that teachers emphasised the benefits of the brief (about 1,5-2 hours) and synchronous virtual workshop. They argued that it is difficult to find time for a long-term asynchronous discussion, which also loses cohesion easier or can be forgotten even. When the time of the virtual workshop is agreed early enough, and when a facilitator takes care that the duration of the workshop is not exceeded, the synchronous, web-based knowledge building can be useful. When discussion was kept brief it gave teachers the feeling of efficiency and they described that they can participate more easily in this kind of workshop, for instance directly after lessons at their own PC, than in traditional face-to-face meetings in other places. Everyone in interviews and in written feedbacks stressed the benefits of brief workshop.

## II) Need for clear problem stating:

*“The clear problem-statements would keep discussion on the subject.”*

The second category, the need for clear problem stating, is critical, and almost all teachers had some feedback related to organising workshop in coherent and meaningful way. They found that a clear problem-statement, a question, which is simple enough, guides the interaction and scaffolds participants to stay on the point. For example, not so many supportive or clarifying questions which were presented, at the beginning of knowledge building is needed. One leading problem presented is a good and clear starting point and guides the discussion to stay on the right subject.

## III) Technical challenges:

*“Unfortunately I couldn't log in at the beginning.”*

The third category, Technical challenges, is about the technical problems that emerged. Fortunately, only a couple of the teachers had problems in technical use of web-based learning environment and the problems were easily solved. This was anyhow very critical, because if teachers couldn't, for instance, log in synchronously and joined in later, it was difficult to find the current stage of the debate.

<b>I Time management</b>
<b>II Need for clear problem-stating</b>
<b>III Technical problems</b>

**Table 2. Categories of description in the first research phase. Teachers' experiences on the possibilities, challenges and problems of the virtual workshop.**

#### **4.2 Results of the second phase: synchronous knowledge building generated meaningful knowledge**

There were altogether twenty one (21) teachers participating in those four workshops, which were evaluated and twelve of them (12/21) wrote their descriptions in a Knowledge Forum. The following categories emerged: I) New knowledge, II) Encouragement to implement web-based knowledge building in teaching, III) Feeling of participation, IV) Usability of the Thinking Types and V) Technical challenges (Table 3).

The first category, New knowledge, was an essential theme from the point of view of knowledge-building's goals. Ten out of twelve (10/ 12) teachers described that they had acquired new and useful knowledge as a result of the knowledge building. There were different emphasis on the component parts of descriptions, but the conceptions teachers used (such as "knowledge", "perspectives", "ideas") were related strongly to gaining new, meaningful and usable knowledge or creating richer understanding of the matters of problems at hand. This supported teachers in the process of implementing technology-supported inquiry learning in practice. Teachers expressed that the knowledge-building had genuinely supported them in their process of learning and implementing new pedagogical practice.

The second category, Encouragement to implement web-based knowledge building, emerged from the descriptions of six (6) teachers. They emphasised that the web-based knowledge building was an encouraging experience, which supports them in trying new pedagogical practices in their teaching. There was a relationship found between the first and second categories: conception of encouragement emerged in the same descriptions where the experience of the workshop was experienced as meaningful new knowledge. In this sense, the experience of reaching new knowledge seemed to motivate and also emotionally support teachers to develop their pedagogical

practice. Anyhow, I chose to create two different categories, because not all teachers, who reported gaining new knowledge, underlined that it was also encouraging them in particular.

In the descriptions of the first or second category there was no conceptions related to the organisation of the workshop, for example controlling time or topic, used. This was a difference when comparing the results to the categories found in the first research phase. The emphasis of the assessment was, this time, on the qualitative analysis of the knowledge building's contents and goals.

Here are two examples from the first and second categories of description.

I) New knowledge:

*“I gained new knowledge and something to think of.”*

*“The problem was interesting and important in this moment. My thoughts around the subject became more clear.”*

II) Encouragement to implement web-based knowledge building in teaching:

*“ I acquired new tips and encouragement to my own attempt.”*

*“ A good experience that helps when I plan the start of my own course[with web-based knowledge building]!”*

The third category is an important finding too, Feeling of participation. This reminds Hargreaves' (1996) descriptions of genuine collaborative cultures, where teachers are participating with their personal efforts to the collaboration. The twelve (12) teachers described very positively their experience of the feeling of participation in knowledge building process. They also assessed that the problem-solving process progressed well or at least quite well, and the group-size was sensible. Ten (10) teachers reflected especially their own contributions and impacts on solving the problem. They found it positive that they had influenced the progress of the knowledge building. Typical for this category of description was, that teachers experienced that their own participation in the knowledge building was meaningful. Reading others' current thoughts and the feeling of being noticed by other participants increased their experience of collaboration. Teachers' feedback, in this category, described strongly their personal experience of the workshops' reciprocity, their own influence and ability to build new knowledge together with other teachers. Only two (2) teachers brought up problems in participation. The other teacher felt that knowledge building had ended too fast. The other teacher described, that it was unclear whether other participants answered his notes or not. Also from these descriptions emerged the importance of feeling of personal participation. The virtual workshop doesn't become a meaningful experience to a person, if she / he experiences that

she / he doesn't have any personal influence on the process. Here are some examples from the third category:

### III) Feeling of participation:

*“The discussion progressed at the right speed. I had time to read the questions and it really felt good when someone commented to my notes.”*

*“The size of the group was good. The discussion didn't get out of hand and I had time to read everyone's notes.”*

In fourth category, Usability of the Thinking Types, the criticisms of Thinking Types were presented. This was an important theme, which, on the other hand, told that the Knowledge Building forum of the web-based learning environment still needed development so that it would better support teachers in collaborative knowledge-building. On the other hand, the appearance of criticism and ideas for further development told also about the commitment of teachers and the safe atmosphere within the process: teachers felt safe to show their real opinions and they could trust, that they would be heard. Altogether eight (8) teachers paid attention into the usability of the Thinking Types that were used in the knowledge building and reflected how they supported problem solving and knowledge building. Six (6) teachers criticised Thinking Types for simplicity and wished to have more different Thinking Types in future. Here is one example of this category:

### IV) Usability of the Thinking Types:

*“I would like to have more Thinking Types. I use Own explanation -thinking type almost all the time and sometimes there would be a need for a Comment -thinking type. And sometimes there would be need for Help.”*

The fifth category, Technical challenges, is related, again, to the technical problems that emerged. It is a meaningful contribution, because according to previous research (e.g., Butler & Sellbom, 2002) technical issues are still one of the biggest barriers preventing every day use of learning technologies. Five (5) teachers described different technical problems in their feedback. Four (4) of the descriptions were related to problems of Internet access. The technical problems that bothered teachers in the second phase are reported in more detail in the ITCOLE project's report (Haatainen & Korhonen 2002, 31-32). Here is an example of description of technical challenges:

### V) Technical challenges:

*“In the beginning I had problems with the Internet connections. But when I finally logged in, there were no more problems with the technical sides this time.”*

<b>I New knowledge</b>
<b>II Encouragement to implement web-based knowledge building in teaching</b>
<b>III Feeling of participation</b>
<b>IV Usability of the Thinking Types</b>
<b>V Technical challenges</b>

**Table 3. Categories of description in the second research phase. Teachers' experiences on the possibilities, challenges and problems of the virtual workshop.**

#### **4.3 Results of the third phase: web-based knowledge building can benefit teacher' collaboration in an unique way**

One and half years after finishing the official ITCOLE project ten (10) advanced teachers were sent an in-depth questionnaire by e-mail. The advanced teachers reported that they had disseminated technology-supported inquiry learning to hundreds of teachers and tens of schools. Five (5) of them had become part-time teacher trainers with support of local educational authorities, and all of them had led at least three training sessions for colleagues. All advanced teachers still used pedagogical models of progressive inquiry and the ITCOLE project's web-based learning environment in their teaching. Teachers reported that they had been continuing implementing both synchronous and asynchronous knowledge building with their students and their colleagues. All teachers, except one, used web-based knowledge building in collaboration with other teachers. The web-based knowledge building had been adopted also in curriculum work, planning courses, sharing knowledge and collaborating with educational researchers outside of the school, for instance. The teacher, who didn't implement the knowledge building with colleagues, used it anyway with his students. All teachers, except one, implemented web-based knowledge building also in their teaching. The teacher, who didn't use it in teaching, had adopted it, in turn, to the collaboration with

colleagues. Nine (9) of ten advanced teachers had experienced that web-based knowledge building supports teachers' professional knowledge building. One teacher didn't have an opinion on this matter.

It is typical for the phenomenographic method to find the most essential characteristics to generalize the phenomena under research. During this research process, new questions emerged, for instance: how teachers, who had actively implemented technology-supported inquiry learning and collaborated with their colleagues longer than just within official project, describe the meaning of web-based knowledge building in teacher collaboration? Or is there any specific meaning in this model within teacher collaboration: is the innovativeness or speciality just a presumption of the research? Also, from the point of view of educational policy makers, it is useful to critically research the elements of web-based knowledge-building and reflect, is the dissemination of the modern technologies, last, worth the political and financial effort?

With these questions I thought it relevant to research the answers to the question “What advantage does the web-based learning environment (which includes Knowledge Building forum) offer to teachers' collaboration that no other media can?” in more detail. This question was included in the questionnaire for advanced teachers introduced in the chapter “The three phases of data collection”.

All ten teachers answered the question. The answers were analysed by phenomenological approach for finding out the qualitatively different ways in which teachers experience and conceptualise the meaning of the web-based learning environment and knowledge building in teachers' collaboration. The following three categories of description emerged from the data: I) Saving the process of knowledge building as a collective memory, II) Developing thinking through the shared writing process and III) Independence of time and place (Table 4). In the first and second categories of description teachers' conceptions were strongly associated with collaborative learning and knowledge building. The third category descriptions the web-based learning environment was perceived as a traditional file of documents, but free from time and place distinctions.

In first category of description, Saving the process of knowledge building as a collective memory, seven (7) teachers reported that the web-based knowledge building serve teachers' collaboration uniquely because of the process of knowledge building can be saved to the Knowledge Building forum. The saved process becomes, in time, a collective memory where teachers can return later. This supports, according to teachers' descriptions, the progress of collaborative knowledge building in a teacher community. Teachers perceived that the web-based learning environment is not just a database for the new knowledge generated. The knowledge building process itself was considered to be meaningful in teachers' collaboration. The web-based learning environment can become, in the best case, a unique, collective memory for collaborators. Teachers can later monitor the different phases of the process and learn from them. Here are examples of teachers' replies in the first category:

I) Saving the process of knowledge building as a collective memory:

*“The web-based learning environment serves as a collective memory and at the same time as a memory of development process itself.”*

*“Discussion on the web is saved and one can return to it later on.”*

Also the second category, Developing thinking by shared writing process, was a critical finding from the perspective of teachers' professional development. Six (6) teachers experienced that the special value of the web-based knowledge building in teachers' collaboration is related to the development of thinking by writing and sharing thoughts collaboratively by writing. In these descriptions, teachers linked the conception of learning strongly to the conception of collaboration and they found the web-based learning environment unique tool in supporting collaborative learning. Säljö (1979) and Marton and colleagues (1993) have investigated how learning has been conceptualised. They found several conceptions of learning with different emphasis, but none of them was related to the collaborative learning or conception of collaboration. Learning is traditionally very strongly associated as an individual pursuit. When interpreting data of this research, it is important to remember the context of the research: teachers had been taking part into professional training, where collaborative learning methods were actively developed. According to the findings described above, it seems that the intervention succeeded in empowering teachers to review conceptions of learning in a more collaborative context. It is also remarkable, that there were strong connections between the first and the second categories. Six (6) teachers' descriptions were grouped both in first and second category. However, teachers presented these arguments as independent entities so that grouping descriptions in different categories was found relevant. Here are some examples of the second category:

II) Developing thinking through the shared writing process:

*“Writing improves thinking and the result can be more organised than in oral face-to-face communication.”*

*“The participants from different schools, cities and even countries add the value of the virtual workshop. Saving knowledge building process into visible paths or layers is an absolute advantage of the virtual workshop.”*

Only three (3) of the advanced teachers emphasised that independence of time and place when describing the web-based learning environment, and the third category, Independence of time and place, was formed on the basis of these descriptions. Typical for these three reports was that there were no concepts related to knowledge building, collaborative learning, learning by writing or collective memory like in reports of other teachers. Here is one example of the third category:

### III) Independence of time and place:

*“Independence of time and place is a practical benefit.”*

In addition, two advanced teachers reflected the meaning of the web-based learning environment from the point of view of democracy and equality in teachers' collaboration, for example: *“In ordinary teacher meetings and seminars the loudest teachers are leading the process. A shared memory is more democratic because every one has a right and responsibility to make his own conclusions.”* Although all teachers were asked to consider if some other media than a web-based learning environment would better support teachers' collaboration, only two teachers considered an option, which was a video conference. Also these teachers emphasised the meaning of shared, written document in collaborative learning: *“Organising a video conference could be almost as good as the using web-based learning environment. The disadvantage would be that the discussion can't be studied afterwards in written form.”* It is good to notice, that in third phase the question as well as teachers' answers involved both asynchronous and synchronous use of web-based knowledge building and their differences were not analysed.

Further, one interesting aspect to teachers' professional development emerged within this research, that is worth of a section of its own. It is the development of the concepts in teachers' description from the first research phase to the third. Longitudinal perspective is offered by those seven (7) pilot teachers, who committed to the process from its first stage and finally became “advanced teachers”. In the first phase they concentrated on technical and organisational aspects and the pedagogical meaning of web-based knowledge building wasn't found yet. In the second phase, when they already had more experience on technology-supported inquiry learning, they used more pedagogical concepts in their descriptions and emphasised, for instance, knowledge-generative elements of knowledge building. Finally, in the third phase, they described knowledge building by advanced pedagogical concepts and reported, such as “collective memory” and reported how they had been implemented it in both in teachers' collaboration and in teaching. In this sense, the professional development of these particular teachers seemed to have a sustainable nature and their expertise had extended into qualitatively new areas of knowledge.

<b>I Saving the process of knowledge building as a collective memory</b>
<b>II Developing thinking through the shared writing process</b>
<b>III Independence of time and place</b>

**Table 4. Categories of description in the third research phase. Teachers' experiences on the advantages of the web-based learning environment for teachers' collaboration no other media can offer.**

## **5. Conclusions and discussion**

In this chapter, first, I offer a summary of the research results and then conclude with some perspectives and advice, “meta-policy”, for educational policy makers for considering synchronous web-based knowledge building as one innovative model for teachers' professional development.

### **Summary of research results**

According to the research results synchronous web-based knowledge building, which was guided and facilitated by accurate Thinking Types and based on clear and authentic, real-life problem statements supported teachers' collaborative problem-solving in a meaningful way. It empowered teachers to create new knowledge, which they found usable when embedding new, technology-supported pedagogical practices in everyday schooling. One particular advantage of synchronous knowledge-building was also the feeling of participation: teachers felt that their thoughts were heard and they had a personal impact on the problem-solving process. Teachers also described that the two unique advantages, that a web-based learning environment, which includes Knowledge Building forum, can offer in general for teachers collaboration are the possibility to save the collaborative knowledge building process of a teacher community as a collective memory and the possibility to develop thinking by shared writing.

The challenges reported were related to technical problems and to the use of Thinking Types, although the technical problems didn't play a major role in teachers' experiences. The effect of technical problems on educational innovations is however crucial and I will discuss this matter later in this chapter. Instead, I have no opportunity to discuss on the development of Thinking Types in

more detail here; the theme is wide and worth its own article. It is in any case important to conclude that the use of labelled notes in collaborative problem-solving process needs constant critical reflection. It is important to assess when they are genuinely scaffolding the collaboration and when, in turn, they are not supporting the advancement of the dialogue in their best possible way. As a summary, the findings of the present research reveal that synchronous web-based knowledge building supports teachers' professional development meaningfully and when planning the implementation, it's important to pay attention to use of Thinking Types and technical challenges.

However, the limitation of the present study is that is focused on one development project only. Hence, it is difficult to judge the effects in the present case and it is possible that some of the teachers' descriptions would appear differently, and be far more critical, for a larger sample and in different school communities.

### **Knowledge-building and generation of new solutions to accurate problems**

From the point of view of educational policy makers synchronous, web-based knowledge building offers one applicable tool for committing teachers personally to their professional development and for supporting them in educational change. This innovation enables them to generate new solutions to the problems at hand quickly, cost-efficiently and in a democratic way in the process of reforming pedagogical practices. The knowledge flows freely between knowledge building participants: it's not received outside of the schools from authorities, but the authorities involved in intervention can participate in to the knowledge building as well. However, it is important to realize that the efficient use of synchronous web-based knowledge building needs a facilitator, a co-learner, a guide, who is familiar with new pedagogical practices, aware of teachers' professional needs and the process of educational change. In this study there was a teacher trainer guiding the knowledge building, but a facilitator can also be, for instance, an experienced teacher from a school or region.

### **The more qualified goals than just information exchange**

Most policy makers are familiar with the suggestions to create more possibilities for information exchange among teachers. However, web-based knowledge building can be used for reaching more qualitative goals than just information exchange: it can empower individuals to exceed their limits and open new perspectives. Web-based knowledge building can also be used as a tool for the whole school community, where participants can share their thoughts by writing and monitor their individual and collective development. This may strengthen schools to take more responsibilities of their own development and its assessment. Knowledge building is also a very democratic tool for collective purposes: all participants have equal possibilities to express their views by writing, not only the most out-going personalities, who easily dominate conversations in teacher meetings.

### **Interweaving informal and formal networks**

A couple more advantages can be pointed out when considering embedding synchronous web-based learning in a teachers' in-service training. As a training occasion, it is easier to include in teachers' busy schedules than face-to-face-occasions, especially when there are teachers from several different schools participating. It can also be more efficient than a long-term asynchronous online discussion which is, after the initial enthusiasm, easily forgotten among everyday schooling rush. Web-based activities, in general, can also be flexibly used as tools for interweaving the informal and formal contacts of teachers and other partners in educational interventions, which may increase teachers' motivation to participate in developmental activities in general. For instance, teachers who actively develop their technology-supported working practices and also mediate this new knowledge to their colleagues use web-based learning environments in many creative ways. Among other things, they communicate through web-based learning environment with their colleagues from other schools, study other teachers' learning projects, create resource banks and personal files for interesting topics, publish their own documents, plan new lessons and chat with their colleagues informally. The innovative use of web-based learning environment may play one supporting role when empowering teacher communities towards genuine cultures of collaboration.

### **Advantages of regional networking**

Through web-based learning it is possible to promote teachers' collaboration at local, regional, national and even at international level. In this research, teachers created local, interschool networks from the same geographical area. Web-based learning environments offer useful possibilities for municipalities from different regions to collaborate and establish networks for reaching joint educational objectives cost-efficiently. In international networks, educational authorities and teachers can make pedagogical innovations available and further generate them even to a global extent. In practice, there are, however, many challenges associated with global learning communities, for instance, language barriers and cultural and political differences.

### **Teachers' partnership in development**

I would like to emphasise, that it is important to involve teachers not only in the process of developing new, technology-supported pedagogical practices, but also in developing new models of teachers' professional development as well. Teachers should take, like any professionals today, more personal responsibility on renewing and reviewing their working practices. Policy makers should respect teachers' dignity and autonomy in this process. The traditional and hierarchical models of school reforms including “contrived collegiality” (Hargreaves, 1994; 1996) won't sustain in practice, but still, the development projects need professional project management and responsibility-taking from educational authorities. Teachers should participate equally in knowledge creation and dissemination, which is advice easier to agree with in theory than put into practice.

Proper balance should be created in each educational intervention between teacher-generated and authority-guided aspects of process.

### **New, innovative practices for policy-making needed**

Many educational authorities represent governmental or regional public sectors, where divisions and departments have traditionally districted carefully their information dissemination and followed hierarchic implementing strategies. In addition, many municipalities are often sensitive to show the limits of their knowledge, which is needed when creating new knowledge (instead of information dissemination) in collaboration with others. Many authorities would benefit of rehearsing new guiding and managing practices related to *participatory planning*, *co-learning* and *collaborative problem-solving*. One applicable tool in this task, supporting the professional development of educational authorities, could be, again, web-based knowledge building and web-based learning environment in general.

### **Combining web-based knowledge building to other training**

The best benefit of the synchronous web-based knowledge-building is gained when it is linked to the larger and longer program of professional development which includes many different activities and is based on pedagogical principles and educational theory. As all policy-makers know, educational change needs time, debate and reflection: it goes through change resistance and early adopters to finally accepted new practices. Knowledge-building can be considered as one practical tool supporting the intervention. It can also offer a possibility to deepen the themes discussed within the program, monitor the change aimed in the process and even accelerate the educational change by making its phases more visible and concrete. It is good to realize, that synchronous web-based knowledge building doesn't replace face-to-face meetings and their meaning, for instance, in collaborative trust building. However, I don't see this innovation just a complementary action to the traditional training either: synchronous web-based knowledge building can be successfully used beside more traditional training occasions because it has its special elements other current practices of teacher in service training can't offer. When planning the training within a development project, it is crucial to realize that teachers need pedagogical support also after official intervention (Ryymin et al., 2005 ). In the context of educational change policy makers should then anticipate the need for continuous support, plan sustainable models for teachers' professional development and involve, for example, resources of web-based collaboration innovatively in to the process.

### **New innovations and public agreements**

The special challenge for educational policy makers is to involve technology-supported educational reforms, which aim qualitatively at better learning and teaching, to political documents, declarations and public agreements. For instance, if policy makers genuinely aim for the innovations of web-

based learning being implemented and disseminated in every school, schools must be obliged to include them to the curriculum, information strategy and annual working plans. Another concrete challenge policy makers may face is that schools still don't have, and they are not guided to make, a qualified plan for the teachers' professional development. With this question the principal of the school is in key role: she / he isn't a traditional school head anymore, but the leader of technology-supported learning community. In this means, also principal's professional development programs should be reformed and modernized.

### **School-based plans for teachers' professional development**

In many schools, teachers decide alone in what training they participate and the training benefits often only individuals or small groups of teachers. Policy makers should support principals to create such an annual, community-level development plan where is clearly agreed what is the most important training according to the school's curriculum, mission, visions and goals, who is to participate in the training and how the knowledge from it is shared with others. Also, when the whole school is joining in the development project an agreement is needed for making the decision visible and concrete for all members of the school community. Many schools are using school-based teacher tutors in empowering use of web-based learning and ICT in teaching in general. This so-called *peer training* has been noticed to be a useful, cost-effective way to offer professional development for teachers in their authentic learning context (Showers, Murphy & Joyce, 1996). Unfortunately, in many cases, the concrete goals of peer training or tutoring in school are not agreed in detail, neither is who is to participate, how the time for tutoring is going to be fitted into the school day, how the process is to be reviewed and improved, what the guiding practices used are going to be nor what credit the tutor gains from his / her efforts. The tutors are also often very alone in the course facing the unpredictable, new problems related to technology-based reforms. Policy makers and principals can offer, among other professional guidance, the model of web-based knowledge-building for teacher tutors to make their work more collaborative and visible; improving the quality of their work.

### **Authority-level reforms required for relevant technical support**

When planning better interventions in technology and education, policy makers will usually face quite disturbing technical problems at some stage of the process. The use of web-based learning environments should be so robust and non-problematic that teachers are totally free from technical worries and able to concentrate fully on the educational process. At least, technical support should be easily and immediately available for teachers. The persons responsible for technical infrastructure of schools and school regions should be seamlessly committed to the pedagogical development projects and strategies. This usually means lots' of arrangements and attitude changing on the educational authority level. In many regions public equipment and software investors and pedagogical reformers work separately and don't always even know about each others interventions.

The responsibilities and the procedures of technical support should be crystal clear and openly agreed with all the participants within the development project. Once again, empowering free flow of knowledge between public sector departments and units needs even stronger efforts from policy-makers than fostering knowledge creation at school level. In addition, when equipment and learning are genuinely merging, there's need for a new kind of expertise among educational authorities: people, who know both technology and education.

### **Awareness of tensions and change resistance**

It is also significant to realize that technology-supported collaborative processes are as full of tensions and contradictions as collaboration among humans in general, if not more because of its technological dimension. There can be many questions related to themes like commitment and disagreement, trust and control, traditions and modernization raised among participants, especially when the process of educational change is proceeding from early adopters to whole school community. Collaboration for collaboration's sake only is not beneficial: it must be constantly analysed and critiqued in order to define the most meaningful benefits for all. It is not enough that policy-makers know the risk elements of collaboration and impacts of change resistance, even if they are specialists of the matter. Also school communities, especially teachers, who are in the middle of the process of educational change, should be offered knowledge as well as tools for analyzing and coping with these phenomena.

### **Future actions**

The future offers variety of new media and technological tools for teachers' professional development. Innovative mobile phones, immersion of television and Internet as well as development of intelligent interfaces offer new choices for interaction and knowledge creation as well as widening the learning communities. Teachers and schools will act, and they are already acting, in networks, which consist of not only people, but intelligent, mediating tools, different information sources and interactive media. But as interesting as researching new technology is to research the meaning that teachers, students and other participants in modern learning communities give to the new technology in their personal and professional life. Understanding and supporting human development is most important, in future too.

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Running head: TEACHERS' PROFESSIONAL DEVELOPMENT IN A COMMUNITY:  
A STUDY OF THE CENTRAL ACTORS, THEIR NETWORKS AND WEB-BASED  
LEARNING

Teachers' professional development in a community:  
A study of the central actors, their networks and web-based learning  
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**Abstract**

The goal of this article was to study teachers' professional development related to web-based learning in the context of the teacher community. The object was to learn in what kind of networks teachers share the knowledge of web-based learning and what are the factors in the community that support or challenge teachers professional development of web-based learning. The findings of the study revealed that there are teachers who are especially active, called the central actors in this study, in the teacher community who collaborate and share knowledge of web-based learning. These central actors share both technical and pedagogical knowledge of web-based learning in networks that include both internal and external relations in the community and involve people, artefacts and a variety of media. Furthermore, the central actors appear to bridge different fields of teaching expertise in their community.

According to the central actors' experiences the important factors that support teachers' professional development of web-based learning in the community are; the possibility to learn from colleagues and from everyday working practices, an emotionally safe atmosphere, the leader's personal support and community-level commitment. Also, the flexibility in work planning, challenging pupils, shared lessons with colleagues, training events in an authentic work environment and colleagues' professionalism are considered meaningful for professional development. As challenges, the knowledge sharing of web-based learning in the community needs mutual interests, transactive memory, time and facilities, peer support, a safe atmosphere and meaningful pedagogical practices.

On the basis of the findings of the study it is suggested that by intensive collaboration related to web-based learning it may be possible to break the boundaries of individual teachership and create such sociocultural activities which support collaborative professional development in the teacher community. Teachers' in-service training programs should be more sensitive to the culture of teacher communities and teachers' reciprocal relations. Further, teacher trainers should design teachers' in-service training of web-based learning in co-evolution with supporting networks which include the media and artefacts as well as people.

**Keywords:** professional development, web-based learning, social network analysis, phenomenography, central actors, teacher community, teachers' in-service training

## 1. Introduction

In-service training of web-based learning has been widely offered to teachers by a variety of development projects, interventions and training programs. New teaching and working practices have been created and technology-supported pedagogical models implemented and further developed within schools (e.g., Ryymin, Veermans & Lakkala, 2005). It has been understood that new knowledge as regards the development of new skills and perspectives is strongly related to the working environment and organizational culture of communities of practices, where, for instance, the roles and relationships of workers have an impact on professional development and knowledge creation. (Senge, 1990; Ruohotie, 1996; Wenger, 1998.)

At its best, new knowledge related to the development of new working practices flows freely among members of a working community. Also, when promoting technology-supported educational change in schools, the traditional way of disseminating knowledge from authors to teachers or from trainers to trainees has been unsuccessful. It has been realized that when establishing new technology-related innovations it is important to strengthen teacher communities and networks (Granger, Morbey, Lotherington, Owston & Wideman, 2002; Ilomäki, Lakkala & Lehtinen, 2004; Supoviz, 2002). Instead of linearity, new knowledge develops in networks of development participants; ideas and practices extend upwards, downwards, across and around and factors like trust and emotional support have significant influence on the process. (Hargreaves & Fullan, 1998; Triggs & John, 2004.)

### **The goal of this study**

The main aim of this study is to answer the question, “How do teachers contribute to each others' professional development in their working environment when implementing web-based learning?”

According to earlier experiences in teacher in-service training it seems that there are usually active adopters among teachers in development projects, who promote new pedagogical ideas as well as offer formal and informal peer support to their colleagues (e.g., Ilomäki, 2002). From these presumptions the following research questions have been designed: Are there exceptionally active, central actors in the teacher community who collaborate in the field of web-based learning as well as share and mediate the knowledge related to web-based learning more than their colleagues? In what kinds of networks do these central actors act and what kind of

knowledge they mediate? What are the factors in a teacher community which support teachers to learn the skills of web-based learning? On the other hand, what are the challenges related in knowledge sharing of web-based learning in the community? By answering these questions the goal in this article is to open new perspectives on teachers' professional development related to implementing web-based learning in schools. This new knowledge may be of particular benefit to teacher trainers, as well as other adult educators, to see the wider context where teachers act and interact today instead of, as traditionally seen, only classrooms and staff meetings. The new aspects offered by this study may encourage the teacher trainers to realize that teachers are not only “participants” or “learning partners” in educational interventions, but creators of constantly renewing knowledge. The teachers' role as knowledge mediators is even more significant in technology-promoted educational change than it may have been considered before.

### **The key concepts of the research**

The key concepts of this research are *professional development*, *web-based learning*, *teacher community* and *central actors*. In the following sections these concepts are described briefly to introduce readers to the research context and the starting points of this study.

#### *Professional development*

According to Beairsto (1996) the concept “intellectual development” involves an extension into the unfamiliar and the emergence of new concepts, skills and behaviours. Thus “professional development” might be used to describe the process of extending into qualitatively new areas of knowledge or ability. In this article, teachers' professional development is reflected in the context, where teachers develop new skills and practices of web-based learning. In this process they are considered to learn new working practices and acquire qualitatively new areas of knowledge.

*Web-based learning*

*Web-based learning* refers in this study to the implementation of new, web-based learning practices in teaching. The teachers in this study implement a web-based learning environment (<http://www.opit.wsoy.fi>) which is software designed for supporting problem-based and collaborative pedagogical practices in schools. It includes several tools for the purpose, for instance, a discussion forum, personal and shared (group) portfolio files, project management tools and learning materials related to the subjects and content areas of the Finnish comprehensive and secondary school ([www.oph.fi](http://www.oph.fi)) curriculum.

The teachers of this study planned and implemented so-called blended courses in their teaching: the web-based learning environment was used in supporting face-to-face studying. For instance, pupils had problem-solving discussions on their learning tasks in the discussion forum, created groupwork in the shared files or made learning material rehearsals with peers (or independently) in the web-based learning environment. The open distance courses or only virtual teaching were not organised in this intervention.

Problem-based and collaborative learning refers in this study especially to *progressive inquiry learning* (Hakkarainen, 2003). Progressive inquiry means a sustained process of advancing and building knowledge characteristic of scientific inquiry. It entails that new knowledge is not simply assimilated but constructed through solving problems of understanding. An essential aspect of this kind of inquiry is to engage collaboratively in improving shared knowledge objects; hypotheses, theories, explanations, or interpretations. Through intensive collaboration and knowledge building, resources of the whole learning community may be used to facilitate advancement of inquiry. Facilitation of progressive inquiry at school appears to require changing in the traditional division of cognitive labour between the teachers and students and to encourage students to take responsibility for their cognitive (e.g., questioning, explaining) and metacognitive (e.g., goal-setting, monitoring, evaluating) aspects of inquiry (Bereiter & Scardamalia, 1987A). However, it is important to realize, that progressive inquiry is an abstract model, which can be applied in various ways in an actual educational setting, and the differences in the pedagogical arrangements have substantial effect on the realisation of the process.

Further, it is important to emphasize here, that the focus of this study is not on the pedagogical models or practices, but on the teachers' experiences on knowledge sharing and professional

development. The pedagogical models and practises of technology-supported inquiry learning are further presented and discussed in other articles (e.g., Ryymin et al., 2005; Ryymin, in press).

### *Central actors*

*Central actors* are teachers, who, according to the results of this study, play a central role in their community related to web-based learning. They are situated in the centre of the communication structure of the community; they have more interaction about web-based learning with their colleagues than other members of the community on average.

### *Teacher community*

In this study, *teacher community* means a school's personnel, which is in practise in charge of teaching. It includes the all teachers of the school and the principal, the two school assistants, the school secretary and the two teacher deputy heads, who assist the principal in addition to their regular teaching work. The terms "school" or "school organization", instead of "teacher community", wasn't found relevant to this study, because in an educational context it refers to the formal school system which also includes students and local educational authorities. In this study, the focus is on the teachers in one certain school.

## **2. Innovative perspectives for rethinking teacher development in schools**

In the following sections an overview of the latest findings from educational research related to the teachers' professional development, collaboration and promotion of new technologies is presented. In addition, some basic principals about learning in social interactions and intelligent actions are reflected on. Criteria for choosing and presenting this particular literature are that it opens new perspectives on teachers' professional development in a collective context.

### **Relational perspective to teachers' professional development**

Ruohotie (1999) introduces a colleague-related insight to professional development: *relationship-based learning*. It underlines horizontal growth and interactive relations in working life. The professional development of a person includes constantly increasing competence, which results from both developing expertise and expanding personal networks. The relationship-based learning is closely related to the concept of *protean career* (Hall, 1976), which involves the idea that the main source of professional development in working life is the peers and other relationships at work. (Hall & Mirvis, 1996; Hall, 2004.) According to Ball and Cohen (1999) as well as Leithwood (1999) it is important to pay closer attention how teachers learn from and in practice and from their colleagues too. Wenger (1998) introduces the concept of *communities of practice* and emphasises the meaning of practices in the process of knowledge creation. Knowledge creation and learning take place through complementary processes of participation, which means the daily, situated interactions and shared experiences of members of the community working towards common goals.

The debate on learning and knowledge creation in organizations has been empowered by many contributors in the last decade (e.g., Senge, 1990; Nonaka & Takeuchi, 1995; Starkey, 1996, Bearsto & Ruohotie, 2003). The idea of learning in an organizational context has its basics in the principles of learning through joint activities and interaction with others; the central importance of *sociocultural theorists*. For instance for Vygotsky (1981), the source of knowledge, and the “higher psychological processes that are involved in the construction of knowledge, is to be found in the cultural activities in which the learner engages with others, and in the interaction that accompanies, directs and reflects their shared endeavours” (see in Wells, 1994).

Bereiter (2002) writes about *knowledge-building community*. Knowledge building can be described as collaborative working for developing conceptual creations, for example practices and theories. One of the benefits of knowledge building is that it makes the thinking of the participants with different expertise open and perceptible. For this purpose new technologies, such as web-based learning environments can offer valuable support for the process. (Scardamalia, Bereiter, McLean, Swallow & Woodruff, 1989.)

### **Creating learning communities for teachers**

The professional development of teachers' aims for better quality of learning and the development of these two proceeds generally hand in hand in learning communities. Wells (1994) wrote already over a decade ago, that teachers should be encouraged to model those same qualities as they work together to improve the climate and opportunities for learning that they provide for pupils. "If the climate for learning in the classroom could be transformed through the creation of a community of collaborative inquiry and conversation why not in the staffroom as well? Since the same principles apply to all learners, teachers, too, might welcome the opportunity to become inquirers into their own practice in collaboration with other members of the community of their peers and colleagues. And if this were true for teachers why not administrators too? And finally, might these various communities of inquiry not benefit from collaborative links between, as well as within, them?" (Wells, 1994, 10).

According to Wells (1999) an opportunity for learning with and from others, "the zone of proximal development" (Vygotsky, 1962; 1978), applies potentially to all participants, and not simply to the less skilful or knowledgeable. From that it follows that it is not only children who can learn in the zone of proximal development; learning continues over the life-span, and can at all ages and stages be assisted by others. In further, the sources of guidance and assistance for learning are not limited to human participants who are physically present in the situation; absent participants, whose contributions are recalled from memory or encountered from semiotic artefacts, such as books, maps, diagrams, and works of art, can also function as significant others in the zone of proximal development.

A fresh point of view on the development of new technologies at school is offered by Triggs and John (2004); they found that teachers' professionalism develops in various communities, where new knowledge, ideas and practices extend upwards, downwards, across and around. One of the central features that underpin teachers' professional development is interaction that involves knowledge exchange as the basis for knowledge transformation.

Building on different theories generated from the basis of sociocultural tradition a paradigm for investigating human intelligent activity is also emerging. Characteristic of these approaches is an emphasis on the role of cultural-historically developed tools and artefacts in human intelligent activity. (Cole, 1996.) Latour (1993; 1999) examined heterogeneous networks that consist of human and non-human actors in the frame of actor-network theory. These actors form clusters,

associations of humans and nonhumans that can be called collectives. Scardamalia's and her colleagues' (1989) innovation of using computers to support collaborative knowledge building is one practical example. According to Bereiter and Scardamalia (1987B) intellectual performance develops only through sustained intellectual efforts and a commitment to break one's boundaries.

Basing on the same theoretical principles, Hakkarainen and his colleagues (2004B) have represented the concept of *networked intelligence*, which means that intelligence cannot be located inside the participating agents but is embedded in their mutual relations and relation to supporting artefacts and the task-environment. Networked intelligence refers also to those individual and collective knowledge structures, practices and reasoning processes that allow the individual or community to function intelligently in its environment. This kind of collective intelligence can arise from three sources: the structure of the social systems, its formal and informal relationships (Blanning & King, 1995). However, the notion of networked intelligence should not be understood to mean that intelligence embedded in artefacts or environment somehow automatically produces significant gains in individual cognitive competence.

Some researchers suggest that the information and communication technologies substantially transform human's intelligent activity by providing more powerful and flexible tools for individual and collaborative creation, elaboration, and sharing of digitalized and dynamic representations. Computers provide tools for mastering, organizing and sharing cognitive tools and, thereby amplify individual and collective learning, thinking and problem solving (Hakkarainen et al., 2004B; Perkins, 1993).

When promoting new, technology-supported pedagogical practices in schools, it has been understood that *teacher collaboration* and *teacher communities* have a crucial role to play (e.g., Granger et al., 2002; Ilomäki et al., 2004; Slegers, Van Den Berg & Geijsel, 2000; Spillane, 1999). Yet, transforming social practices is difficult. There are tensions between new and traditional pedagogical practices within the development projects, which must be respected (Grossman, Wineburg and Woolworth, 2001). According to some studies, it takes several years of effort before teachers start using information and communication technology intensively in preparing and conducting their instructional activities (Hakkarainen, Muukkonen, Lipponen, Ilomäki, Rahikainen, & Lehtinen, 2001).

### 3. The context of the study

The study was carried out in an upper secondary comprehensive school in the Helsinki area. There were 300 students and 29 teachers, a principal, two school assistants and a school secretary working in the school. Students of the school are from 13 to 16 years old and they study in seventh, eight and ninth stages of compulsory education. In addition, there were two preparatory classes for immigrants and two supplementary classes (so called 10<sup>th</sup> classes) with emphasis on Finnish language teaching. In 2004, the school had a second pilot year for a web-based learning environment, although they had had emphasis of ICT (information and communication technology) in the curriculum since 1995. In this two-year pilot project, the school implemented the Opit web-based learning environment ([www.opit.wsoy.fi](http://www.opit.wsoy.fi)), which is the software of the main Finnish commercial learning material producer.

The empirical data for this study was collected in the second year of piloting. There had been afternoon workshops for the whole teacher community about the use of the learning environment at the school. The training has been offered by the software producer's teacher trainers. In this training all teachers of the community had been encouraged to implement web-based learning in their teaching as blended courses, including both face-to-face learning and learning by support of the web-based learning environment. Teachers were also offered to use their official planning time to plan new courses and exchange experiences on their trials. Three (3) of the teachers had also been participating in the three-month intensive training program outside of school. This support was offered by the local educational authority. The pedagogical goal of this program was to introduce teachers to how they could support especially inquiry learning (Hakkarainen, 2003) by web-based learning environment. The purpose of this study is not to and this is why is not introduced here

It is good to remind here, that the original initiative to pilot the web-based learning environment in teaching had been offered by the local educational authority of Helsinki. However, in the interviews of this study, the principal and the teachers described that the community had made a decision to participate after joint reflection in a staff meeting. The web-based learning environment that we describe in this article was piloted altogether in ten (10) schools from elementary to secondary stages in the region. Besides this project, there were several other web-based learning environments under piloting in Helsinki schools. In the city of Helsinki, these projects were situated in both the local as well as the wider national frame of reference and also as part of the policy of promoting web-based learning in schools. The latest national curriculum

reform (in 2003) in Finland includes progressive inquiry learning and web-based learning (learning in networks, technology-supported learning) in the national curriculum of nine years comprehensive school (<http://www.oph.fi>). In Helsinki there was also a special emphasis on the development of web-based learning at all educational levels (<http://www.hel.fi>). The goals of this process were to develop innovative pedagogical practices supported by web-based learning environments, and finally, to find one pedagogically and technically sustainable web-based learning environment for the permanent use in schools in the future (<http://www.edu.hel.fi>).

#### **4. Data collection and research methods**

##### **Social network analysis (SNA) of school community**

The empirical data of this research includes the analysis of the social network (Scott, 1991; Wasserman & Faust, 1994) of 33 members of a teacher community: 29 teachers and a principal, a school secretary and two school assistants. In this study the principal, the school secretary and the school assistant are included to the teacher community, because they are in charge of planning and assisting the teaching and further, according to the principal, they closely participate in the pedagogical development together with teachers.

The data was gathered through a networking questionnaire that consisted of a list of names in which the respective rows represented contained names of the each of the 33 members of the community, and the columns indicated for five types of networking relations. In the case of each colleague, the member was guided to think about the following questions: 1) to whom they go with technical questions related to information and communication technology, 2) to whom they go with pedagogical questions related to information and communication technology, 3) with whom they collaborate on web-based learning, 4) from whom they receive new knowledge or ideas about web-based learning and 5) with whom they interact informally. In addition, the members were guided to specify what media they use in each of their relations in the following six categories: 1) e-mail, 2) Internet: web sites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else, what?.

In this study, it has been chosen to analyse the answers to the questions 3 and 4 in more detail: they are considered as the most relevant when studying the interaction related especially to web-based learning. The social network analysis (SNA) was used to find individual actors, who are in a central position of communication, who have more connections to other teachers than their

colleagues on average. This kind of centrality value can be measured in a number of ways, but we chose the method to count the number of relations to others with whom a teacher maintains relations. This was done by calculating the centrality value of each teacher by using Freeman's degree-function (Scott, 1991), which means the amount of information and knowledge the participant provides for or receives from the other participants. Since Freeman's degree has been chosen for centrality analysis, the centralization measure is based on indegree (number of incoming networking linkages) and outdegree (number of outgoing network linkages). The centralization of a whole network thus accounts for the variation in outdegrees or indegrees of the actors in a network. For instance, the indegree value of the teacher related to question 4 ("From whom do you receive new knowledge or ideas related to web-based learning?") means: the colleagues get new knowledge and ideas from the teacher, and, in turn, outdegree value means: the teacher gets new knowledge and ideas from his colleagues.

When using SNA, relations were marked as a non-existing tie (coded zero), and an existing tie (coded one). For example, when teachers were asked to tell: "From whom do you receive new knowledge or ideas about web-based learning? ", respondents coded a person from list either zero or one. The results of the SNA formula were codified to a data matrix used in SNA and analysed by Freeman's degree-function implementing the UCINET-program (Borgatti, Everett & Freeman, 1996). There are some difficulties in using degree measure for searching central actors. For example, degree doesn't show the reciprocal relationship between actors. However, in this study, the measure of Freeman's degree was chosen to guide in picking up the central actors, because both directions of information flow were considered meaningful from the point of view sharing and mediating knowledge.

### **Analysing mediative tools and other artefacts in teacher networks**

One of the problems in analysing social networks is that only people and their communities are understood to be actors. The role of mediating communication and information artefacts is neglected. The framework of this study emphasizes such a perspective that the networks in working life are heterogenous and include not only people but also artefacts (Hakkarainen et al., 2004B). For instance, when teachers are searching for answers to problems they may not consult only their colleagues, but also different sources of information and when they are consulting colleagues, they do not always communicate face-to-face, but use alternative media. For finding out in what kind of networks the central actors are involved in, the teachers wrote in the SNA questionnaire also what media they used in their relations (as described earlier). They also

answered an open question on what other information sources they consulted beside their colleagues.

Schools' networks do not only include the relationships and communication inside a school community. As schools try to be interconnected over school boundaries, we found it also meaningful to explore teachers' relations which cross the school community borders. In addition to reporting intra-school connections, the teachers reported their inter-school relations in the questionnaire, and again, which media they used in these relations. It is good to notice here, that the respondents didn't report how often they use each medium they mentioned, so the frequency of media is not analysed in this study in detail.

### **Interviews of the central actors**

In the second phase of collecting data, the central actors chosen by SNA were interviewed. The interview was carried out on the hypothesis that the qualities and working practices of central actors may reveal essential aspects about learning and developing web-based learning in the teacher community. The semi-structured, in-depth interviews focused on teachers' genuine experiences and the meanings they gave to their actions. (Fontana & Frey, 2000.) The open-ended questions included elements concerning teachers' background, networks, working practices, and use of different mediating artefacts or information tools. Special attention was paid to the questions associated with the content of knowledge exchanged and the factors, which according to teachers' experiences, promote and challenge web-based learning in the community.

### **Phenomenographical approach in analysing central actors' descriptions**

This study aims to understand the meaning of intelligent action in the teacher community and teachers' networks; this is why also the qualitative methods were needed in analysis. The central actors' answers to the three open-ended interview questions were chosen for deeper content analysis by implementing phenomenographical approach (Marton, 1988). These essential questions were

1) What kind of challenges are there in sharing knowledge of web-based learning in a teacher community?, 2) Has your working community had an effect on the development of your skills of web-based learning?, and 3) Are there some specific factors in your working community which support and enhance the professional development of teachers in general? The analysis unit consists of the following: each of the central actors answered to the same question and these

answers were put into one or several of the categories of descriptions. The researcher defined and labelled the categories of descriptions on the basis of the qualitatively different ways how teachers' expressed and described different factors and challenges in their answers. When categorizing the answers, the different aspects of expressions were identified and grouped on the basis of similarities, differences and complementarities. In other words, the categories of description are characterised and presented for the grouped conceptions.

Marton, Dall' Alba and Beaty (1993, 282-283) found that expressions often represent different fragments of the same conception. In addition, the conception refers to actual experiences, understandings and conceptualizations that people have of phenomena. Categories of description are abstract tools used to characterise these conceptions. In order to see expressions as representing different fragments of the same whole, the researcher has to have an idea what the whole is like. To be able to decide whether or not two expressions reflect the same conception, a researcher must also have an idea of what the conception is. The conception is abstracted from the expressions that are considered to reflect it. The categories of description, which emerged from the data of this study, are abstractions, which are interpreted to be meaningful in understanding the process of developing web-based learning and teachers' professional development within the community.

The phenomenographic approach was found to be purposeful in this study, because it supported finding out teachers' genuine experiences and the personal meanings they gave to them. This method offered teachers also the possibility to emphasise those aspects they found most important.

When assessing research, one has to pay special attention to the relationship the researcher has to the research object as well as to the research context. In this study, the researcher was involved with the research process by defining study context, methods and interpreting the results and this means that researchers' presumptions and concrete actions have had an effect on the research process. However, for the phenomenographic approach it is typical that the research is strongly related to the researcher's presumptions and interpretations. According to Laine (2001) the researcher's awareness of his/her presumptions supports him/her to assess their impacts on interpretation. In this research process, the researcher has discussed her presumptions with the teachers participating in the study and with the theoretical and methodological guides of this article. On this basis the categories of descriptions that emerged from the data, have been analysed several times critically taking into account the researchers' impact on the process.

## 5. Results

### **Central actors related to web-based learning were found by social network analysis**

When analysing results of the question 3 ("With whom do you carry out collaboration on web-based learning?") Freeman's degree-function revealed eight (8) teachers, who's in- and outdegree values were above the average of the community (Table 1). Seven (7) of them with the highest values were chosen to more in-depth interviews: Teachers 24, 21, 7, 18, 29, 19 and 12. The interviews were ended in seven cases, because it was noticed that the new teachers' descriptions didn't bring any new information. According to Eisenhardt (1989) the ideal number of cases in research cannot be defined in advance, and acquisition of the cases can be finished when theoretical saturation is reached. However, Teacher 28 had exceptionally high indegree value in this question, which means that her colleagues seemed to consider her as a meaningful partner in web-based learning collaboration. She was included in the central actors of the community and interviewed as well. The actors, who acquired the highest in- and outdegree values in question 3, were interpreted to be in the centre of the communication structure of the community related to web-based learning. They collaborated most actively on web-based learning in their community and were considered to play an important intermediary role among their colleagues.

**Table 1. The centrality of the members of the teacher community (individual teachers) related to the question of collaboration on web-based learning. Teachers, who were chosen to interviews, are in bold. (The numbers refer to teachers' names in alphabetical order.)**

Teachers	Freeman's Degree (Outdegree)	Freeman's Degree (Outdegree)
Teacher 1	0	1
Teacher 2	1	1
Teacher 3	3	1
Teacher 4	0	3
Teacher 5	2	4
<b>Principal 6</b>	4	2
<b>Teacher 7</b>	9	3
Teacher 8	0	0
Teacher 9	1	1
Teacher 10	0	0
Teacher 11	3	2
<b>Teacher 12</b>	3	6
Teacher 13	0	5
Teacher 14	1	3
Teacher 15	0	1
Teacher 16	2	0
Teacher 17	5	2
<b>Teacher 18</b>	6	4
<b>Teacher 19</b>	5	3
Teacher 20	3	4
<b>Teacher 21</b>	10	6
Teacher 22	0	2
Teacher 23	0	1
<b>Teacher 24</b>	11	10
Teacher 25	2	2
Teacher 26	3	0
Teacher 27	1	2
<b>Teacher 28</b>	1	11
<b>Teacher 29</b>	6	3
School assistant 30	3	0
School assistant 31	0	2
School secretary 32	2	0
Teacher 33	0	0

The results of question 3 ("With whom do you carry out collaboration on web-based learning?") were compared to question 4 ("From whom do you receive new knowledge or ideas of web-based learning?") in the process of searching the central actors of the community. The results revealed that the all seven teachers, who collaborated most, had also above average outdegree values in question 4 (Table 2). This result strengthens the perception, that these teachers had also mediative role related to the knowledge of web-based learning in their community. They were not only collaborating with their colleagues but also seeking new information from them. In line with this interpretation, also teachers' interviews revealed that these teachers were interested in developing themselves in the web-based learning. Specific attention must be paid to the two teachers. Teacher 24 had the highest in- and outdegree values in collaboration of web-based learning (question 3) and the remarkably high indegree value in acquiring new knowledge or ideas of web-based learning (question 4). The other high indegree value in question 4 belongs to Teacher 28, who also received high indegree value in question 3. These teachers are significant sources of new knowledge and ideas related to web-based learning for their colleagues.

### **The principal was one of the central actors**

Also, the values of the school's principal (number 6 in Tables 1 and 2, the numbers refer to the alphabetical order) were analysed. In question 3 ("With whom do you carry out collaboration on web-based learning?") his outdegree value was above the average of the community: he experienced that he is actively collaborating with the members of the community in web-based learning. The indegree value was, instead, under the average of the community. This means that other members in the community didn't consider him as a concrete partner in web-based learning collaboration. In question 4, acquiring new knowledge or ideas on web-based learning, the principal had, again, both in- and outdegree values that were above average. The interviews revealed that teachers perceived the collaboration of web-based learning as concrete, joint practices, but the principal understood idea exchanging and future planning as also being concrete collaboration. This difference in perspectives may explain the contradiction in principal's values in questions 3 and 4.

**Table 2. The centrality of the members of the teacher community (individual teachers) related to the question of receiving new knowledge or ideas of web-based learning.**

Teachers	Freeman's Degree (Outdegree)	Freeman's Degree (Outdegree)
Teacher 1	0	0
Teacher 2	1	0
Teacher 3	5	2
Teacher 4	0	4
Teacher 5	0	9
Principal 6	5	8
Teacher 7	9	1
Teacher 8	1	0
Teacher 9	3	0
Teacher 10	3	3
Teacher 11	3	5
Teacher 12	8	3
Teacher 13	0	6
Teacher 14	0	4
Teacher 15	1	1
Teacher 16	2	1
Teacher 17	4	2
Teacher 18	7	2
Teacher 19	9	3
Teacher 20	1	3
Teacher 21	5	6
Teacher 22	3	2
Teacher 23	3	2
Teacher 24	4	16
Teacher 25	9	2
Teacher 26	5	0
Teacher 27	1	0
Teacher 28	3	15
Teacher 29	7	2
School assistant 30	2	0
31 School assistant	1	1
School secretary 32	0	0
Teacher 33	0	2

### **Central actors bridged different expert fields of teaching in their community**

The nine (9) central actors represented different subject domains and expert fields of teaching. They participated in a variety of different teams, e.g., Curriculum Development Team, Immigrant Teaching Team, Information and communication technology (ICT) team, Special Educational Needs Team and Language Teaching Team. Central actors' serving years varied from 1,5 to 24 years: they represented also different time periods of working experience in their community. Three of the central actors had participated in in-service training program of web-based learning, which was organised by the local educational authorities (This training was described in chapter 2, "Context of the study"). Teachers 24 and 28 had specific roles in ICT team, which explains their exceptional centrality values: they both acted as peer support for their colleagues besides their regular teaching work. Peer support was originally local educational authorities' initiative and agreed yearly between teachers and the principal. These teachers' high centrality values (see in Table 1 and 2) reveal that peer support is an effective way to strengthen the use of information and communication technology among teachers.

The interviews revealed that all eight teacher central actors implemented actively web-based learning in their teaching. They carried out blended courses, which means that their teaching included both face-to-face occasions and studying supported by web-based learning environment. None of them implemented virtual teaching only. The functions of the web-based learning environment they used most actively were the discussion forum, personal and group portfolios, e-mail embedded in learning environment and the learning tasks and materials in different subjects. The central actors collaborated with their colleagues in planning and sharing lessons, teaching and by participating in joint afternoon training and idea exchange occasions. In addition, the collaboration (for instance course planning) took also spontaneously place in their informal meetings.

The eight teacher central actors were transferring general knowledge of web-based learning to their own field of expertise. For instance, they planned peer and teacher guided learning discussions for students with lingual disorders with the purpose of encouraging them to be more active in expressing themselves, created specific groups for immigrant and other students for fostering the positive cultural change and or planned working life-oriented contents to the group

portfolios of supplementary class students. They also presented their projects and ideas to other teachers in formal staff meetings or in specific afternoon workshops. In this way they also brought their own domain of expertise to the knowledge of their community. Five (5) teachers had even demonstrated their projects from web-based learning environment to others. However, only four (4) of them wrote reports or memos of their pedagogical innovations or trials for the use of colleagues.

### **Central actors had collaborative links over community borders**

Four of the central actors (4/9) told that they carry out concrete collaboration on web-based learning with their contacts outside of school. These four teachers had each about 1-4 contacts. Half of these contacts were teachers from other schools and other half teacher trainers from different in-service organizations. Teachers detailed that they collaborated mainly in face-to-face but also by using different media, for instance, e-mail and the web-based learning environment they were implementing in their teaching.

All central actors (9 / 9) reported that their cross-school collegial relations they benefit when acquiring new knowledge or ideas of web-based learning.

There were 1-5 collegial contacts per central actor in the knowledge acquiring pursuit. Every central actor (9) had at least one important colleague outside of the school, from which he/ she received knowledge. In addition to colleagues, new knowledge or ideas were acquired also from trainers of different teacher in-service training organizations (5 mentions), coordinators from inter-school development projects (3 mentions) and from family members (2 mentions).

### **Central actors used several media and artefacts in their networks**

When searching for new knowledge or ideas from their contacts *outside school* all nine central actors preferred face-to-face contacts (9 mentions) and six (6) of them used also telephone and e-mail. In addition, three (3) of them used the web-based learning environment and two (2) central actors used websites. When acquiring new knowledge or ideas from colleagues *inside school*, the central actors preferred face-to-face-occasions (9 mentions) again. Further, three (3) central actors also used e-mail, web sites, web-based learning environment and telephone. When carrying out collaboration of web-based learning *inside the school* the learning environment was in more active use: six (6) central actors reported that they use it as a medium in collegial collaboration. The central actors detailed, that they use it in collaborative lesson planning, idea

sharing and lesson demonstrations for other teachers. However, the most general way to collaborate related to web-based learning inside the community were face-to-face occasions, all nine (9) central actors reported this choice. The central actors used also e-mail (4), web sites (3) and telephone (4) when collaborating with their inter-school colleagues. None of the central actors suggested other media for this purpose.

It is good to remember, that the results don't reveal how often teachers used the media they mentioned. Teachers and the principal, anyhow, experienced these media meaningful in their relations, and the results offer general overview on networks of teachers, which doesn't seem to consist of only people but also mediative tools. The central actors were also asked what other information sources they use when acquiring new knowledge or ideas related to web-based learning in general. The most popular source of information was the Internet (8 mentions). Seven (7) actors also used professional magazines and newspapers and seven (7) actors read books on the subject. In addition, seven (7) central actors considered different teacher in-service training organizations as sources of information. Four (4) central actors reported that they received new knowledge or ideas from television, one teacher mentioned also videos, one the library and one a teachers' trade union as information sources.

### **Central actors mediated pedagogical and technical knowledge in their networks**

The central actors were asked in interviews, what kind of advice their colleagues ask them most often and, in turn, what they ask from their colleagues about web-based learning? Four (4) of them reported that colleagues ask mainly pedagogical support, for instance:

*“One asked me, could I help him to implement this web-based project with a pupil with lingual disorders.”* Teacher 7

Four (4) central actors described that their colleagues usually ask the practical user for web-based learning environment support. One teacher reported that she's supporting her colleagues in information search and another teacher told that she's giving general advice in the use of office programs.

When turning to their colleagues, five (5) central actors reported that they are looking for new pedagogical ideas and tips to their teaching, for instance:

*“I ask for advice on how they motivate their pupils in web-based learning projects. And in general, if I have failed in something, I ask how others have succeeded.”* Teacher 28

They also asked for user support for the web-based learning environment (2 teachers), support for technical problems (2 teachers) and ideas for the practical use of new devices and equipment from their peers (2 teachers). In their inquiries, the central actors seemed to have meta-knowledge about who knows what in their community. For instance, they mentioned same persons they turn to with technical worries. In their pedagogical advice, they were bridging different fields of teaching and translating knowledge of web-based learning to their colleagues' subject domains. For instance, they supported other teachers to innovate and benefit from web-based collaborative writing in language teaching, or, how to organize students' evaluation by personal or group portfolios.

### **The community can support learning of web-based learning in multiple ways**

The phenomenographical (Marton, 1988) analysis of the central actors' answers to the question “Has your working community had an effect on the development of your skills in web-based learning?” revealed five different categories of descriptions. The categories are: 1) Learning from advanced colleagues, 2) Learning from colleagues' inquiries, 3) Learning from everyday working practices, 4) Safe and supportive atmosphere empowers learning and 5) Commitment on the community-level supports learning.

It is relevant to emphasise here, that the categories of descriptions are not hierarchical in regard to the quantity or quality of teachers' expressions. For instance, every category involves several expressions of teachers but none of the categories contains an exceptional amount of expressions compared with others. In the following section the contents of the categories are explained briefly and one example of teachers' expressions from each category is presented.

The central actors described, how useful it is to ask for guidance from a colleague, who's advanced in her / his subject (*“knows more than me”*), and on the other hand, how the questions of other colleagues support them to search for answers. They also said that the use of the web-based learning environment is more and more embedded in the daily working practices of the school community, so that it's even “difficult to avoid learning” new things regarding web-based learning at school. The central actors underlined that the safe working atmosphere encourages them to share their knowledge gaps and ask advice from colleagues without being embarrassed.

They made it also very clear, that the community-level commitment fosters development of web-based learning. For instance, the school's web-based learning environment project was agreed to be part of the teachers' annual working plan and in the school curriculum.

Category 1, “Learning from advanced colleagues”, reveals that the expertise of colleagues is important for teachers. They find it meaningful for their personal development and respect it openly. Teachers also seemed to have knowledge of who has experience and knowledge in certain subjects in their community. This refers possibly to the transactive memory (Wegner, 1986) of the community and it seems that individual teachers make benefit of it in their professional development. Transactive memory is a shared system for encoding, storing and retrieving information; knowledge of one another's memory areas, who knows what in other words. Here is one example from this category, “Learning from advanced colleagues”:

*“If we didn't have people here who know about it [web-based learning], I probably wouldn't have learnt about it.”* Teacher 12

The central actors also answered the question “Are there some specific factors in your working community which support and enhance the professional development of teachers in general?” In addition to the categories reported above, the following new categories emerged: 1) Encouragement to participate in in-service training, 2) Flexibility in planning work, 3) Demanding pupils, 4) Supportive principal, 5) Shared lessons, 6) Training occasions at school and 7) Professional teachers.

The central actors told that teachers are personally encouraged to participate in in-service training in their school. The teachers had also possibility to plan their work quite flexibly. They, for instance, could use the time for staff meetings to study web-based learning, plan new courses and share experiences with colleagues. Teachers emphasised that these quite simple practices were very meaningful for them and made it concretely possible to develop themselves professionally in their working context. All the central actors who were teachers stressed the importance of a supportive principal for their professional development. They described, that a supportive principal is personally interested in teachers' work and its' development. Also, pupils were mentioned several times as generators for professional development. Teachers told that they need multiple professional skills in supporting, for instance, immigrant pupils or pupils with special educational learning needs. Pupils inspire them to learn and try new strategies in teaching. Also the principal emphasised this factor.

Central actors considered shared lessons important for their professional development. This means lessons, which are planned and guided by, at least, two teachers in collaboration. Further, the central actors preferred the training occasions at school instead of outside-school training. They expressed, that it is more efficient to learn from peers in every-day working environment and with their every-day technology than visit simulation classrooms in training organizations. They also highlighted the meaning of professionalism among teachers in general. Educated teachers, who are experts in their subject domains and in pedagogical use of information and communication technology, share relevant knowledge with others too.

The category 1, "Encouragement to participate in in-service training", shows that personal guidance plays a crucial role for teachers' professional development in a teacher community. Teachers told that the principal didn't only inform teachers about the available training occasions, but personally suggested individual teachers or teacher teams to certain courses. Teachers felt that their principal was positively interested in their professional competence, and its development, and this feeling was encouraging and motivating them. Here is one example from the category 1, "Encouragement to participate in in-service training":

*"I have found it really positive, that teachers' willingness to develop themselves is supported here. The training occasions are even actively introduced and personally proposed to you here."*

Teacher 21

### **Knowledge sharing demands structure, safety and transactive memory**

The analysis of teachers' descriptions on the challenges related to the knowledge sharing of web-based learning in their community revealed six categories of description: 1) Mutual interest in dialogue relations, 2) Transactive memory, 3) Need for time, facilities and structure, 4) Need for community-based peer support, 5) Emotionally supportive and empowering atmosphere and 6) Use of web-based learning environment in a pedagogically meaningful way.

Teachers emphasised the importance of mutual interest and respect in reciprocal relationships between colleagues when introducing new pedagogical practices of web-based learning. They described how important it is also to have knowledge who in the teacher community knows what, to whom to turn with questions. If there are a lot of personnel changes, or many substitute teachers in charge, this knowledge doesn't appear so easily. These descriptions refer, again, to Wegner's (1986) transactive memory, which means, that people in social communities

spontaneously develop accurate meta-knowledge concerning distribution of knowledge and competencies. The central actors reported also that for successful collaboration, there should be special time, structures and facilities offered in school. In the middle of every day teaching hurries it is difficult to concentrate on meaningful knowledge sharing with colleagues. Teachers wished to have, for instance, more shared lessons and regular afternoon workshops.

The central actors found it important that knowledge sharing happens at school and in close relation to their every day work. They found peer support better than traditional teacher training, where a teacher or a group of teachers participate in training outside school. Also, the emotionally supportive atmosphere was found to be very meaningful for knowledge sharing. It is important to feel that one is accepted in the community. These descriptions were in line with Mahn and John-Steiner's (2002) idea of emotional Zone of Proximal Development that allows one to work at the edge of his or her competence without being afraid of unavoidable failures and mistakes. The central actors underlined that development of better pedagogical practices in general, encouraged teachers to share knowledge; to tell about their trials, challenges and successes to colleagues. And open knowledge sharing, in turn, supported and inspired teachers to develop further their pedagogical practices.

The category 5, "Emotionally supportive and empowering atmosphere", refers also to Ruohotie's (1996) idea of emotional security in organizations and to the Engeström's (1999) suggestion that if the inevitable conflicts are debated openly they progress to creating new forms of knowledge and practice. Teachers detailed that the emotionally supportive and empowering atmosphere allowed them to talk about new challenges and difficulties and this was seen as a valuable asset for the community to maintain. Teachers reflected that it is important to feel accepted among their colleagues although one doesn't know something, but also in the case that one knows more than others. This feeling of acceptance encourages teachers to positively seek the opportunities for professional development. Here is one example of the Category 5, "Emotionally supportive and empowering atmosphere":

*"This open atmosphere, that people are ready to share their knowledge. That no one is hiding...the opportunity for collaboration is always there."* Teacher 18

## 6. Conclusions and discussion

In this section, a summary of the research results is made and then some new perspectives for designing more innovative teacher in-service training of web-based learning in future are offered.

The results of the research revealed, that there were nine (9) central actors, eight teachers and the principal in the community, who carried out collaboration and shared knowledge of web-based learning more than their colleagues on average. The central actors had internal and external relations in the community, for instance, collaborative colleagues in- and outside of the school, and their networks involved people, artefacts and variety of mediative tools. They shared knowledge of web-based learning not only in face-to-face occasions but also, for instance, by phone, e-mail and web-based learning environment. Further, they acquired new knowledge or ideas about web-based learning besides from people also from different sources of information, such as the Internet, books and magazines.

The central actors shared both pedagogical and technical knowledge of web-based learning, often very practical advice and tips for teaching practices and use of web-based learning environment. They seemed to have meta-knowledge about the locus and availability of community members' knowledge capital: they knew "who knows what" and they made benefit from that knowledge in their professional development. This research result might indicate, that there was *transactive memory* (Wegner, 1986) developed within the community. The transactive memory is developed by experience and in a long time period within working communities and it means knowledge of one another's memory areas. It is not traceable to any one of individual, nor can it be found between individuals: it is a property of the group.

The central actors bridged different expert fields of teaching in the community, for instance, they made innovative use of web-based learning in different subjects and learning tasks. They also translated knowledge from one field of expertise to others, for instance by bringing new ideas on web-based learning to immigrant teaching and by further developing the practices of web-based learning to the needs of special educational pupils. This finding is in line with research results of Robinson, Anning and Frost (2005), who revealed, that teachers in multi-agency teams brokered connections, introduced practices, and passed knowledge related to work across boundaries. Barabasi (2003) calls these linking agents in networks "information hubs", which bridge different small-worlds, which can be groups, teams, or even whole organizations. The central

actors can be also called as “gatekeepers” (Gould & Fernandez, 1989), because they have connections to outside parties, and they may control information flow to their own groups.

According to the central actors' experiences the important factors that support teachers' professional development related to web-based learning in the community are; the possibility to learn from colleagues and from everyday working practices, an emotionally safe atmosphere, leader's personal support and community-level commitment. The research result of safe atmosphere and leader's personal support are in line with Ruohotie's (1996) findings that supportive culture and participative management are important factors in organizational learning. When organizational culture offers security and safety to workers, they can work also in their *emotional* zone of proximal development (Vygotsky, 1962; 1978), at the edge of their competence without being afraid of unavoidable failures and mistakes (Mahn & John-Stainer, 2002). Also Thompson, Gregg and Niska (2004) have revealed that trust among community members is vitally important in the professional development.

Also, the flexibility in work planning, challenging pupils, shared lessons with colleagues, training occasions in an authentic working environment and colleagues' professionalism are considered meaningful for professional development. As challenges, the knowledge sharing of web-based learning in the community needs mutual interests, transactive memory, time and facilities, peer support, safe atmosphere and meaningful pedagogical practices. Also Ruohotie (1999; Ruohotie & Nokelainen, 2000) remind that learning takes place only when an individual gives a meaning to her/his experiences.

In this study, the size of the present teacher community (N=33) may be a limitation; it was chosen to be manageable. It is difficult to judge the effects in the present case, but it is possible that some of the teachers' descriptions would appear differently for a larger sample and in different teacher communities.

However, from the basis of study findings it is suggested, that by intensive collaboration related to web-based learning it is possible to break the boundaries of individual teachership and create such sociocultural activities, which support collaborative professional development in the teacher community. Teachers' in-service training programs should be more sensitive to the culture of teacher communities and teachers' reciprocal relations. Further, teacher trainers should design teachers' in-service training of web-based learning in co-evolution with supporting networks including not only people, but also the media and artefacts.

The challenge of developing web-based learning in a school community is often geared to the problem of embedding new innovations to every day practices of the school. In this study, the central actors were, already in the second year of the piloting project, implementing actively web-based learning in their teaching, but how about the other teachers in the community? It is important to notice, that all teachers in the community had received the same training and had same possibilities to apply web-based learning in their teaching as the central actors. Will the new pedagogical practices of web-based learning be disseminated on a wider scale in the community later? How could the networks of collaboration and knowledge sharing of the central actors be expanded to involve the whole teacher community?

It would be interesting in future to research what it is that has made central actors the central informants in their communities? For instance, what are the personal triggers, prerequisites or attributes which explain that these teachers are best placed to take advantage of development of web-based learning? If development activities concentrate only on a few actors in a community, what may later follow is that tasks within a community are divided unequally, so that challenging development projects are directed to the same actors, who already have received in-service training and whose knowledge and skills are constantly cumulating compared with less active colleagues. In the field of education, this leads to problems in pupils' democracy. All pupils should have equal rights to enjoy such teaching, which benefits from modern, technology-supported and high-qualitative pedagogical practices. It is not a privilege of those pupils only who are lucky enough to get an interested, development-oriented "central actor" teacher.

There is a need for such genuine collaborative culture of different agencies, where the knowledge of networking, adult education and new technologies are united with political and administrative will. The realization that teachers can very concretely contribute to each other's professional development in their daily circumstances could be better used in the teaching training programs. Today, schools are already acting, more or less consciously, in networks, which consist of not only people, but mediating tools, different information sources and interactive media. How this networked intelligence and widened pedagogical communities could be better utilized when planning educational interventions with teachers?

In future research, it would be interesting to study collaborative knowledge creation in pedagogical communities in more detail, for instance the different groups and their coherences, the reciprocity of knowledge change and the gaps and blocks in knowledge flow. Also the leadership of modern, networked pedagogical communities should be examined deeper. In

addition, it is always interesting to hear teachers' voices in the processes of educational change: what are the meanings that they give to new technologies in teaching and learning? Do these meanings change in time? In near future, a variety of new media and technological tools will be innovated and offered for teachers' professional development. For instance, immersion of television, Internet and mobile opens new possibilities for networking and widening the learning communities. This continuous development challenges teacher trainers to constantly redefine and redesign the innovative and meaningful teacher in-service training.

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## QUESTIONNAIRE

Name: \_\_\_\_\_

How many years you have been working in this school: \_\_\_\_

**In the Table A you find the names of your colleagues. Read the names and mark tick to the columns 1-5 to the following persons:**

1. from whom you ask help, guidance or advices related to *technical questions* of information and communication technology?
2. from whom you ask help, guidance or advices related to *pedagogical questions* of information and communication technology?
3. with whom you *collaborate on web-based learning*?
4. from whom you *receive new knowledge or ideas* about web-based learning?
5. with whom you interact *informally*?

**In each column (in each relation), specify what media you use in advice seeking or collaboration in the following six categories:**

1) e-mail, 2) Internet: web sites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else, what?.

**If you use several media, mark all numbers needed.**

**Think your relations and media use in last 6 months!**

**TABLE A: Networks in the school**

In each column (in each relation), specify what media you use in advice seeking or collaboration in the following six categories:  
 1) e-mail, 2) Internet: web sites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else, what?.  
 If you use several media, mark all numbers needed.

COLUMNS	1		2		3		4		5	
	I ask help, guidance or advices related to <i>technical questions</i> of information and communication technology		I ask help, guidance or advices related to <i>pedagogical questions</i> of information and communication technology		I <i>collaborate on web-based learning</i>		I <i>receive new knowledge or ideas</i> about web-based learning		I interact <i>informally</i>	
Examples:	(X)	Media	(X)	Media	(X)	Media	(X)	Media	(X)	Media
1. Maija Miles	x	1, 4					x	5	x	1,4,5
2. Lauri Mäki			x	1,4, 5	x	3,5				
3. xx										
4. xx										
33.										

**TABLE B: External networks**

To the Table B you can fill in your external relations (persons outside of the school community) from whom you receive advices related to information and communication technology. Please fill in also the employer of your contact.

In each column (in each relation), specify what media you use in advice seeking or collaboration in the following six categories:  
 1) e-mail, 2) Internet: web sites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else, what?.  
 If you use several media, mark all numbers needed.

COLUMNS	1		2		3		4		5	
Persons outside of the school community	I ask help, guidance or advices related to <i>technical questions</i> of information and communication technology		I ask help, guidance or advices related to <i>pedagogical questions</i> of information and communication technology		I <i>collaborate on web-based learning</i>		I <i>receive new knowledge or ideas</i> about web-based learning		I interact <i>informally (related to my work)</i>	
	(X)	Media	(X)	Media	(X)	Media	(X)	Media	(X)	Media
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										
9.										

**TABLE C: Other information sources**

To the Table C you can fill in other information sources (e.g., organizations, web sites, literature, magazines, books, TV, DVD etc.) from which you acquire information related to information and communication technology.

**Mark tick to the columns 1-3 to the following information sources:**

1. wherefrom you acquire information related to *technical questions* of information and communication technology?
2. wherefrom you acquire information related to *pedagogical questions* of information and communication technology?
3. wherefrom you acquire *new knowledge or ideas about web-based learning*?

<b>COLUMNS</b>	<b>1</b>	<b>2</b>	<b>4</b>
Other information sources	I acquire information related to technical questions of information and communication technology	I acquire information related to pedagogical questions of information and communication technology	I acquire new knowledge or ideas about web-based learning
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Networking relations of using ICT within a teacher community

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*Contributions by authors:*

*Essi Ryymin has collected and analysed the data, interpreted the results and written the manuscript. Dr. Tuire Palonen and Dr. Kai Hakkarainen have provided theoretical and methodological guidance during the research process.*

**Abstract**

The purpose of the present study was to examine the network structure of a teacher community in relation to their use of Information and Communication Technology (ICT). The participants in the study were the 33 members of the teacher community of an upper comprehensive school from a suburban area of Helsinki, Finland. The methodology of the study was Social Network Analysis. The participants were asked to assess their networking relations according to the following five dimensions: 1) providing technical advice regarding ICT, 2) providing pedagogical advice for using ICT, 3) collaboration regarding web-based learning, 4) acquiring new knowledge or ideas of web-based learning, and 5) informal interaction between the members of the community. The results indicated that there were a few central actors in the community who dominated technical and pedagogical knowledge exchange and to whom their colleagues actively turned when seeking advice. Two of the cognitively central actors represented hybrid expertise, a characteristic of which was to merge technological and pedagogical expertise in using ICT in education. These actors also tended to have their own external networking relations that helped them keep up their high level of competence. The participants' ICT-related egocentric networks differed in size and density. There were some actors central in the network of informal interaction that were, simultaneously, peripheral in ICT-related networking activities. On the other hand, the central actors of ICT were not necessarily the socially central persons in the community. Four patterns of networking were identified in the analysis; The Counsellor offers advice actively without seeking information herself from colleagues; The Inquirer is an active seeker of ICT-related information capitalizing on her social relations; The Collaborator engages in collaborative efforts of web-based learning by using several media; and The Weakly Social prefers media rather than face-to-face contacts in his information seeking.

**Keywords:** teacher community, information and communication technologies, network structure, networking relations, social network analysis, media use in networks

## 1. Introduction

The purpose of the present article is to examine the network structure and exchange of knowledge concerning information and communication technology (ICT) in a teacher community. The study focused on studying how intensively the members of a teacher community participate in sharing knowledge of the use of ICT. This was examined by assessing with the means of Social Network Analysis their knowledge exchange across five networking dimensions: 1) providing technical advice regarding ICT, 2) providing pedagogical advice on ICT use, 3) collaboration regarding web-based learning, 4) acquiring new knowledge or ideas of web-based learning, 5) engaging in informal interaction between participants of a teacher community. The research aims at identifying cognitively central actors regarding ICT-related knowledge sharing in a teacher community. Further, the study examines what kinds of actors of knowledge exchange there are in the chosen community, and what kind of media actors utilize in their process of knowledge sharing.

Previous research has revealed that an important factor in establishing and scaling up technology-supported pedagogical innovations is creating stronger teacher communities and enhancing teacher networks and collaboration (Granger, Morbey, Lothington, Owston & Wideman, 2002; Lehtinen, Sinko, & Hakkarainen, 2001; Triggs & John). There have been numerous projects carried out in many countries that introduce pupils and teachers to new learning technologies and new pedagogical models, such as inquiry learning (Lehtinen, Hakkarainen, Lipponen, Rahikainen & Muukkonen, 1999). Some of the projects manage to reform pedagogical practices in schools, but many of them fail. According to Slegers, Van Den Berg and Gejsel (2000), most system-level school reforms have led to unsatisfactory outcomes, because the innovations have not been sufficiently sensitive to the problems arising from the school context and organizational culture. Therefore, the main strategy in pedagogical development projects in schools should be building the pedagogical community, so that it better connects the various cultures of expertise to support learning and teachers' professional development (Hakkarainen & Järvelä, 1999; Hargreaves, 1999; Bransford, Brown & Cooking, 1999).

The school culture and teacher's collective practices play crucial roles in developing technology-enhanced learning and instruction because ICT facilitates meaningful learning and teaching only through transformed social practices (Hakkarainen et al., 2001). In order to incorporate ICT with their teaching practices, teachers need to change their everyday practices of working with knowledge. Yet, transforming social practices is difficult for all professionals (Roth, 2002). According to some studies, it takes several years of effort before teachers start using ICT intensively in preparing and conducting their teaching activities (Hakkarainen et al., 2001; Feldman, Konold, Coulter & Conroy, 1999). In the transformation with ICT teachers' work appears to be becoming more and more knowledge intensive in nature. As a consequence, teachers have to engage in efforts of keeping knowledge, expertise, and competence up-to-date throughout their life. Further, the objects of teachers' activity appear to be expanding, for instance, in developing the *information strategy of the school* that mediates collective rather than individual activity (Engeström, 1999). Shared projects and school-level developmental activities take up much more of the participants' working time and intellectual resources than was the case during "traditional teaching" in earlier decades.

From the multi-professional nature of teacher communities follows that *horizontal* learning between the participants, as distinguished from vertical advancement of one's own expertise, becomes extremely important (Engeström, 1999). Triggs and John (2004) studied the development and dissemination of professional knowledge as it relates to teaching with ICT. They demonstrated that the knowledge flows among participants actively engaged in developmental efforts and projects. Working within a collaborative community is likely to provide overlapping zones of proximal development (Vygotsky, 1962) that facilitate professional development. Teachers taking active part in using ICT are likely to belong to networks-of-practice (Brown & Duguid, 1999) that connect practitioners across the boundaries of their schools.

Implementing collaborative technologies in practices of learning and instruction is likely to require various types of expertise from a teacher in terms of bridging the subject domain and pedagogical knowledge with that of using ICT. Professionals who represent *hybrid expertise* (Howells, 1999; Hakkarainen, Palonen, Paavola & Lehtinen, 2004) integrate working practices and tools that are able to cross the boundaries of domains of professional competence. Such integration develops when

individuals in intensive interplay cross boundaries of between expert communities. These actors may function as the “glue” that binds together a heterogeneous community and helps to capitalize on available, diverse, intellectual resources.

Strong and weak networking links can be distinguished from one another. Links between participants who engage in intensive interaction or mutual collaboration are typically strong (Hakkarainen et al., 2004). These kinds of links tend to occur among small groups of actors where everyone knows what the others know. Consequently; the participants are likely to understand each other from hearing half a sentence. Strong links are essential in transmitting complex knowledge and competences, such as information regarding educational use of ICT, which may require sustained interaction before becoming absorbed. Strong links allow sharing of expertise within a community but do not always provide new information for the most experienced participants. In contrast, weak links support knowledge exchange by transmitting information to and from the organization. Weak links that reach beyond boundaries of the organization assist in searching for new information. Yet, many studies that rely on social network analysis have reported that weak ties do not provide the same kind of socio-emotional support or trust needed for solving complex professional problems as the strong ties (e.g., Haythornthwaite, 2005).

The autonomy of teaching has traditionally meant that a highly motivated and self-regulated teacher can find ways to implement novel instructional methods and practices. In the absence of such exceptional determination and self-control, it is much more likely that the individual will quickly lapse into familiar patterns (Ruohotie, 1999). If development activities in a school are focused on the highly-motivated teachers only, it may lead to the situation where vital knowledge, practices, and competences regarding novel ICT-enriched pedagogy is, accordingly, concentrated in a small number of active participants. According to Palonen, Hakkarainen, Talvitie and Lehtinen (2004), the highly centralized communication structure is familiar to many workplaces functioning within a field undergoing rapid change. While routine tasks can be handled by most of the professionals, the newest techniques and know-how are in the hands of only a few workers. In school, this kind of centralization may lead, ultimately, to serious problems in pupils’ rights to receive equal opportunities for learning. According to Haythornthwaite (1996), improving awareness of existing patterns of exchanging knowledge is likely to assist communities in bridging gaps of knowledge flow, initiating novel collaborative efforts

for increasing the coherence of the community, and re-directing efforts knowledge sharing.

One goal of this study was to examine what kind of media and other information sources teachers utilize in their networks of knowledge exchange. Haythornthwaite, Wellman and Mantei (1995) have studied the alternative means of communication in working relationships. Their research revealed that most communication was done by relying on a combination of media, but predominately through unscheduled encounters, electronic mail, and informal meetings. These investigators concluded that it is essential to consider norms and practices of work groups as well as networking relations when analysing media use. Haythornthwaite (2005) also studied the impact of communication media among members of an academic research group; the findings indicated that members who were more strongly tied used more media to communicate with each other than weakly tied members.

Wellman, Salaff, Dimitrova, Garton, Gulia and Haythornthwaite (1996) have presented the concepts of *computer-mediated communication* and *computer-supported social networks* in their studies of the interactive relationships in work, use of collaborative technologies and various media. When computer networks link people as well as machines, they become social networks. The nature of the medium both constrains and facilitates social control. Information is only one of many social resources exchanged on-line. Despite the limited social presence of computer-mediated communication, people find social support, companionship, and a sense of belonging through the course of computer-supported social networks (Wellman & al., 1996). Teachers have reported that the benefits of on-line networking are sharing knowledge, expressing and receiving collegial and emotional support, an opportunity to air frustration and to learn new things (Lieberman & Grolnick, 1996; Neil & Morgan, 2003; Selwyn, 2000). Wellman et al. (1996) revealed that many on-line ties among workers do meet most of the criteria of so-called strong ties: they facilitate frequent, reciprocal, companionable, and often supportive contact. Much on-line contact is between people who see each other in person and live locally. Conversations started in one medium continue on others.

## **2. Setting and participants**

The study was carried out in an upper- secondary comprehensive school of the Helsinki metropolitan area. There were 29 teachers, a principal, two school assistants and a school secretary working in the school. There were 300 students in the school, who were from 13 to 16 years of age.

The students studied in the seventh, eight and ninth grades of compulsory education. In addition, there were two preparatory classes for immigrants and two supplementary classes (so called 10th classes) with emphasis on Finnish language teaching. About 30% of the pupils were immigrants. In 2004, the school had its second piloting year using a web-based learning environment, although ICT in learning had been emphasised in the school's curriculum since 1995. In this two-year pilot project, the school implemented the Opit web-based learning environment ([www.opit.wsoy.fi](http://www.opit.wsoy.fi)), which is software produced by the main publisher of learning material in Finland. It is designed for supporting collaborative pedagogical practices in schools. It includes several tools for this purpose, for instance, a discussion forum, personal and shared (group) portfolio files, project management tools and learning objects related to the subjects of curriculum of Finnish comprehensive and secondary school.

In the present study, *web-based learning* refers to the use and implementation of new, networked learning environments and associated practices in teaching. This implies student-centred and problem-centred learning supported partly by the web-based learning environment in terms of organizing so-called blended courses, where the learning environment was used alongside the more traditional face-to-face studying. Accordingly, pupils may have problem-solving discussions on their learning tasks in the discussion forum, they pursue group work by creating shared files or engage in rehearsal of learning material with peers or independently. Before the present investigation there had been four afternoon workshops for the whole teacher community on the use of the learning environment at the school during the school year. The training emphasized the user support and functions of the learning environment as well as the principles of problem-based learning. Three of the teachers had also participated earlier in the three-month intensive training course offered by local educational authorities.

It is essential to acknowledge that in the case of the present school community, the use of ICT in teaching and participation in the web-based learning development project was approved to be included in the school curriculum, the annual plan of the school and the information strategy. All members of the community had opportunities to participate in ICT training and also had equal opportunities to use the ICT facilities and equipment. However, participation varied between voluntary and mandatory; in practice the keenest teachers had already started the implementation of new technologies, while the less interested had only formally participated in the information sessions.

### 3. Research data and methods

#### *Networking questionnaire*

All the members of the teacher community (a total of 33) took part in the study. The data was gathered through a networking questionnaire that consisted of a list of names in which the rows represented names of each of the 33 members, and the columns indicated five types of networking relations. In the case of each colleague, the member was guided to think about the following questions, which are also described as the chosen, different networking dimensions within this study: 1) to whom they go with technical questions related to ICT, 2) to whom they go with pedagogical questions related to ICT, 3) with whom they carry out collaboration regarding web-based learning, 4) from whom they receive new knowledge or ideas of web-based learning and 5) with whom they interact informally. In addition, the members were guided to specify what media they use *in each of their relations* from the following six categories: 1) e-mail, 2) Internet: websites, 3) Web-based learning environment, 4) Phone, 5) Face-to-face and 6) Something else? What? In the questionnaire, the respondents were guided to think of their interaction with their colleagues during the last six (6) months.

The dimensions of the questionnaire were formed on the basis of earlier research as well as the experiences of the authors as teacher trainers (Hakkarainen, Järvelä, Lipponen & Lehtinen, 1998; Ryymin & Korhonen, 2003). These previous studies have indicated that some teachers specialize in technical questions whereas others are merely pedagogical actors in their communities in the process of adopting new technologies, and that there are usually early adopters, who disseminate their knowledge to the other members of the community. In addition, in the first phase of adoption of new technologies, teachers usually start with e-mails, but may use a variety of media when they have more experience, skills, and knowledge of new technologies.

The questionnaire was tested by a group of teachers (from other schools) to verify that teachers genuinely understand the questions and the structure of the questionnaire. The data was analysed according to social network analysis (SNA), which is a method focused on uncovering the patterning of people's interaction and relational information on participation (Scott, 1991; Wasserman & Faust, 1994). The data consisted of the links between members, indicating who engages in what kind of

interaction and with whom. All the dimensions were computed on the matrix. A tie between members existed if a member of the community had reported it in the matrix. The matrix cell only accepted values 1 (the tie is observed) or 0 (there is no tie). The interaction and knowledge exchange between the members of the community was studied for its density, centrality, centralization and egocentric networks of the individual members of the community. Social network analysis was supported by the Ucinet 6 program (Borgatti, Everett & Freeman, 2002).

Furthermore, the members of the community were guided to report what networking relations they had outside the community. The questions were laid out in open rows, where the members completed the names and organizations of their contacts, and columns showed the same five types of networking relations. The members also detailed for each contact the medium they used. In addition, the members of the community were guided to report other sources from which they acquired information about 1) technical questions related to information and communication technology, 2) pedagogical use of information and communication technology and 3) new knowledge and ideas related to web-based learning.

### *Social network analysis*

SNA is a method for studying social relations among a group of actors (Scott, 1991). Social relations can be thought of as dyadic attributes, whereas mainstream psychological sciences are concerned with monadic attributes and corresponding statistical measures. The relations may, for instance, be kinship, social roles, affective or cognitive properties, actions, flows, distance or co-occurrence (Hakkarainen & Palonen, 2003). The method is especially designed to facilitate the analysis of structural data (Scott, 1991; Wassermann & Faust, 1994). SNA modelling allows researchers to represent relational structures of social actors, where the relationships are defined by social interactions, e.g., collaborating, seeking advice, mediating knowledge, and providing socio-emotional support. Access to knowledge and other resources is determined by the structural context of relationships, that is, to whom one is connected via direct or indirect links (Hakkarainen & Palonen, 2003). The present study focuses on examining the nature of teachers' social networks related to the information regarding ICT.

The idea of centrality of individuals and organizations in their social networks originates in the sociometric concept of “the star”, the person who is the most popular in his or her group or who stands at the centre of attention. The term “centrality” is restricted to the idea of point centrality, while the term “centralization” refers to the overall cohesion or integration of the graph (Scott, 1991, 85). In the present study, the network centrality of individual members of the community was measured by Freeman’s degree function, which means the amount of information and knowledge the participant provides for or receives from the other participants (Scott, 1991, 88). The measure is based on indegree, which means the number of incoming networking linkages, and outdegree, which means the number of outgoing network linkages. Every individual’s centrality was measured related to all five networking dimensions mentioned earlier. Also, the extent to which a whole community had a centralized structure was examined within the dimensions. Density, in turn, measures how often information flows between members. The more actors have relationships with one another, the denser the network will be. Because centralization and density are important complementary measures (Scott, 1991, 92-93), the density of the networks of the teacher community was also measured within the five dimensions.

In addition to examining the density of the overall network, density can be analysed with the links surrounding particular agents: the personal networks of the members of the community. This approach is called “egocentric networks” (Scott, 1991, 75). In this study, the egocentric networks of the individual members of the community have been analysed within the five dimensions by their size and density. In this context of measuring the egocentric networks, the size of the egocentric network means the number of actors that an individual, “an ego,” is directly connected to, while the density of the egocentric network means the number of ties (total number of ties in the ego network) divided by the number of pairs multiplied by 100 (Borgatti et al., 2002). The goal of the analysis of the egocentric networks within this study is to find out whether the same actors are central in different networks, for instance, are the central actors of the network of pedagogical knowledge sharing also central in the network of technical knowledge sharing? Further, the QAP-correlation was used to analyse whether the five dimensions examined could have be combined or summed up for further analysis. (Borgatti et al., 2002.) In addition, ten (10) of the central actors identified in social network analysis were interviewed to investigate the hypothesis that the qualities and working practices of these actors may reveal essential aspects of knowledge exchange in the community.

### *Multi-dimensional scaling*

In this study, the network of informal interaction was illustrated also by MDS map (see Figure 1). The MDS map indicates the distances between the members and the structure of the network of informal interaction in the community. The basic idea behind MDS is that of using the concepts of space and distance to map relational data. As a configuration of points and lines can be made into a metric map, it is also possible to measure distances and directions in ways which differ from the path distances, where the distance between two actors is the length of the shortest path that connects them (a geodesic path). Contrary to the path distance, the metric concept of distance is close to the everyday understanding of physical distance. MDS is an attempt to convert graph measures into metric measures (Wasserman & Faust, 1994, 287-289; Scott, 1991, 151-156). The validity of each map can be measured by a value of stress, where the greater the value the worse the model. The value is dependent on the data: the number of actors and the scale of measures. The stress value presented in Figure 1 is 0,114 which is reasonably good.

The starting point for the present study was to acquire new perspectives on how teachers share knowledge of ICT in the context of work. As mentioned earlier, it takes several years of effort before teachers start using ICT intensively in schools (Hakkarainen et al., 2001). However, the goal of this study was not to observe educational change in school from a long term perspective. Instead, SNA is applied for examining a method for observing ICT-related knowledge flow between teachers, connections that link teachers to one another. These phenomena are often invisible when one uses standard statistical methods in researching teacher communities.

## **4. Results**

### **4.1 Knowledge exchange and collaboration in the teacher community on the network level**

Table 1 presents the density and centralization of the teacher community's social network. The measurements depict the networks of the teacher community according to five networking dimensions: 1) knowledge exchange on technical questions, 2) knowledge exchange on pedagogical questions, 3)

collaboration on web-based learning, 4) acquiring new knowledge or ideas of web-based learning and 5) engaging in informal interaction. Table 1 shows, that the network of knowledge exchange related to ICT in general was quite sparse within the teacher community although there were four different questions used in data gathering. The fifth dimension, informal interaction, was the densest of the networks revealed; the informal communication among the community members is more active than the communication related to ICT. Table 1 also indicates that the density of the network regarding collaboration of web-based learning is lower than other ties. This result may indicate the fact that it is likely to be more demanding to maintain collaborative activity than just exchange information on ICT; Palonen and Lehtinen (2001, 502) have also reported similar findings.

To find out whether the dimensions can be seen as the same aspects, the QAP-correlations were analysed. The results indicated that the dimensions of pedagogical questions, collaboration in web-based learning and acquiring new knowledge or ideas of web-based learning correlate, and can be seen as the properties of the same, “pedagogical support” dimension of ICT. The Pearson’s correlation (Borgatti et al., 2002) coefficient values varied from 0,404 (min) to 0,521 (max) when comparing these dimensions with each other. Technical questions correlated partly with pedagogical dimensions; the results varied from a minimum value 0,183 (technical questions and collaboration of web-based learning, which correlated only weakly) to a maximum value 0,370 (a medium correlation) which was found when analysing relations between technical questions and pedagogical questions. However, the dimension of informal interaction did not correlate much with any other dimensions (min 0,090 – max 0,263), and it can be considered as a distinct dimension. Since one of the interests of this study was to acquire new knowledge on different types of actors in a teacher community specifically, the networks are not summed up, which would have simplified the analysis of the data, but are instead analysed separately.

Table 1. The networks of the whole pedagogical community related to the four dimensions of ICT (1-4) and informal interaction (5). The analyses have been made with asymmetric matrices.

Dimensions	Density	Centralization Freemans' Degree % Outdegree / Indegree
1. Technical questions regarding ICT	0,13	67 / 67
2. Pedagogical questions regarding ICT	0,10	19 / 54
3. Collaboration on web-based learning	0,08	27 / 27
4. New knowledge and ideas on web-based learning	0,09	19 / 41
5. Informal interaction	0,25	77 / 13

#### 4. 2 Knowledge exchange and the key actors

Table 2 shows centrality measurements on the individual level. It presents the cases of individual members of the community across the five networking dimensions. Being asked for information related to ICT appeared to be centred on certain workers, whereas informal interaction was also more equally distributed among all participants than other dimensions. There were differences in the out- and indegree values of the individual members of the community across the five networks. The indegree value means the number of colleagues who reported that they received information or collaborated with the teacher (incoming tie). Outdegree value indicates, in turn, the number of colleagues from whom the participant actively asked for information or collaborated with (outcoming tie) according to his or her own assessment. In other words, the indegree value can be considered as peer assessment and outdegree value as self-assessment regarding one's centrality within the community.

Table 2. The centrality of the members of the pedagogical community (individual teachers) related to the four dimensions of ICT (1-4) and informal interaction (5). The analyses have been made with asymmetric matrices.

Centrality Freemans' Degree	1. Technical questions	2. Pedagogical questions	3. Collaboration of web-based learning	4. New knowledge or ideas of web-based learning	5. Informal interaction
	Outdegree / Indegree	Outdegree / Indegree	Outdegree / Indegree	Outdegree / Indegree	Outdegree / Indegree
Teacher 1	5 / 1	9 / 0	0 / 1	0 / 0	0 / 4
Teacher 2	25 / 1	3 / 2	1 / 1	1 / 0	2 / 9
Teacher 3	4 / 0	4 / 3	3 / 1	5 / 2	30 / 8
Teacher 4	1 / 3	0 / 2	0 / 3	0 / 4	2 / 9
Teacher 5	0 / 19	1 / 10	2 / 4	0 / 9	8 / 11
Principal 6	4 / 8	1 / 4	4 / 2	5 / 8	32 / 7
Teacher 7	8 / 4	9 / 2	9 / 3	9 / 1	32 / 10
Teacher 8	4 / 1	1 / 0	0 / 0	1 / 0	0 / 9
Teacher 9	4 / 1	5 / 0	1 / 1	0 / 0	0 / 7
Teacher 10	3 / 10	2 / 2	0 / 0	3 / 3	13 / 10
Teacher 11	1 / 1	3 / 1	3 / 2	3 / 5	1 / 11
Teacher 12	4 / 1	5 / 3	3 / 6	8 / 3	22 / 9
Teacher 13	3 / 3	2 / 2	0 / 5	0 / 6	11 / 7
Teacher 14	2 / 2	1 / 3	1 / 3	0 / 4	11 / 11
Teacher 15	4 / 0	1 / 0	0 / 1	1 / 1	0 / 6
Teacher 16	3 / 0	5 / 0	2 / 0	2 / 1	12 / 4
Teacher 17	3 / 1	4 / 3	5 / 2	4 / 2	7 / 6
Teacher 18	3 / 1	5 / 3	6 / 4	7 / 2	8 / 8
Teacher 19	5 / 2	6 / 4	5 / 3	9 / 3	9 / 12
Teacher 20	3 / 1	5 / 3	3 / 4	1 / 3	31 / 10
Teacher 21	6 / 1	6 / 7	10 / 6	5 / 6	9 / 8
Teacher 22	3 / 1	3 / 3	0 / 2	3 / 2	2 / 10
Teacher 23	5 / 2	7 / 1	0 / 0	3 / 2	1 / 6
Teacher 24	4 / 13	1 / 20	11 / 10	4 / 16	3 / 9
Teacher 25	8 / 2	8 / 2	2 / 2	9 / 2	10 / 6
Teacher 26	5 / 1		3 / 0	5 / 0	2 / 6
Teacher 27	2 / 1	1 / 0	1 / 2	1 / 0	0 / 8
Teacher 28	1 / 25	0 / 17	1 / 11	3 / 15	0 / 8
Teacher 29	5 / 3	4 / 4	6 / 3	7 / 2	6 / 9
School Assistant 30	0 / 1	0 / 0	3 / 0	2 / 0	0 / 5
School Assistant 31	2 / 1	1 / 1	0 / 2	1 / 1	1 / 5
School Secretary 32	3 / 4	0 / 0	2 / 0	0 / 0	0 / 6
Assistant teacher 33	3 / 23	1 / 4	0 / 2	0 / 2	0 / 11
	4,1 / 4,1	3,2 / 3,2	2,6 / 2,6	3,2 / 3,2	8 / 8

The indegree and outdegree values revealed the central actors in the community within the different dimensions. Table 2 shows, for instance, that there are five “stars”, the highly chosen informants, in a network of exchanging technological information on ICT: Teachers 5, 10, 24, 28 and 33. Two of these actors had a central role in respect of receiving, also, high indegree values in the network of giving pedagogical advice: Teachers 24 and 28. Further, Teacher 5 received higher indegree value in the dimension of pedagogical questions than the average members of the community. Due to the role of Teachers 24, 28 and 5 as “stars” of both technical and pedagogical networks, they may be regarded as *hybrid experts* (Howells, 1999; Hakkarainen et al., 2004). People who represent *hybrid expertise* integrate working practices and tools that are able to cross the boundaries of domains of professional competence. Such integration develops when individuals in intensive interplay cross boundaries of know-how. Apparently, these actors crossed the boundaries of the technical and pedagogical domains. Teacher 24 characterized her role within the community as follows: *“I am a pedagogical support person, but not only in web-based pedagogy, but also in ICT in general.”*

Table 2 reveals that the dimensions of collaboration in web-based learning and acquiring new knowledge or ideas of web-based learning are even more centralized on certain actors than are other dimensions of ICT. However, compared with the technical and pedagogical dimensions, there are new central informants found in this dimension. In addition to Teachers 24, 28 and 21, also teacher 12 (in the dimension of collaboration), Teacher 5 and the principal (in the dimension of acquiring new knowledge or ideas of web-based learning) received higher indegree values than their colleagues. There were also several new actors showing interest in web-based learning. For instance, Teachers 7, 29, 21, 19 and 18 had clearly higher outdegree values in both dimensions than other members in the teacher community. Teacher 18 said in the interview: *“I’m preparing a small experiment with my students using web-based learning. Then, when I’m collaborating with other teachers of my subject field, I can guide those colleagues, who are not so experienced.”*

One of the central actors of web-based learning is Teacher 21, who reported 10 collaborative ties to her colleagues related to web-based learning, whereas her colleagues have reported six ties to her. In an interview, Teacher 21 explained that her collaboration consisted of both presenting and demonstrating her projects to interested teachers and taking part in concrete collaboration, including shared courses, joint teaching and learning projects. She had also developed new ways to implement

web-based learning and problem-based learning with several different pupils and for various subject domains, with her colleagues. Her interest was focused on the pedagogical use of ICT in relation to web-based learning and on its further development in collaboration with her colleagues. Teacher 21 described web-based learning and her work in interviews as follows: *“I think that I have a kind of innovator role, and I collect other peoples’ ideas and develop them further.”* When she was asked to detail what kind of advice her colleagues asked her for, she replied: *[For example] once, one of my colleagues asked me for advice on how to carry out a [web-based learning] project with a student with poor language skills.”* In addition, she emphasized that her knowledge of web-based learning was best distributed to others *“by collaboration”*.

#### *Networking practices of the two most central actors*

Table 2 shows that teachers 24 and 28 were central informants of new knowledge and ideas of web-based learning as they were in technical and pedagogical questions too. The interviews of these “stars” revealed that they both had a specific role in advancing ICT within the community; they had, for instance, agreed with the principal to carry out peer tutoring in ICT; they were so called *“pedagogical support persons”* in their community. Teacher 24 had also actively participated in the recent intervention of web-based learning. She had, for instance, acted as an administrator of the learning environment (e.g., managing the user groups) in the community. Teachers 24 and 28 had only a few outgoing ties to their colleagues, indicating that there were not so many who could provide advice or new information to these experts inside the community. They both reported in the questionnaire, and also in interviews, that they had to search for new information outside the community.

However, in one of the dimensions Teacher 24 acted as a fellow collaborator with her colleagues; i.e. in web-based learning. As it is seen in her indegree values within the dimension of collaboration in web-based learning, she herself reported 11 ties to her colleagues; and 10 colleagues reported a tie to her. Nine of the 11 ties were reciprocal. However, the interview of Teacher 24 revealed that the collaboration was not only related to her role as an administrator of the learning environment, but also included concrete actions, such as planning and sharing courses together, and participating in joint teaching and learning projects. On the contrary, Teacher 28 reported only one collaborative tie to her colleagues, whereas 11 colleagues reported ties to her. In interview, Teacher 28 detailed that she

was not currently concretely collaborating with her colleagues, but rather introduced her earlier projects by demonstrating them and sharing “lessons learned”. Yet, many of her colleagues appeared to consider these unbalanced relations in which she had a leading role as instances of concrete collaboration.

*The active advice seekers and the passive in the community*

In studying Tables 2 and 3, it can be seen that, in addition to the central informants, to whom their colleagues actively turn to, there were also active information seekers in the community. They received high outdegree values and some of them have quite large egocentric networks as well. For instance, Teachers 7 and 2 were active in proposing questions to their colleagues on technical matters, Teachers 7, 21, 8, 1 and 6 were active in asking their colleagues regarding pedagogical questions, and Teachers 7, 29, 12, 19 and 18 indicated special efforts acquiring new knowledge or ideas of web-based learning. The interviews of Teachers 7, 29, 12, 19 and 18 revealed that these teachers were enthusiastic beginners in web-based learning. They had recently started their web-based learning projects, and were now actively seeking for support and ideas from each other and from their more experienced colleagues. Teacher 7 showed activity in inquiries related to all dimensions. She described her experiences in social relations in the community as follows: *“They never leave you alone in this community, people help each other. This is why I love this working place!”*

Table 2 shows that there were some passive actors in the network of knowledge exchange of ICT in the community. For instance, Teachers 8 and 15 were not so active in acquiring information on ICT and, in addition, they were quite peripheral according to their own assessment (see outdegree values) in informal interaction too. However, their colleagues assessed their role differently; they both received an average indegree value. This assigned value indicates that they were not isolated from the community, but apparently in relation to several of their colleagues. Also the school secretary and two school assistants played more passive roles in knowledge exchange on ICT than the teacher members in the community.

*Focusing on the central informants within the study*

In this study the teachers who were examined more closely and interviewed, were chosen from the basis of the research results of Freeman's degree analysis. They were the teachers who actively turn to their colleagues in advice-seeking or collaboration (outdegree values) and /or to whom their colleagues reported turning to (indegree values). There could have been many possibilities to carry out this research, for instance examining only central informants, teachers to whom their colleagues actively turned to (indegree values), or the teachers who were rather peripheral in the network structure. However, in this study the interest was on those teachers of the community who make the information flow; who both spread and gain information. Regarding this, individual teachers' activity and interest to acquire information on ICT was considered to be meaningful as well. Above average outdegree values appears to indicate teacher's motivation and orientation to adopt more knowledge on ICT.

For future research one interesting question would be how the central informants became central in their community? The goal of this study was not to analyse how and why the central persons had grown into their roles. Yet, in interviews the teachers were asked, what are the factors which possibly have supported them in their professional development in their community? According to teachers' experiences they were, amongst others, the principal's personal encouragement to participate in in-service training, flexibility in planning work, demanding pupils who benefited from new methods, shared lessons with colleagues, training occasions at authentic learning environments (at schools) and professional colleagues. Furthermore, all the interviewed actors emphasized that they found ICT genuinely meaningful in their teaching; they implemented and further developed it as daily routine. They had also strong, personal growth-orientation, for instance, they were all seeking more in-service training related to ICT. These descriptions are reported in more detail in another article (Ryymin, Lallimo & Hakkarainen, 2005), in which also teachers' descriptions about the contents of their communication (what are, i.e., the pedagogical questions?) are introduced and analysed closer. In addition, the central informants' teaching subjects are not presented in this study to protect their anonymity. In general it can be pointed out, that there were both women and men representing different ages, subject domains and work experience.

*The network of informal interaction*

The fifth network investigated was the network of informal interaction. In line with Table 2, also Table 3 reveals that there were different members in the centre of the network of informal interaction than those in centres of the networks related to ICT in the community. Some of the technical informants (such as Teachers 5 and 10) received quite high indegree values in informal interaction, and their networks, especially Teacher 10's, were denser and larger than that of the others.

Nevertheless, "the stars" of informal interaction are clearly other members in the community than the central actors of ICT. For instance, Teachers 7, 3, 20 and the principal had large informal networks (see size values in Table 3) in the community. This can be explained by the fact that they reported ties to almost all of their colleagues. On the other hand, Teachers 7 and 20 received an above-average number of incoming ties (indegree values in Table 2), and their networks were quite dense (see density values in Table 3). In addition, Teachers 12, 14, 19 also appeared to be socially active and centrally positioned in the network. Despite some participants being in the centre of the network, the network of informal information, in general, appeared to be only moderately centralized, and participation was apparently distributed quite equally across the teacher community.

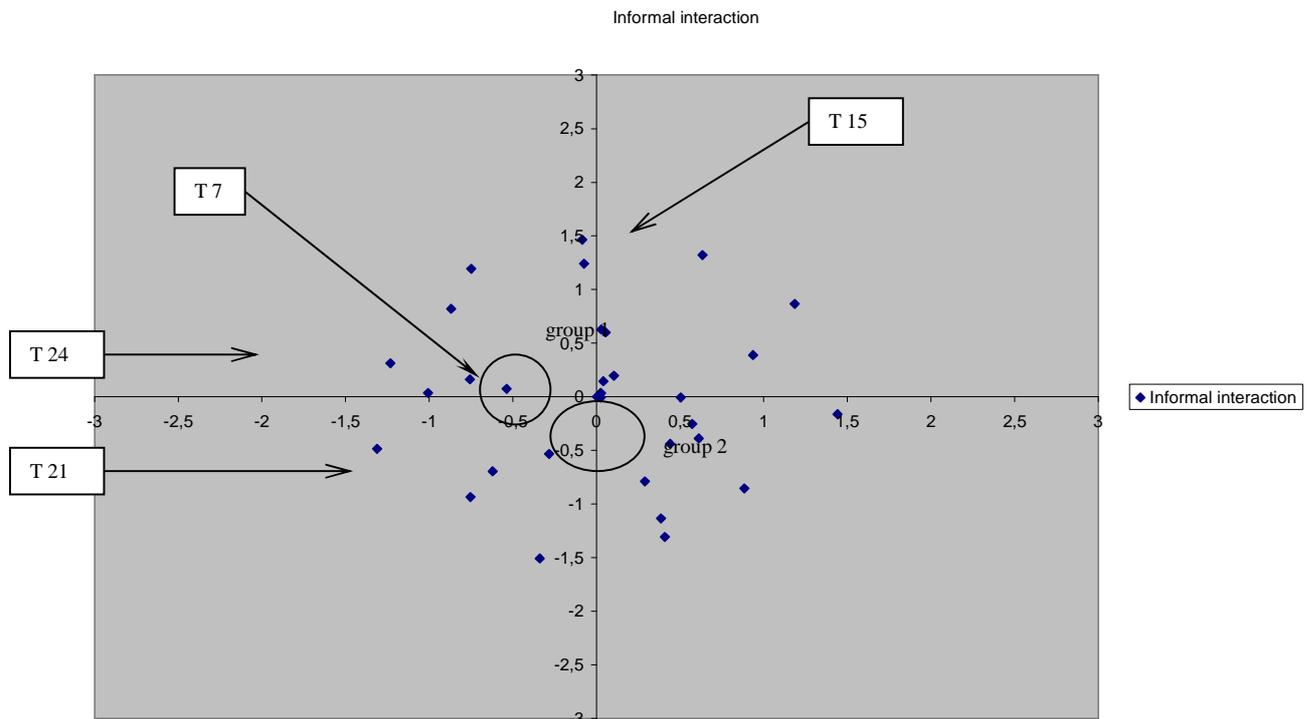


Figure 1. Informal interaction in the pedagogical community (multidimensional scaling). The arrows point to the different types of actors on the map: T 24 (Teacher 24, the Counsellor), T 7 (the Inquirer), T 15 (the Weakly social) and T 21 (the Collaborator).

In line with Tables 1 and 2, it is possible to recognize from the multidimensional scaling (MDS) map that the network of informal interaction is not remarkably dense, although it is denser than other networks, and the members of the community are networked with each other quite equally (see Figure 1). From the MDS map it is also possible to examine the structure of the network of informal interaction by circling on the map the different actors, and the actors that are nearest to them, which may belong to the same culture of knowledge. The most central members of informal interaction are situated in the centre of the map. One may distinguish two small groups (Group 1 and 2) of members in the core, or near the core of the network (see in Figure 1). When the members of these small groups were examined, they turned out to represent teachers of different various subject domains. It would have been natural to assume that same-subject teachers were interacting more intensively with one another, and, therefore, are more closely positioned in the picture. In this study, however, what constituted the attributes or properties of socially central persons was not studied in detail.

Being a central informant of ICT is not related to being a central person in the network of informal interaction in this teacher community. This can be illustrated also by situating the two different types of central actors, Teachers 24 and 21, onto the map of informal interaction (Figure 1). For instance, Teacher 24, to whom her colleagues actively turned to with their ICT-related questions (see in Table 2), was not in the centre of the map, neither did she belong to any dense group of informal interaction. Teacher 21, who was the most active collaborator of web-based learning in the community (see Table 2), is not situated in the core of the informal interaction either. Yet, when circling Teacher 7 on the map, it appears that she belongs clearly to the core of the network of informal interaction in the community. The manner, in which she is situated on the map, indicates that she is socially active, and other research results (see Table 2) show that she also benefited from her several social relationships when acquiring information on ICT. On the contrary, Teacher 15 is situated quite peripherally within the map. Yet, just like any other member of the community, he is not, on the present evidence, isolated and completely lacking contacts.

### **4.3 Egocentric networks and the media in teachers' interaction**

Media use was examined by questionnaire in this study, teachers reporting their media choices concerning each collegial relation during the previous six (6) months (the frequency of media use was not reported). In order to concretize the results, the present authors have identified four different patterns of teacher networking. These characterizations are included for illustrative purposes only and should not be interpreted as deeper archetypes of teachers. While the four distinct patterns of networking emerge from the data, we acknowledge that there may be several other justifiable ways of categorizing the participants.

The four case examples presented closer are Teacher 7, 15, 21 and 24. These teachers were chosen because of the specific qualitative characters of their egocentric networks and media use when comparing them to their colleagues' networks and media choices. Further, the data gathered by the interviews was used as validation for the classifications that were made when analysing these teachers' networks and media use. In this study, hereafter, these teachers are called, "The Counsellor" (Teacher 24), "The Collaborator" (Teacher 21), "The Inquirer" (Teacher 7) and "The Weakly Social" (Teacher 15) according to their special characters in interaction.

Figures 2-5 represent the egocentric networks and the media use of these four actors in detail. The figures illustrate the first four dimensions of interaction of the questionnaire (technical and pedagogical questions, collaboration in web-based learning and acquiring new knowledge or ideas on web-based learning) and the media used in these dimensions and, in addition, teachers' outer-community contacts and other information sources. In further, Figure 1 represents these participants in the fifth dimension; in the network of informal interaction.

*The colleagues preferred to interact with The Counsellor in face-to face*

The Counsellor (Teacher 24), differed from her colleagues in the fact that she was surrounded by advice seekers in her community (see in Figure 2). However, she was not central in informal interaction (see in Figure 1). There were only four members within the community, from whom the counsellor asked advice herself, including the principal. She also collaborated in web-based learning with other community members (see in Table 2). The colleagues preferred turning to The Counsellor in face-to-face situations. Also, The Counsellor only asked for information from her informants face-to-face. The Counsellor tended to have her own external networking relations that help her to keep up her high level of competence. For these contacts she used e-mail and a web-based learning environment. In addition, she acquired technical and pedagogical information on ICT and new knowledge of web-based learning from the Internet, professional literature, and journals. In the interview, The Counsellor told that she offered step-by-step demonstrations often to her colleagues and in this face-to-face contact was essential. She also described her communication in the community as following: *“If there’s something new regarding web-based learning, I tell it in the staff meeting to everyone. And everybody knows that they can always turn to me.”*

*The Inquirer prefers face-to face contacts too*

The Inquirer (Teacher 7) assessed herself to be the most active actor of informal information in the community (see in Table 2). She belongs to the core of the socially most central persons in the community (see in Figure 1). Yet, her egocentric network differed from other active teachers of informal information (i.e., teacher 3 and teacher 20) in her manner to seek advice and information about ICT rather actively too, not only in the community but outside of the school as well. Figure 3

shows, that The Inquirer acquired information from several colleagues. She had also contacts outside the community from whom she received advice and ideas or with whom she collaborated. In these contacts, she used e-mail, phone and a web-based learning environment.

Moreover, she had several other information sources; for example, she acquired technical and pedagogical information from the Internet, professional literature, journals, TV, videos, libraries, teacher associations and university. The Inquirer told in interviews that her manner to solve problems was to ask immediately advice from others and this is why she preferred face-to-face contacts, as it was, according to her, the quickest way to acquire information. The Inquirer: *“I’m not afraid of showing my lack of knowledge. If there’s something I don’t know, I ask someone else straightaway.”*

#### *The Collaborator uses several media*

The Collaborator (Teacher 21) reported that she collaborated actively in web-based learning in her community. Nevertheless, she was not very active in informal interaction (see in Figure 1). There were also other collaborators in the community (see teachers 18, 20, 24 and 7 in table 2), but compared to them, The Collaborator used a bigger number and wider range of media in her relations. Figure 4 shows that The Collaborator used several media, as did the teachers who collaborated with her or turn to her while seeking new knowledge.

For instance, the web-based learning environment was used as a medium for collaboration or knowledge acquisition in the eight (8) of the 15 relations of The Collaborator (medium number 3 in Figure 4). Also e-mail, websites and phone were in active use. Also The Collaborator has outer-community contacts, from whom she received pedagogical advice face-to-face and by phone. In addition, The Collaborator acquired new knowledge or ideas of web-based learning also from the Internet, journals, professional literature, and from a teacher training organization. The Collaborator described in interview how she used the web-based learning environment as follows: *“I visit the learning environment every so often, looking around, searching for new ideas. I use it for planning my teaching and acquiring new ideas.”*

There are several reasons that might explain the use of different media in the relations of The Collaborator. One reason is that new pedagogical practices supported by a web-based learning

environment may also transform teachers' other working practices, for example, planning the teaching. As The Collaborator said, she used the web-based learning environment not only in teaching, but also in planning the teaching with her colleagues and demonstrating her projects to others. Another explanation may be Haythornthwaite's (2005) finding that community members, who were more strongly tied together, used more media to communicate with each other than others. From this point of view the use of media can be considered as a property of a tie. Collaboration is more demanding than just asking for advice, and it is easily established between colleagues who are close to each other and feel comfortable and emotionally safe in each others' company. (See the emotional zone of proximal development in Mahn & John-Stainer, 2002; referring Vygotsky, 1962.)

*The Weakly Social gets information from his colleagues through media*

The Weakly Social (Teacher 15) seemed to be one of the rather passive teachers in pedagogical information seeking (see in Table 2) in the community and also socially quite peripheral (see in Figure 1), but he differed from other "pedagogically passive" teachers (like Teachers 8 and 27) in the fact, that he reported in the questionnaire that he, however, acquires information on ICT using media instead of face-to-face communication. Figure 5 shows, that there were four contacts in the community from which The Weakly Social received technical or pedagogical information or new knowledge or ideas on web-based learning. The Weakly Social reported being in face-to-face contact only with one of his colleagues, Teacher 33. He acquired advice from other colleagues through websites (Teacher 7 and 29) or through the web-based learning environment (Teacher 28).

He had one collegial contact outside the school from whom he acquired technical advice through a web-based learning environment. However, one of his colleagues, Teacher 26, reported that he was also collaborating and receiving new knowledge or ideas on web-based learning from The Weakly Social. Although he appeared to be quite passive in knowledge exchange related to ICT, he was part of the information flow and networks of the community. He preferred two distinct media, web sites (medium number 2 in Figure 5) and web-based learning environment (medium number 3 in Figure 5) instead of face-to-face contacts in information seeking. There may be many explanations for this interaction pattern, one of which is probably that he might not consider face-to-face contacts very comfortable or meaningful for their purpose of acquiring new knowledge. He merely preferred a particular medium in the case of each of his fellow teachers. In any case, he was interested in ICT to

some extent; he reported acquiring information related to technical questions from TV and ICT magazines.

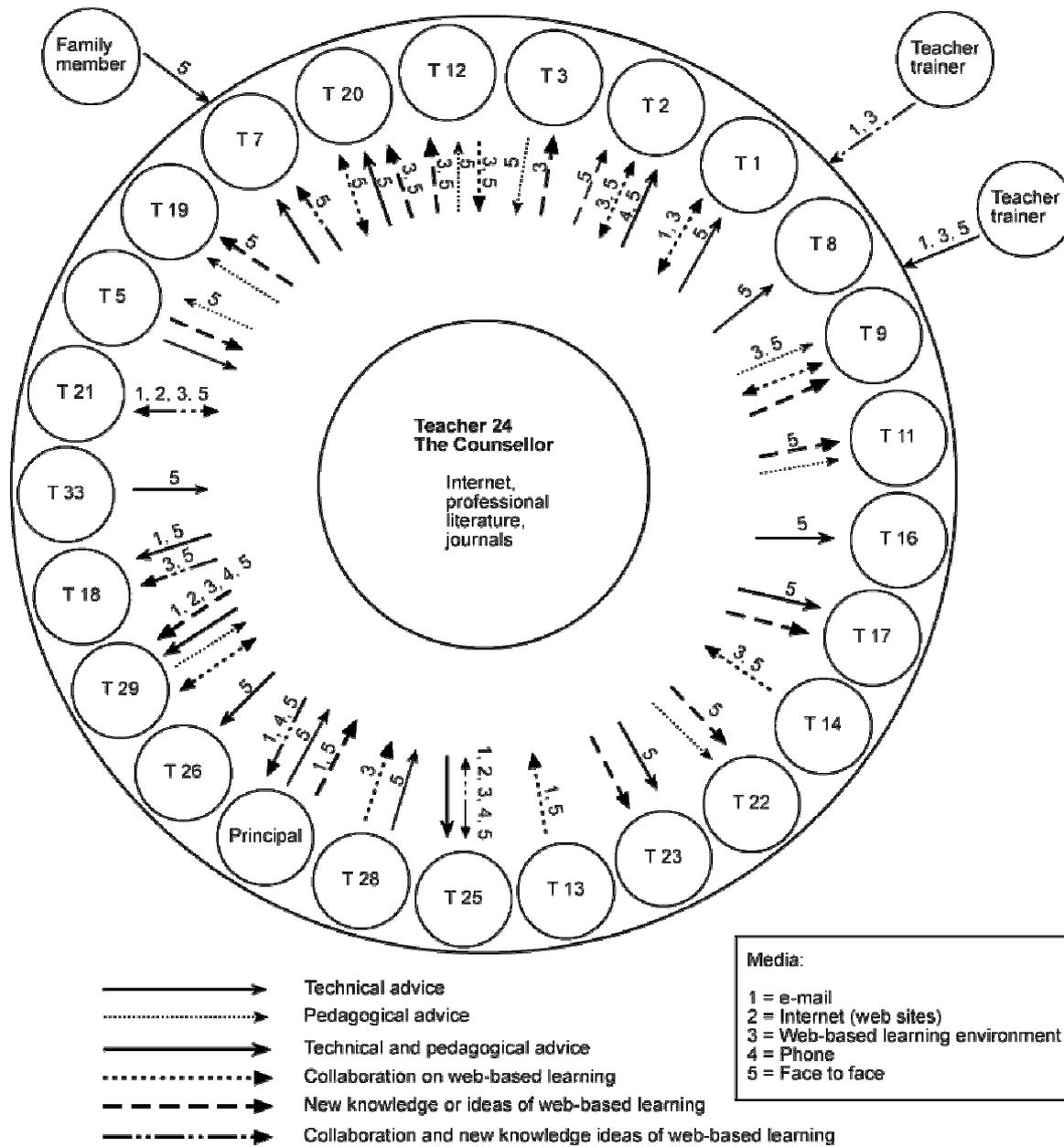


Figure 2. The Counsellor’s egocentric network related to the first four dimensions, including the outer-community contacts, media used in interaction, and other information sources.

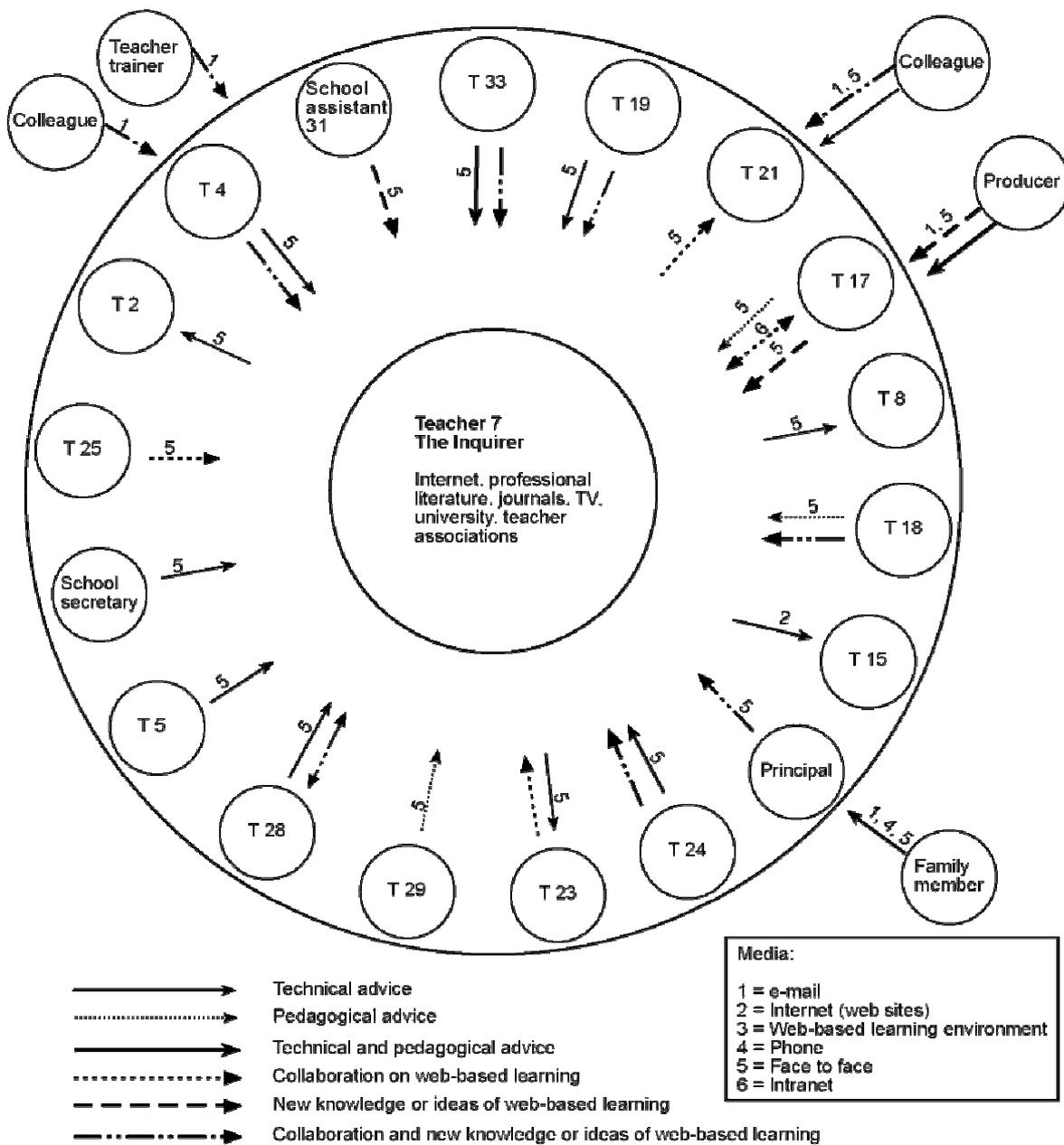
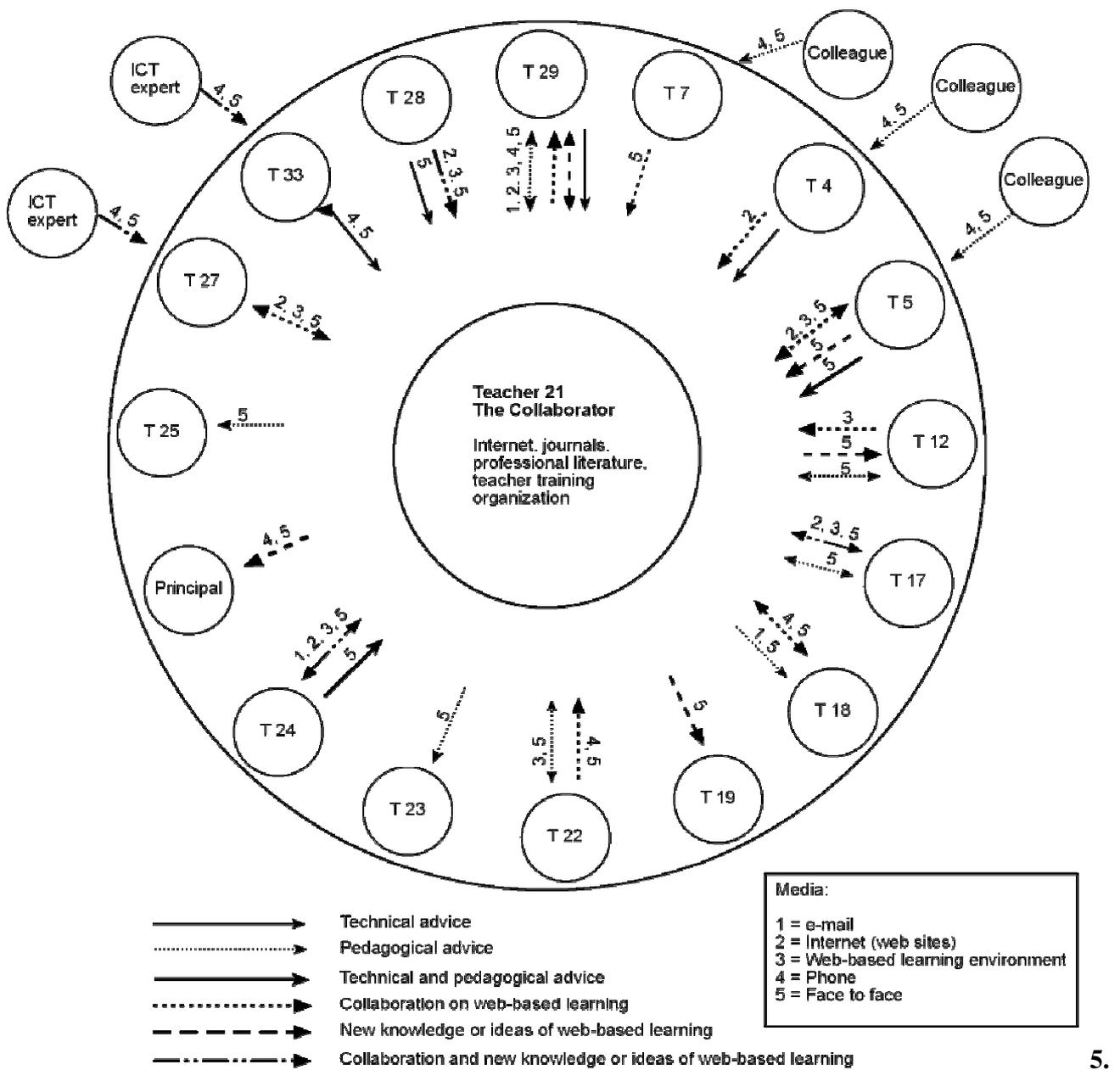


Figure 3. The Inquirer’s egocentric network related to the first four dimensions, including the outer-community contacts, media used in interaction, and other information sources.



5.

Figure 4. The Collaborator’s egocentric network related to the first four dimensions, including the outer-community contacts, media used in interaction, and other information sources.

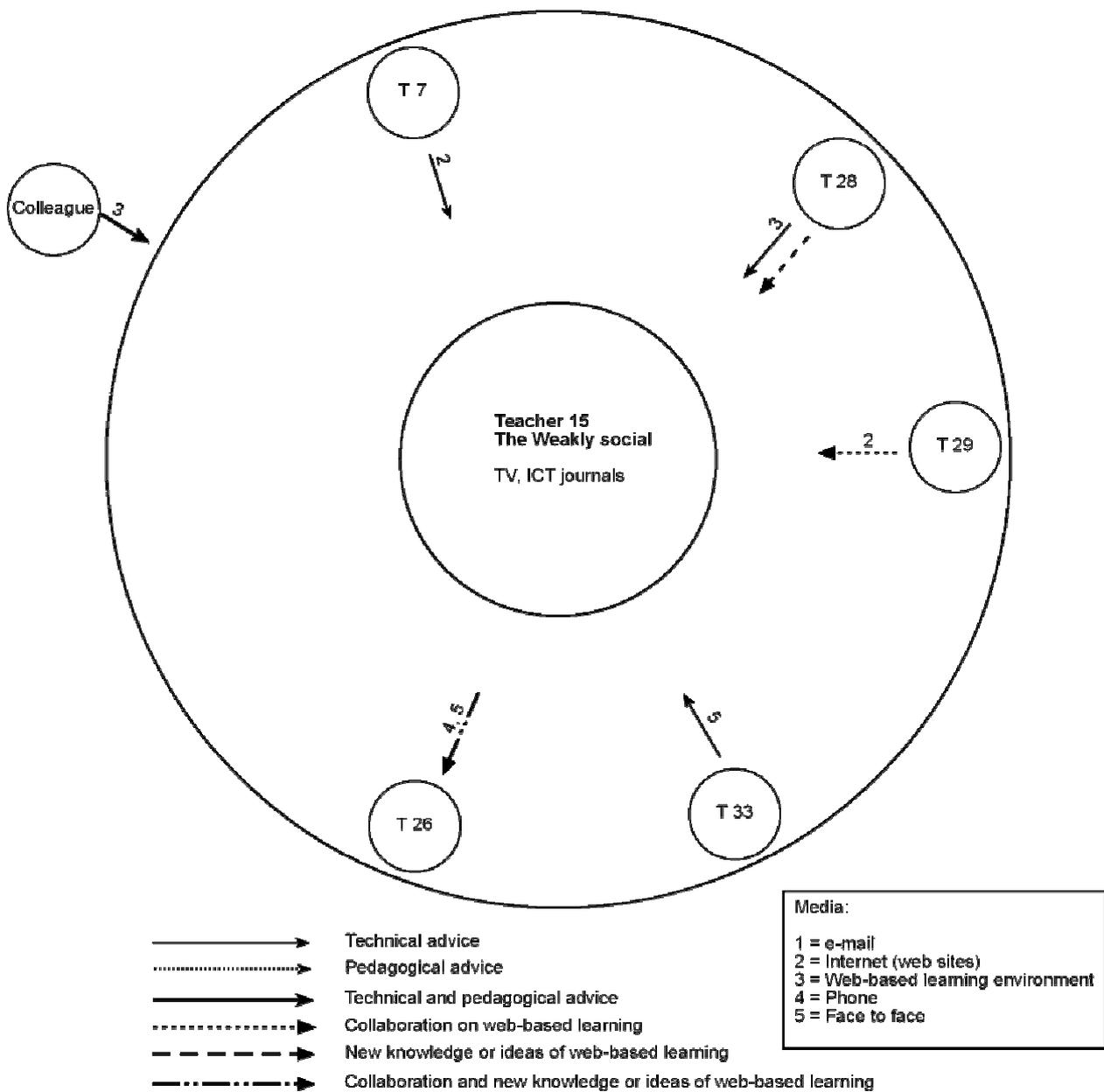


Figure 5. The Weakly social's egocentric network related to the first four dimensions, including the outer-community contacts, media used in interaction, and other information sources.

## Discussion

The goal of this study was to examine how intensively the members of a teacher community participate in knowledge exchange related to the use of ICT according to the following five dimensions: 1) providing advice regarding technical aspects of using ICT, 2) providing pedagogical advice concerning ICT, 3) collaborating in web-based learning, 4) acquiring new knowledge or ideas of web-based learning and 5) engaging in informal interaction. Furthermore, the study focused on examining the participants' role in knowledge exchange within the school community, and what kind of media, and other information sources, actors utilize in their knowledge exchange.

### *1. The assessed networks correlated partly and were divided unequally*

The research results showed that the relations among community members were divided quite unequally within the different dimensions; some of the members reported more outgoing ties, some incoming ties. There were certain central actors found, relating to the technical and pedagogical knowledge exchange, to whom their colleagues actively turned to in their advice-seeking. The network of providing technical advice correlated with that of providing pedagogical advice on using ICT; these networking dimensions had substantial correlation and the same persons were asked both technical and pedagogical advice. The network technical advice did not correlate very much with other networking dimensions, whereas the network of providing pedagogical advice, collaborating in web-based learning and acquiring new knowledge or ideas of web-based learning correlated clearly, and they can be seen as the properties of the same coefficient factor of “pedagogical support network” of ICT. The network of informal interaction did not correlate with any other networks.

### *2. The key actors of ICT were not always the socially most central ones*

The results revealed that the central actors of ICT were not necessarily the socially central persons in the community. This was an interesting finding, especially from the perspective of educational policy makers and teacher trainers: in many in-service training programs, which emphasise peer tutoring in ICT implementation, the trainers and principals recruit the socially most active teachers to the task. The present evidence, however, indicates that the most sociable colleagues in the

community are not necessarily the key actors in ICT.

When examining ICT central actors more closely, it turned out that they were both women and men representing different ages, subject domains and working experiences. Being in a central position in this teacher community in the subject domain of ICT was not connected to teachers' gender, teaching subject, experience or age. What, then, could explain their central role of ICT in the community? One perspective was opened up in interviews. All the interviewed actors emphasized that they found ICT genuinely meaningful in their teaching; they implemented and further developed it as daily routine. They had also strong growth-orientation, for instance, they were all seeking more training in ICT.

One can hypothesize that there are also some other attributes of these advisers which encourage their colleagues to turn especially to them. They might, for instance, have certain specific, subject-related social skills, such as understanding the questions ("receiving the message") of an advice-seeker and offering relevant, understandable and usable advice. They may have the capability to concentrate on the needs of the advice-seeker and respect an individual's intelligence. The examination of the properties and attributes of the central actors of ICT in the teacher community is a challenge for future research.

The results indicated that the network of technical and pedagogical advice was a little bit denser than that of ICT-related collaboration. This result may refer to the fact that it is likely to be more demanding to maintain collaborative activity than just exchange the information of ICT. It may also indicate that the collaboration of web-based learning is a quite a new activity in the community.

### *3. The members of the community interact and build networks in personal ways*

The results revealed also, that the egocentric networks of the community members were qualitatively different across the networks measured. Different characters of actors have personal egocentric networks, and people interact in qualitatively distinct ways in their networks. For instance, The Counsellor offered advice actively, but does not turn so much to her colleagues in advice seeking. The Inquirer was an active information seeker, who benefited her from social relations in ICT

knowledge exchange as well. The Collaborator concentrated on concrete collaboration in web-based learning, and The Weakly Social preferred media instead of face-to-face occasions in information seeking.

#### *4. The use of media in interaction is a personal and complex phenomenon*

The use of media in relations of knowledge exchange of ICT was a complex phenomenon, which was strongly related to the actors' personal egocentric networks. The use of media explained members' individual ways of carrying out interaction with others, and the different kinds of characters appeared to have "personal media profiles". The quality of a tie between individuals and the content of knowledge exchanged appeared to have an impact on the media choices. For example, The Counsellor often gave practical advice and demonstrations in face-to-face situations to her colleagues. The Inquirer preferred face-to-face contacts because of instant information seeking, whereas The Collaborator used several media in her close and collaborative relationships. The Weakly Social was a part of the network of the ICT-related information flow in the community by using a certain, distinct, medium instead of face-to-face contacts.

#### *Limitations of the study and suggestions for future research*

Studying a dynamically evolving network would also be important because the present method required that participants made retrospective generalizations regarding their networking relations (Reis & Gable, 2000). In the present study, it may have been cognitively rather demanding to determine the nature of networking relations across all members of one's workplace community. A more optimal, but much more labour-intensive method would have been to ask the participants to keep a record of their networking interaction on day-to-day basis.

In addition, the size of the present community (N=33) may be a limitation; it was chosen to be manageable. It is difficult to judge the effects in the present case, but it is possible that some of the less frequent interactions would appear differently for a larger sample. In the case of two or three couple of the respondents, he or she reported informal networking relations with all of their colleagues. These participants had possibly different interpretations of the concept "informal interaction" than the others.

In most cases, incoming ties indicated that these were really the most central actors regarding the network of informal interaction.

In future research, it would be important to study the co-evolution of teachers' pedagogical practices and their social networks: how the knowledge of pedagogical innovations is shared, and how this process could be supported, in the networks, which consist of people, artefacts and media? One needs to look how the different cultures of expertise can help schools to widen their pedagogical communities of practice towards the principles of innovative knowledge communities? There are some open-source computer programs, such as TECFLOW and SONIA, which can be used to examine dynamically changing social networks (Bender-deMoll & McFarland, 2005).

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