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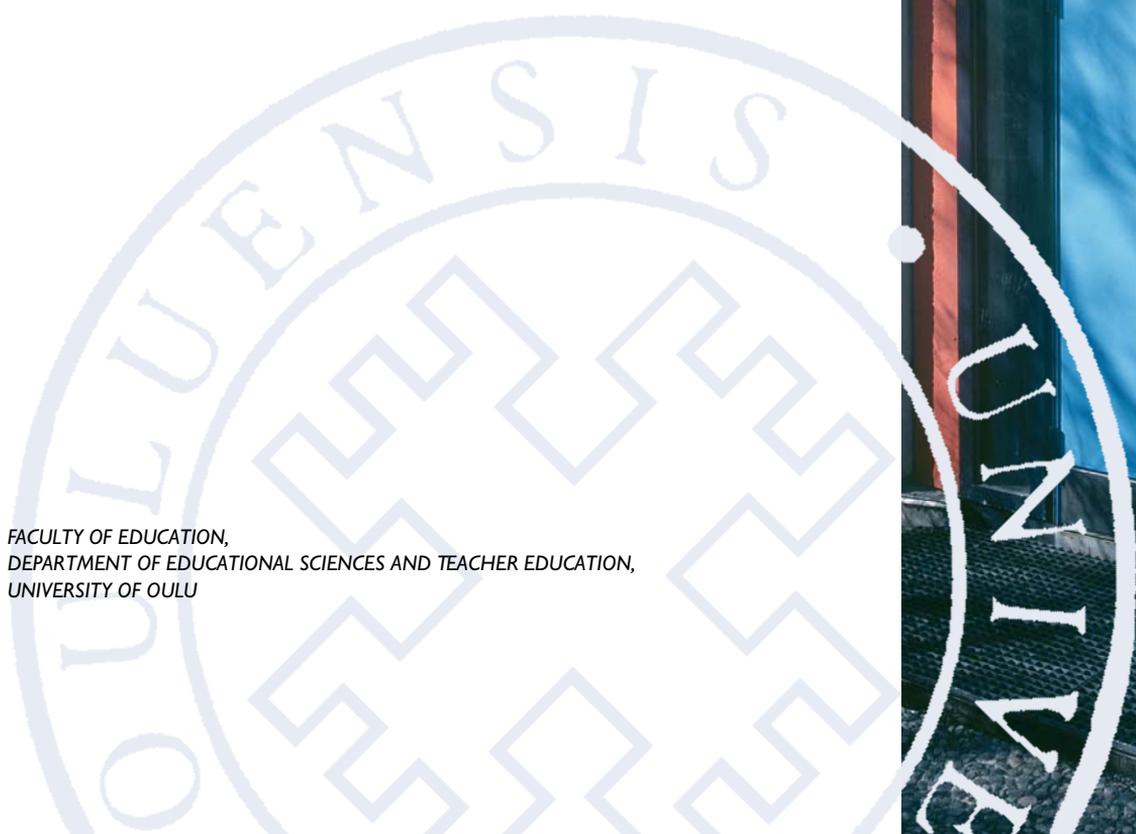
Piritta Leinonen

INTERPERSONAL
EVALUATION OF
KNOWLEDGE
IN DISTRIBUTED
TEAM COLLABORATION

FACULTY OF EDUCATION,
DEPARTMENT OF EDUCATIONAL SCIENCES AND TEACHER EDUCATION,
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PIRITTA LEINONEN

**INTERPERSONAL EVALUATION OF
KNOWLEDGE IN DISTRIBUTED
TEAM COLLABORATION**

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Abstract

The study investigated how individuals evaluate others' knowledge when they work as a distributed team. Theoretically, the study was based on contemporary theory on collaborative learning and combined with the theories which explain how individuals evaluate others' perspectives in social learning situations. Interpersonal evaluation of knowledge was conceptualized as one mediating process which is needed between social and individual knowledge planes.

This study builds on a design-based research approach. Three research experiments were conducted. In the study, a pedagogical model and a visualization tool were developed based on the findings gathered from the first and the second empirical research experiments. It was also investigated how the working model and the visualization tool supported interpersonal evaluation of knowledge. In practice, the model and the tool were tested in the experiments with distributed teams. The results of the experiments are reported in four research articles (Articles I–IV).

Based on the analysis of the three research experiments, it can be concluded that when the distributed team members evaluate the other team members' thinking, they use several cognitive reasoning strategies. The findings indicate that the evaluation strategies, such as perspective-taking, comparing, attribution and categorization fulfill each other when the team members try to take the perspectives and shared knowledge of others into account. The results showed also that with the working model or the visualization tool it was possible to support only some strategies of interpersonal evaluation of knowledge at one time.

The findings highlight the fact that interpersonal evaluation of knowledge is a multidimensional process. The dimensions which affect the evaluation of others' knowledge are externalized knowledge presented in communication, and an individual's knowledge about, for instance, others' expertise, which may not be externalized in communication. In future studies different levels of analysis are needed to understand how interpersonal evaluation of knowledge is related to the interactions between team members and with technological resources in practice.

Keywords: collaborative learning, interpersonal evaluation of knowledge, perspective-taking, teamwork, virtual team

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Tiivistelmä

Tässä tutkimuksessa tarkastellaan hajautetun tiimin jäsenten pyrkimyksiä arvioida toistensa tietoa. Yhä useammin sekä suomalaisten että globaalien organisaatioiden toiminta perustuu ongelmien ratkaisemiseen ja uuden tiedon kehittämiseen tiimeissä. Yleensä monimutkaisten ongelmien ratkominen edellyttää tiimiläisten tapaamisia ja keskusteluja, mutta se ei ole aina mahdollista esimerkiksi pitkien välimatkojen vuoksi. Tällöin tiimiläiset kommunikoivat pääosin teknologian välityksellä, mikä osaltaan tekee tiimiläisten keskinäisestä ymmärtämisestä ja siten myös ongelmien ratkaisusta haastavaa.

Teoreettisesti tutkimus nojautuu kollaboratiivisen yhteisöllisen oppimisen teoriaan ja sosiokognitiiviseen oppimisenäkemykseen, joissa toisten tietojen arviointi ja pyrkimys vastavuoroiseen ymmärtämiseen nähdään oppimiselle tärkeinä prosesseina. Tutkimuksessa sovelletaan myös sosiaalipsykologian tutkimuksissa käytettyjä teorioita attribuutiosta ja kategorioinnista.

Tutkimus koostuu kolmesta osatutkimuksesta, ja se seuraa Design Based Research -tutkimusotetta. Ensimmäisen ja toisen osatutkimusten tulosten perusteella kehitettiin yhteisölliseen hajautettuun tiimityöhön työskentelymalli ja visualisointityökalu, jota hajautetun tiimin jäsenet käyttivät tietorepresentaatioiden ja jaetun tiedon arvioimisen tukena kolmannessa osatutkimuksessa. Yleisesti visualisointityökalun ja työskentelymallin avulla pyrittiin tukemaan hajautettujen tiimien jäsenten vastavuoroista ymmärrystä. Toisten tietojen arvioimiseen käytettyjä strategioita tarkasteltiin useiden laadullisten tutkimusmenetelmien avulla.

Tutkimuksen tulokset osoittavat, että ymmärtääkseen toistensa näkökulmia hajautettujen tiimien jäsenet käyttävät kognitiivisina strategioina perspektiivinottoa, vertailua, attribuutiointia ja kategorisointia. Perspektiivinotossa pyrkimyksenä on ymmärtää toisen tiimin jäsenen näkökulma jaetun tehtävän sisällön kannalta. Vertailu perustuu omien ja toisten tiimiläisten tietorakenteiden erojen ja yhteneväisyyksien etsintään. Lisäksi tuloksista nousee esille erityisesti tarve ymmärtää, mikä tieto on jo jaettua tiimin jäsenten kesken. Tutkimuksen tulokset osoittavat, että yhteisöllisen ongelmanratkaisun tutkiminen hajautetussa tiimityössä vaatii yksilön kognitiivisten toimintojen analysointia osana sosiaalista tilannetta.

Asiasanat: kognitiiviset strategiat, tiimityö, virtuaalinen tiimi, yhteisöllinen oppiminen

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Oulu, September 2007

Piritta Leinonen

List of original articles

This thesis is based on the following articles, which are referred to in the text by their Roman numerals:

- I Leinonen, P., Järvelä, S., & Lipponen, L. (2003). Individual students' interpretations of their contribution to the computer-mediated discussions. *Journal of Interactive Learning Research, 14*(1), 99-122
- II Leinonen, P., Järvelä, S., & Häkkinen, P. (2005). Conceptualizing the awareness of collaboration: A qualitative study of a global virtual team. *Computer Supported Cooperative Work, 14*(4), 301-322.
- III Leinonen, P., & Järvelä, S. (2006). Facilitating interpersonal evaluation of knowledge in a context of distributed team collaboration. *British Journal of Educational Technology, 37*(6), 897-916.
- IV Leinonen, P., & Bluemink, J. (2007). The distributed team members' explanations of knowledge they assume to be shared. Accepted for publication.

Contents

Abstract

Tiivistelmä

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1 Introduction

Learning in teams is crucial in a knowledge intensive society. Currently, organizations increasingly rely on teams to solve a variety of complex tasks and problems. In order to be effective and successful in the solving of problems, it is crucial that knowledge is continuously shared and constructed in teams (Derry, DuRussell & O'Donnell, 1998; Billet, 2004). Today, team problem-solving is often conducted by team members who engage in collaborative knowledge construction from a distance.

Although there are many benefits associated with teamwork and knowledge construction, the reality is that there is no guarantee of success, as many teams fail to solve their problems for number of reasons (Salas & Fiore, 2004). If a problem is expected to be solved through collaboration with remote colleagues, the distribution of the team challenges the effectiveness of working as a team. For example, some beneficial learning mechanisms, such as negotiation (Beers, Boshuizen, Kirschner, & Gijsselaers, 2005; 2006), might be difficult to conduct, if communication between the team members is mainly mediated by the technological tools. Nonetheless, a knowledge intensive society and technological advances motivate the adoption of a greater amount of distributed teamwork. Therefore, an understanding of how new knowledge is constructed in collaborative teamwork and how learning environments can be designed to promote the team's problem-solving abilities is needed (Sawyer, 2006). In this thesis, the focus is on the interpersonal process of how team members try to take the perspectives of others into account when they work as a distributed team.

In order to communicate effectively and to understand what others are saying, an individual team member must make many assumptions about what other team members do and do not know. Critical questions that must be asked in a situation where team members should work and learn collaboratively are: How do we know what the other team members know and how accurate are our perceptions of others' thoughts about the shared task (Nelson, Kurglanski & Jost, 1998). In other words, the team members had to try to see how others perceive the issue they are working with. This is conceptualized as an interpersonal evaluation of knowledge (Bromme, 2000; Shirouzu, Miyake & Masukawa, 2002). It can be considered as one mediating process between social and individual knowledge planes.

Both Piaget and Vygotsky have explained the social origin of learning and understanding (Piaget, 1985; Vygotsky, 1978). In order to internalize new knowledge representations people must interact in with the social knowledge plane

of their environment (Vygotsky, 1978). Deep learning requires that learners evaluate new ideas, and relate them to conclusions. In social learning situations, such as in teamwork, the ability to view a situation from others' perspectives is also needed in order to contribute to discussions with a new knowledge representation (Piaget, 1985). In practice, we examine the other speakers' positions on issues and adapt to the needs of the audience. This evaluation of others' knowledge is especially needed in collaborative problem-solving (Shirouzu & al., 2002; Hausmann, Chi & Roy, 2004) and in teamwork between different experts (Bromme & Nückles, 1998).

However, in distributed teams, when communication is mediated mainly by technological tools, there are several challenges which may affect the strategies used by distributed team members as they attempt to take the perspectives of others into account. Studies have shown that working across dispersed locations typically reduces the situational information that collaborators have about each other and affects how information is processed (Weisband & Atwater, 1999; Cramton, 2002). Therefore, in this thesis a working model and a visualization tool to support interpersonal evaluation of knowledge were designed and implemented in empirical experiments with authentic distributed teams. Following the main ideas of the design-based research approach, interpersonal evaluation of knowledge was investigated within the teams employing these tools.

In summary, the aim of this thesis was to investigate how individuals evaluate others' knowledge when they work as a distributed team. The other aim was to investigate how interpersonal evaluation of knowledge can be supported in the context of distributed team collaboration using the working model and the visualization tool designed in the study.

The thesis consists of two parts. The first part contains the introduction, the theoretical framework for the study, aims and methods following the main findings and discussion. The second part consists of four individual articles published by (or submitted to) international peer-reviewed journals. The articles report the body of empirical results from this thesis study.

2 Theoretical framework

Chapter two introduces a theory of collaborative teamwork and interpersonal evaluation of knowledge. In the first theme of the chapter, collaborative teamwork will be conceptualized. Secondly, the chapter will progress to a discussion focusing on the relation between the cognitively oriented acquisition and the socio-culturally oriented perspectives in learning studies. The third main theme of the chapter considers the theories relevant to explaining interpersonal evaluation of knowledge. In this theme communication and cognitively oriented research approaches are discussed in order to conceptualize interpersonal evaluation of knowledge as a mediating process between the social and individual knowledge planes. Because this study focuses especially on distributed team members, the fourth major theme of the chapter considers the challenges of computer-supported distributed team collaboration. In addition, how pedagogical models and technological tools are seen as supportive elements for learning in these settings is introduced.

2.1 Conceptualizing collaborative teamwork

Learning processes in knowledge intensive work and in formal education situations are much alike. In both of these settings collaborative learning demands that individuals engage in various structured and intentional activities to produce an outcome considering their work (Hutchins, 1995; Billet, 2001; Kleinsmann & Valkenburg, 2006). When individuals engage in workplace activities, their knowledge is changed in some way by their work practices, or in other words, they learn (Tynjälä, 1999; Billet, 2004). These changes can be permanent or semi-permanent changes in how they think and act (Kirschner, Sweller & Clark, 2006). Because of the similarities in learning processes between workplaces and formal learning situations, studies conducted from the perspective of the learning sciences can enrich our understanding of how new knowledge is constructed in teamwork settings as well (Tynjälä & Häkkinen, 2005; Sawyer, 2006).

In this study, the focus is on individual team members who are engaged in collaborative teamwork. The conceptualization of a team follows Levine and Moreland's (1991) definition of a work group, according to which a work group consists of three or more persons who regularly interact to perform a joint task, who share a common frame of reference, and whose behaviors and outcomes are interdependent. Specifically, the focus is on individuals of a team, or in other

words, the team members who work together to construct new knowledge. To describe this kind of team in more detail, conceptualization of a 'negotiation team' follows. According to Devine (2002), members of a negotiation team are especially engaged in an intellectual task which is usually fairly structured. To solve their shared task the members of a negotiation team may have critical debates for various reasons, such as their different understandings considering their common goal. In a negotiation team, the primary uncertainty associated with their shared task stems from not knowing how the other team members or the team will act or respond during collaborative activities. If the team members meet face-to-face only occasionally, and otherwise their communication is mainly mediated by technological tools such as e-mail and workspace software, a negotiation team can be referred to as a distributed team (Maznevski & Chuboda, 2000).

Conceptualization of collaborative teamwork follows Stahl's (2006) definition of collaborative learning, in which an explicit goal is to build knowledge that helps answer an initial question posed by the group's shared task or provide group members with a deeper understanding of a topic they are working with. Such processes typically occur in a collaborative teamwork context as well, where a common goal is the aim of two or more persons and who work together to construct new knowledge (Salomon & Globerson, 1989; Derry, Gance, Gance & Schlager, 2000; Salas & Fiore, 2004).

To set apart the concept of collaborative learning from the concept of cooperative learning, Dillenbourg (1999) states that in cooperation the shared work task is split into sub-tasks which are solved individually. Then the partial results from these sub-tasks are assembled into the final output. When comparing this learning process to the process of collaborative learning, noteworthy is their insights towards the construction of new knowledge. In collaborative learning it is expected that learning may occur during, and may be based on, collaborative knowledge construction if participating individuals share their own point of views, internalize others' presented point of views, contribute to discussions with new points and draw together conclusions about their shared understanding of the problem at hand (Roschelle, 1992; Dillenbourg, 1999). These are the essential phases of collaborative activity where new knowledge is expected to be constructed together. Construction of knowledge is defined as the joint process (Hausmann & al., 2004). In this thesis, collaborative teamwork is conceived as a process in which team members negotiate and share meanings relevant to the problem-solving task at hand, as they would do in a collaborative learning situation.

2.2 Theoretical perspectives to study collaborative teamwork

The two main approaches to empirically study and theoretically conceptualize how new knowledge is constructed in social interaction have been the cognitively oriented acquisition perspective and the socio-culturally oriented situative perspective (Sfard, 1998; Anderson, Greeno, Reder & Simon; 2000; Billet, 2004). Drawing on cognitive perspectives (Anderson, 1982; Piaget, 1985), Billet (2004) has proposed that when an individual engages in work activities, there is a potential to extend what the individual knows through the creation of new cognitive structures. Even though Piaget's research work focused mainly on developmental psychology (Brainerd, 2003), Billet (2004) argues that Piaget's (1985) theory of the two learning mechanisms, assimilation and accommodation, can be adopted to explain how individuals make sense of the workplace activities in which they interact and how they integrate these experiences into their understanding. Assimilation refers to reconciling what is experienced and what an individual already knows, and accommodation refers to creation of new categories of knowledge from experiences (Piaget, 1985). In the socio-cultural perspective, learning is considered as a progression along trajectories of participation, which can involve contributing to the functions of communities (Lave, 1997; Suchman, 1987). Instead of emphasizing an individual's cognitive processes and knowledge acquisition, in the studies conducted from the socio-cultural perspective, the individuals' participation in social practices are usually analyzed (Hutchins, 1995; Barab, Barnett & Squire, 2002).

However, even though the approaches of the cognitively oriented acquisition perspective and the socio-culturally oriented situative perspective, have been seen as rather different ways of conducting research and theoretical conceptualizations, there are some points of agreements as well. In both of these perspectives it is underlined that in order to construct new knowledge, which is usually demanded in the case of a negotiation team, it is beneficial if individuals are active with each other in a social context. Neither of the perspectives is limited to either activity by groups or to individuals acting alone (Anderson & al., 2000).

In a recent commentary article Dillenbourg (2006) argues that the distributed cognition perspective on learning (Pea, 1993; Salomon, 1993; Hutchins, 1995) was expected to diminish the gap between the researches conducted from the cognitive and the socio-cultural perspectives and provide us with a deeper understanding of the relation between individual cognition and social interaction. However, in the same commentary he shows how these two perspectives of

conducting research and conceptualization of learning still exist, though he also explains that there are some bridges over the gap as well (see also Akkerman, Van den Bossche, Admiraal, Gijsselaers, Segers, Simons & Kirschner, 2007). As an example for this kind of 'bridge', he proposes that an integrated learning script is one practical implication of how both theoretical perspectives on an individual's cognition and participating in social knowledge construction are taken into account when designing learning situations. A script promotes specific types of interactions in order to stimulate knowledge construction, and an integrated script is a kind of scenario in which activities for a group or a team and its members are both scripted. In a collaborative work situation the integrated script may include scripts for individual activities such as reading papers, and scripts for team activities such as discussing and summarizing the results of the project as a team (Dillenbourg & Jermann, 2007; Leinonen, Järvelä & Häkkinen, 2005).

Despite Dillenbourg's example of the integrated script, in a recent review article Akkerman *et al.* (2007) conclude that to produce reliable theoretical conceptualizations on learning in social situations it still seems to be very challenging to integrate the cognitive and the socio-cultural research perspectives. According to Akkerman *et al.*, a full integration of the perspectives would mean losing sight of some of the basic theoretical assumptions of one of these approaches. However, Akkerman *et al.* still do not close the door entirely on bringing the perspectives closer. As also suggested by Greeno (1998), they see that the most meaningful step to bringing the cognitive and the socio-cultural perspectives together is for each perspective to extend itself to include some of the explanations offered by the other approach.

Collaborative learning and work situations entail social processes which give rise to both an individual's cognitive development and a group's or a team's shared construction of new knowledge (Shirouzu & al., 2002; Hausmann & al., 2004). Therefore, the notion considering research work in which aspects from both perspectives are gradually incorporated is worthy of consideration in collaborative learning and work studies. There are few studies (Derry & al., 1998; Shirouzu & al., 2002; Barron, 2003) in which the combination of an individual's own cognitive activity and participation in social activities have both been analyzed to explain problem-solving on an individual and on a group level. For example, Shirouzu *et al.* (2002) showed how the key in social construction of new knowledge was an individual's opportunity to monitor the shared problem-solving situation and the perspectives of others. After monitoring and evaluating others' perspectives, she

or he was able to construct a new knowledge representation and again was able to contribute to the discussion about the shared task.

In this thesis, the object is not to make distinctions or an integrative perspective for the cognitive and socio-cultural perspectives. Instead, following the road paved by Derry *et al.* (1998) and Shirouzu *et al.* (2002), interpersonal evaluation of knowledge is investigated as one mediating process which is needed between social and individual knowledge planes. This means that the critical questions in a situation where individuals should learn collaboratively are: How do we know what other people know, and how accurate are our perceptions of others' thoughts, feelings, and attitudes? These questions are the primary basis for an individual participant who tries to critically evaluate different goals and means, that arise during collaboration, to decide how to contribute to collaborative knowledge construction (Nelson & al., 1998). In the next chapter a more detailed introduction is provided explaining how in communication and cognitively oriented research approaches the strategies of how others' perspectives are taken into account.

2.3 Interpersonal evaluation of knowledge – perspectives from different theoretical traditions

A high level of social interaction requires that we take another's perspectives into account (Levine & al., 1993). However, answering questions about others' knowledge seems difficult for at least two reasons. First, we do not have direct access to other people's ongoing or likely future thinking processes (Bromme, 2000). Second, even if we manage to evaluate others' inert psychological processes in some situation, it is not certain that people will behave in the manner that we expect because situations may change. Despite these apparent challenges, adults and even young children have little trouble answering questions about other people's likely future reactions and psychological states. Evaluation of others' thinking and emotions is needed in order to communicate and cooperate with others effectively (Jost, Kruglanski & Nelson, 1998; Nelson & al., 1998), especially if a shared problem should be solved collaboratively by different experts in work (Bromme & Nückles, 1998; Derry & al., 1998).

Within social psychology there is a wide branch of experimental studies focusing on the factors that may affect how others' perspectives are evaluated and how impressions of other individuals are formed (Quinn, Macrae & Bodenhausen, 2003; Karniol, 2003). When social situations became an important context for

learning science studies (Webb & Palincsar, 1996; Salomon & Perkins, 1998), interpersonal evaluation of knowledge was also paid a significant amount of attention (Bromme & Nückles, 1998; Bromme 2000; Shirouzu & al., 2002; Chi & al., 2004). A short review on earlier studies considering the strategies which individuals use when they try to understand others' perspectives is presented next. The way in which interpersonal evaluation of knowledge has been noted in studies on communication and common ground, and how it is approached in more cognitively oriented studies on learning, are reflected. Knowledge is conceptualized as an individual's beliefs, inferences and understanding of a discipline, including content-level knowledge (facts and procedures) and higher-order knowledge (problem-solving strategies and styles of justification) (Perkins, 1993; Chi & al., 2004).

2.3.1 Communication studies approach

Research on cognition and communication has shown that to communicate and understand what others are saying, an individual must make many assumptions about what other participants do and do not know, and about the assumptions they are likely to make about what others know (Clark & Marshall, 1981; Kraut & Higgins, 1984; Clark & Schaefer, 1989). This is especially noted in studies on common ground which focus on understanding how common ground is updated in communication. Common ground is never completed shared knowledge, but is an interactive and ongoing process in which perceived mutual knowledge and beliefs are accumulated and updated (Clark & Brennan, 1991; Beers, Boshuizen, Kirschner & Gijsselaers, 2006).

Based on studies on written communication, Nystrand (1986) has pointed out that in communication interpersonal evaluation of knowledge is needed in order to understand what the level of mutual knowledge between communicators is. According to Nystrand (1986), mutual knowledge is knowledge that two or more individuals possess in common. This means that, for example, experts in the same research field or witnesses to the same event have a high degree of mutual knowledge even if they never discuss it. However, people of course do not need mutual knowledge to communicate. They do need a mutual frame of reference (Clark & Marshall, 1981). It can be possessed by individuals, and once they externalize their knowledge in communication, they use their mutual frame of reference to be understood and to communicate effectively. Once they have shared

their knowledge within this mutual frame, the knowledge once shared becomes mutual knowledge.

When individuals communicate, they show to each other, with verbal or non-verbal communicative acts, that they try to see the others' perspectives and have or have not understood and accepted them. They listen to what they themselves and others have just said and based on that make inferences about the others' state of knowledge, or they rely on direct feedback received from collaborating individuals (Fussell & Krauss, 1991). Clark & Schaefer (1989) have concluded that when an individual has understood the other's perspective, she or he might only continue her or his attention, acknowledge the other's point by saying 'uh', or continue communication by presenting the next contribution.

All the communicative acts described above indicate that there was an attempt to understand the other's perspective, and therefore some strategy to understand other's knowledge must have been used (Bromme, 2000). However, despite that the studies on common ground and mutual knowledge have provided us understanding on important elements of communication in collaborative problem-solving, these studies do not necessarily tell us how, for instance, different experts try to evaluate the other experts' knowledge in collaborative teamwork. According to Bromme and Nückles (1998), Krauss and Fussell (1990; 1991), for example, used rather simple communication tasks when they studied communication and mutual knowledge. Communication situations in these studies did not consider complicated tasks in which a shared problem was expected to be solved by different experts in their authentic workplaces.

In addition to rather simple experimental conditions, the strategies concerning how an individual comes to conclusions about the others' states of knowledge are not necessarily externalized as a level of communication or actions. Chi & al. (2004) showed in their study of peer-to-peer tutoring that conclusions about the other's knowledge are not necessarily based on what the others have presented in discussions. In their study the tutors' evaluation about the students' knowledge was based on the tutors' own understanding about what the students were expected to know, and not from an accurate diagnosis of what the students in fact did know or what knowledge they presented in their discussions. This finding proposes that even though communication has a central role in the evaluation of others' knowledge, individuals use other information sources as well when they try to take others' perspectives into consideration. Therefore, there is also a need to find other approaches than the communication study approach to investigate how individuals evaluate others' knowledge when they work together to construct new knowledge

(Nisbett & Wilson, 1977; Ericsson & Simon 1980; Chi, Siler & Jeong, 2004). This has been one aim within cognitively oriented studies on interpersonal evaluation of knowledge.

2.3.2 Cognitively oriented approach

In cognitively oriented studies on learning it has been shown that subjective construction of knowledge demands processes such as self-explanation and reasoning (Linn; 2006). However, as the significance of social learning situations for individual learning became evident in learning studies, it also became clear that successful shared construction of new knowledge by individuals having different perspectives is a phenomenon requiring explanation (Salomon & Perkins, 1998; Hausmann & al., 2004), especially in workplace learning studies (Bromme, 2000; Billet, 2004). If construction of new knowledge is seen as being social in nature, one important process is also interpersonal evaluation of knowledge. An individual has to evaluate others' perspectives in order to contribute to social knowledge construction with a new knowledge representation, which has not been presented yet. Through evaluation of others' perspectives an individual can compare and explain how the others' knowledge structures differ from their own, if they are they similar or if they show shared knowledge on any level at all (Shirouzu & al., 2002). How an individual comes to conclusions of others' knowledge and how she or he compares the knowledge to her or his own knowledge has been investigated within cognitively oriented studies in social and educational psychology.

In studies conducted in social psychology it has been shown that in interpersonal evaluation of knowledge, one underlining strategy is categorization, that is, we make inferences about the others' state of knowledge based on their category membership (Rosch, 1978; Quinn & al., 2003). These studies have shown that we use a plenty of categories when we draw conclusions about the inner states of others. For instance, when having a discussion with a software developer or with a chef, very different impressions and expectations are formed simply based on their expert category memberships. To form these impressions, firstly, we observe the target person. Observation leads to a process of attribution when attributes that are presumed to describe the target person are connected to that person. Through the process of attribution, categorization leads to a characterization or inference about the target person. The attribution and categorization have an impact on our evaluation of the others and based on that we

can expect certain behavior from them. However, these evaluations may not always be accurate or even correct (Nisbett, Caputo, Legant & Marecek, 1973; Quinn *et al.*, 2003). In this case we usually moderate our evaluations by a process of correction in which we consider other (perhaps situational) factors that might have produced the behavior we did not expect from, for example, a software developer or a restaurant chef upon first impression.

Social psychological studies on attribution and interpersonal evaluation of knowledge have shown that we do not make the same causal attributions about ourselves as we do about others (Nisbett & al., 1973). When we rationalize our own actions and behavior in some situation, we may explain it with our own situational limitations and expectations considering the task with which our behavior is coordinated. Instead, when considering other people, we may expect that they behave more according to their stable attributions, such as professional status or other general feature which we presume the target person has (Nisbett & al., 1973). This also has been shown with distributed teams in a more recent study conducted by Cramton (2001; Leinonen & Järvelä, 2006, Article III). Cramton investigated 45 distributed student teams who took courses which included collaborative learning tasks. The analysis of the students' reports about their studying as distributed teams revealed that because the students failed to share and remember information about the remote students' problem solving situations and contexts, they tried to rationalize others' actions by evaluating, for example, their stable personal features such as nationality. In other words, working across distributed geographical locations decreases the situational information that collaborators have about each other. The dispersed locations bias evaluations of causes of behavior toward dispositional explanations rather than situational explanations (Cramton, 2002).

In addition to attribution, perspective-taking has been proposed to be an important process when we try to understand others' knowledge and ways of thinking about shared tasks. In the attribution research approach the research subjects are asked about the likely psychological processes that may have caused the others' prototypic behavior or thoughts. When considering the perspective-taking research approach, the focus is primarily on other people's likely thoughts, or in other words, making assumptions of others' minds (Bromme & Nückles, 1998; Jost & al., 1998; Chi & al., 2004). This has been noted especially in learning studies on collaborative problem solving. For example, Hausmann, Chi and Roy (2004) argued that in collaborative learning there are three mechanisms which stimulate an individual's learning. The mechanisms are self-directed explaining, as

well as other-directed explaining and social construction of knowledge. In all of these three mechanisms it is important that an individual can recognize others' perspectives considering the shared problem which is expected to be solved collaboratively (Shirouzu & al., 2002). Recognition of others' perspectives provides the collaborating individual with a possibility of comparing others' knowledge to the individual's own knowledge. This instead provides the individual with a possibility to self construct a new knowledge representation. Then she or he can explain it to others and contribute to the constructive discussions with the new knowledge representation, which may not have been presented yet by the other group members (Shirouzu & al., 2002). Ideally, this is the process which hopefully occurs also within distributed teams in which expert team members have to collaboratively solve complex problems. There are some indications that in collaborative problem-solving varying expertise between team members is related to perspective-taking as well, which is discussed in more detail below.

Within cognitively oriented learning studies, perspective-taking between different experts has been investigated by Chi, Siler and Jeong (2004) and Bromme and Nückles (1998). In a study of peer-to-peer tutoring Chi *et al.* (2004) found that when an expert evaluates other experts' or novices' knowledge she or he uses diagnosis and assessment as evaluation strategies. Diagnosis is the form of evaluation which forces the evaluator to take the perspective of the other's knowledge. In assessment the degree of incorrectness between the evaluator's own knowledge and others' knowledge is in focus (Chi & al., 2004).

Bromme and Nückles (1998), instead, studied medical doctors and nurses when they together planned a prognostic judgment considering a patient. Based on analysis of interview data, Bromme and Nückles concluded that both the doctors and the nurses showed quite good perspective-taking with respect to the sources of information which was relevant to the prognostic judgments. In terms of their communication, the results showed that nurses seemed to perceive a commitment to achieving a mutual understanding between them and the doctors in communication. However, for the doctors such a commitment to achieving mutual understanding in communication was not found. In addition, the doctors had no idea how the nurses thought about the prognostic judgments that the doctors presented concluding their communication with the nurses. This indicates expertise and roles are related to perspective-taking and commitment to establish mutual understanding in communication (Bromme & Nückles, 1998). These findings suggest that when investigating interpersonal evaluation of knowledge it

is important to go ‘beyond’ communication and to investigate strategies whereby an individual evaluates others’ knowledge.

In short, the research discussed above shows that, in addition to communication, there is a need to understand the cognitive level of the situations in which individuals are expected to construct new knowledge collaboratively. However, in addition to evaluation of others’ knowledge, evaluations concerning the knowledge which is already shared are also needed (Kraut & Higgins, 1984; Jost & al., 1998). The next chapter contains a discussion focusing on how knowledge, which is presumed to be shared between the members of a team, is conceptualized in studies in which social knowledge construction in a collaborative learning situation has been the focus.

2.3.3 Evaluating shared knowledge

In order to construct new knowledge in collaborative learning the participating individuals have to evaluate what the other participants are thinking, as well as what knowledge they already share. Evaluation of shared knowledge helps them to coordinate their actions related to the shared task and contribute to discussions with new knowledge representations (Kraut & Higgins, 1984). Various concepts have been used to describe the shared knowledge which affects both the process and the outcome of collaboration (Thompson & Fine, 1999; Mulder, 2004; Akkerman & al., 2007). For example, shared knowledge has been defined in terms, such as, team mental model (Klimoski & Mohammed, 1994; Levesque, Wilson & Wholey, 2001; Lim & Klein, 2006) common ground (Clark & Brennan, 1991; Beers & al., 2006), or distributed cognition (Hutchins, 1995). Generally, the common factor for all these conceptions is that there is an expectation for knowledge representations which are shared and similar to the members of a group (Thompson & Fine, 1999). What distinguishes these concepts from each other is, for example, their definition of where the shared knowledge representation is localized; knowledge may refer to the individual team member or social activities between team members (Akkerman & al., 2007).

In this study the conceptualization of shared knowledge follows the studies of collaborative learning and work (Suchman, 1987; Barron, 2003; Beers & al, 2006; Kirschner & al., 2006), in which it is argued that shared knowledge is more than a founded structural shared outcome or feature of minds. Instead, shared knowledge is tied to situated activities and is developed thorough complex situated interrelations between team members. In practice, when they search, collect and

share resources relevant to their problem-solving, they construct knowledge which is shared between them. In beneficial collaborative learning the participating individuals should be aware of this process of collaborative problem-solving (Barron, 2003; Beers & al., 2006; Leinonen, Järvelä & Häkkinen, 2005, Article II). For example, Barron (2003) showed how essential joint attention is in successful collaborative learning. Joint attention does not have to be maintained all the time when working together, that is, individuals of a group can perform tasks individually during their collaborative learning project. But to achieve a solution to their task, together they should pay joint attention to the shared task at the solution-critical times. This means that each team member should have knowledge concerning the teams' collaborative working processes in order to participate in discussions especially during these solution-critical times (Barron, 2003). Therefore, collaborating team members have to constantly evaluate what knowledge they share considering their work processes and shared task in order to act effectively in their team. However, these evaluations may not always be correct, which means that and an individual team member holds an idea of 'a presumed shared knowledge' (Bromme, 2000).

Taken together, theories about interpersonal evaluation of knowledge have concluded that individuals have to take others' perspective into account to construct knowledge collaboratively. In addition, there is a need to evaluate shared knowledge considering the process of collaborative knowledge construction. The current thesis focuses especially on distributed team members who have together constructed new knowledge for their shared tasks. However, in an authentic teamwork situation the team members have different backgrounds, they represent different experts with different working histories, which might affect how others' perspectives are evaluated (Bromme & Nückles, 1998; Jost & al., 1998). Therefore, in this thesis the aim is to go beyond communication and to understand the bases on which individuals draw conclusions about others' knowledge and their shared knowledge considering their collaborative task. It is expected that distributed team members try to take others' perspectives, although they do also assign attributions to team members considering their areas of expertise. In addition, in order to work and communicate effectively, they try to understand their shared collaborative knowledge construction process. Figure 1 below gives an overview of the strategies which are used in order to take others' perspectives into account in collaborative team work.

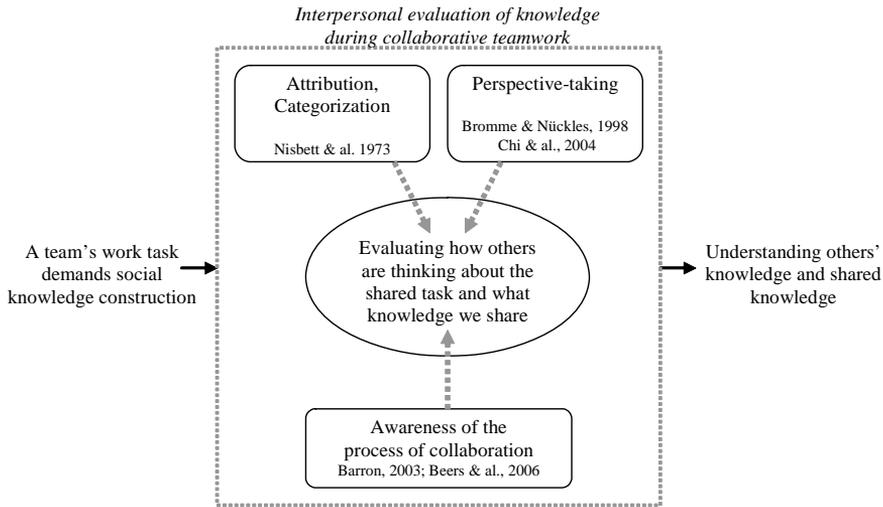


Fig. 1. Interpersonal evaluation of knowledge as a part of collaborative teamwork.

2.4 Supporting interpersonal evaluation of knowledge

In this section the challenges of interpersonal evaluation of knowledge and possibilities to support it in the context of computer-supported collaborative learning are discussed in more detail. The question of how members of a learning group (Jeong & Chi, 1997; Barron, 2003; Fischer & Mandl, 2005; Dillenbourg & Traum, 2006), or a work team (Derry & al., 1998; Derry & al., 2000; Fiore & Schooler, 2004) construct new knowledge to solve their shared problems or tasks has been paid a lot of attention recently. When members of a team have similar knowledge representations of the task at hand, it can be expected that collaboration will be more effective by means of communication (Clark & Marshall, 1981) and the problem will be solved more effectively than if group members do not share knowledge (Rochelle, 1992; Fiore & Schooler, 2004). To show the benefits of collaborative group work, it has been pointed out, especially in learning oriented studies, that collaboratively constructed group performances include a higher frequency of abstract knowledge representations than the performances of isolated individuals (Schwarz, 1995; Shirouzu & al., 2002).

However, research and practice show that new knowledge is not always achieved in these settings, especially if collaborative knowledge construction is expected to be conducted in computer-mediated communication (Guzdial &

Turns, 2000; Kreijns, Kirschner & Jochems, 2003; Leinonen & Järvelä, 2006, Article III). Therefore, there is a need to find new methods for collaborative knowledge construction in complicated work environments with computers and team members who work together from a distance. The question of how collaborative knowledge construction can be supported with technological tools has especially been studied in the research fields of Computer-Supported Cooperative Work and Computer-Supported Collaborative Learning.

2.4.1 CSCW and CSCL: Focus in collaborative knowledge construction

Teamwork which is supported with information technology has been the general research interest area in Computer-Supported Cooperative Work (CSCW). In CSCW the focus is on, for instance, how affordances of technological media affect the initiation of discussions, establishing common ground, and maintaining awareness of potentially relevant changes in the collaborative environment (Kraut, Fussell, Brennan & Siegel, 2002). This focus is close to the basic idea of Computer-Supported Collaborative Learning (CSCL), which concerns studying how people are able to learn together with the help of computers (Stahl, Koschmann & Suthers, 2006). Briefly, the focus of both CSCW and CSCL is to understand how new knowledge is achieved with the help of networked computers in situations which have a social base.

What separates CSCW and CSCL research focuses is that in CSCL the research subjects' activities are often integrated into, for instance, their personal motives and knowledge construction (e.g. Järvelä & Salovaara, 2004; Lipponen, Rahikainen, Lallimo & Hakkarainen, 2003). In other words, emphasis is on learning and factors affecting learning outcomes. Instead, in CSCW the empirical research interventions can also be conducted with workers whose task is to take care of routines and new knowledge is not expected to be constructed at all as an outcome of their teamwork (Schmidt, 2001; Heath & Luff, 1996). However, as knowledge work and geographically distributed teamwork increase, it has become important to understand how new knowledge can be constructed and how shared problem-solving processes can be supported in these settings as well. Therefore, what we learn in CSCL studies about collaborative knowledge construction can provide us with important information on how we should design collaborative teamwork settings as well. Even though CSCL research has traditionally been concerned with the world of education, it has become an emerging branch in

workplace learning studies as well (Stahl, 2006; Tynäjä & Häkkinen, 2005; Leinonen & al, 2005; Bromme, Jucks, & Runde, 2005).

2.4.2 Challenges of knowledge construction in CSCL

Recent studies on knowledge workers have shown that they almost always apply their expertise in complex social settings, with a wide array of technologically advanced tools. Most of the current computer-mediated communication systems allow the workers to send an e-mail message, read or post a message on the message board and have a discussion with someone else using an audio connection or a chat room (Finholt, Sproull & Kiesler, 2002). However, even though these software and computers are easy-to-use and they have effective capacities to process large amounts of information, there seems to be several pitfalls which may negatively affect the construction of new knowledge. For example, there might be a lack of social information such as a feeling of belonging to the team (Kreijns & Kirschner, 2004). In addition, Lipponen, Rahikainen, Lallimo and Hakkarainen (2003) showed that in CSCL contexts there is often a lack of engagement in sustained, connected and high-quality discourses in technological CSCL environments. Cramton (2001), instead, identified the uneven distribution of unique information as an important communication problem inherent in distributed team arrangements. Evaluation of what others think about the shared task at hand seems to be especially difficult if communication takes place in an online computer environment and is asynchronous in its nature (Kreijns, 2004; Dillenbourg & Traum, 2006).

In addition, considering the outcomes of collaborative learning, Fischer and Mandl showed in their study (2005) that when discussions between higher education student pairs in a collaborative learning situation were mediated with a synchronous computer environment, the relation between shared and unshared knowledge was less than 1:5 after studying together in the computer environment. Overall, the studies introduced above show that when individuals collaborate as a team to solve a shared task, it is not self-evident that collaboration leads to the evaluation of others' knowledge representations and conclusions about what is known by all group members. A lack of face-to-face communication seems to have a negative effect on effective social knowledge construction and therefore the use of tools which support interpersonal evaluation of knowledge might have several benefits for collaborative knowledge construction in CSCL and CSCW situations.

2.4.3 Pedagogical models and technological tools for enhancing collaborative team work

In this study a pedagogical model and a visualization tool were designed and developed to support interpersonal evaluation of knowledge in a context of distributed team collaboration. Recent studies on scripting collaborative knowledge construction with a pedagogical model have shown that in a structured condition better learning outcomes are achieved than in the non-scripted condition (Weinberger, Stegman & Fischer, 2005; Mäkitalo, Weinberger, Häkkinen, Järvelä, & Fischer, 2005; Rummel, Spada, Caspar, Ophoff & Schornstein, 2003). Considering this possibility, several various scripts and models have been presented, especially for computer-supported learning situations (Järvelä, Häkkinen, Arvaja & Leinonen, 2003; Dillenbourg & Jerman, 2006; Fischer, Kollar, Mandl & Haake, 2007; Kirschner & al., 2006). For instance, Beers *et al.* (2005) showed that in computer-supported collaboration, instructing participants to explicitly verify and clarify contributions, increased their negotiation of common ground, which instead was related to the success of their collaborative team work. These findings encourage the idea that pedagogical guidelines, or models, can also be supportive tools for a distributed team which aims to construct new knowledge collaboratively. In the current dissertation study a working model was designed for distributed team collaboration. The aim was to increase the distributed team members' awareness of their collaborative working processes (Leinonen & al., 2005, Article II).

In addition to pedagogical guidelines, various kinds of computer software have also been designed to support learning in CSCL and CSCW situations. For instance, in the CSCW approach, a lot of attention has been paid to issues of group awareness (Kraut & al., 2002). Group awareness considers an individual's awareness of the other members of the group, in other words, where they are and what are they doing in the shared workspace. Typically this aspect is adopted to CSCL applications as well. However, as showed by Kreijns (2004), collaborative construction of new knowledge can and should also be supported with other software, like those which facilitate the emergence of the social relationships (e.g. roles) amongst the team members. In addition, in learning situations there are also other necessities than a need to deliver material and to show who is working with some information. There is a need to support collaborative reflection of this information (Stahl, 2006). It has been argued that in the case of different expert

workers, evaluations of others' perspectives should also be supported (Bromme & al., 2005).

In this study a visualization tool was developed to facilitate interpersonal evaluation of knowledge (Article III and IV). The main design ideas for the visualization tool came from the Experience-Sampling Method (Csikszentmihalyi & Larson, 1987). The goal of designing the tool was to support the externalization of each individual's point of view considering the shared task which would enhance an individual's understanding of how others think about the shared task at that moment and what knowledge is shared and agreed upon. In other words, the tool offered a possibility to evaluate others' knowledge in other ways in addition to reading asynchronous computer messages or e-mails.

In conclusion, it seems that interpersonal evaluation of knowledge in distributed team collaboration constitutes several strategies, such as attribution, perspective-taking and evaluation of the team's shared knowledge. However, for distributed team members it is challenging to view a situation from others' perspectives and then contribute to discussions, since it is difficult to examine the remote team members' positions and adopt their knowledge levels. Hence, new methods to enhance collaborative knowledge construction in these settings are needed. To discover these methods, a better understanding of the interpersonal evaluation of knowledge as a mediating process between social and individual knowledge planes is demanded.

3 Aims of the study

The main aims of this doctoral thesis are to study interpersonal evaluation of knowledge in the context of distributed collaborative teamwork and to develop ways to support it. Following the studies on collaborative learning, in this study it is expected that distributed team members construct new knowledge through cycles of displaying and articulating their individual points of view (Rochelle, 1992; Derry & al., 1998), which demands interpersonal evaluation of knowledge representations (Shirouzu & al., 2002; Bromme, 2000). Through interpersonal evaluation of knowledge individuals are able to compare their own knowledge representations to others' knowledge representations, and in that way to draw conclusions about what knowledge is shared between the group members (Shirouzu & al., 2002) and to coordinate collaborative activities (Barron, 2003).

This study constituted three empirical experiments. The first experiment was conducted with upper elementary school students. The results showed that there are problems in the interpersonal evaluation of knowledge in the context of computer supported collaborative learning. The Experience Sampling Method (Csikszentmihalyi & Larson, 1987) was used in the first experiment which gave the idea to adopt some points of it into the second and third empirical experiments. The other two studies were conducted in distributed team settings.

The detailed aims of the current thesis are presented below (numerals I-IV referring to scientific articles belonging to this thesis):

1. The first aim is to understand interpersonal evaluation of knowledge in the context of distributed collaborative teamwork by exploring how an individual interprets his or her contribution to computer supported collaborative learning discussions. (I, II)
2. The second aim is to investigate how individuals evaluate their own, others' and shared knowledge in distributed collaborative teamwork (III, IV)
3. The third aim is to develop a working model for distributed team collaboration and to investigate how it supports an individual's awareness of collaborative working. (II)
4. The fourth aim is to develop a visualization tool for interpersonal evaluation of knowledge and to investigate how it contributes to interpersonal evaluation of knowledge and collaborative work activities. (III, IV)

4 Methods of the study

4.1 Research design

In this study a design-based research approach was used. In recent learning sciences publications design-based research (DBR) has especially been presented as a paradigm which blends empirical educational research with theory-driven design of empirical environments (The DBR Collective, 2003; Barab & Squire, 2004; Confrey, 2006). DBR is a form of interventionist research that creates and evaluates novel conditions of learning (Schwartz, Chang & Martin, 2006). The important difference between traditional controlled experiments and design-based research interventions is that in a traditional controlled experiment the setting is suited to the research intervention, whereas in the DBR the intervention is suited to the setting. In DBR the aim is to understand how, when, and why an innovation works in a setting over time and across settings (Brown & Campione, 1996).

DBR has its roots in design experiments, in which new theoretically constructed models to support learning are iteratively designed and tested in authentic learning contexts (Brown, 1992). In practice, in designed experiments, work in the classroom informs the researcher of what to study in more detail in the laboratory, and work in the laboratory informs the design of the new learning environment in the classroom. The desired outcomes of these iterative research interventions include new insights on the process of learning, which should deepen theoretical understanding, but also develop learning practices with implications (Brown 1992; The DBR Collective, 2003; Schwartz & al., 2006). This is also the main point in a broader approach of design based research.

It has been argued that studies which are conducted purely in laboratory contexts are missing some crucial aspects of educational interventions to support learning (Brown, 1992). To externalize critical mental events of the learning process, the authentic context of learning should be taken into consideration more than just describing the laboratory situations (Lave, 1997; Barab & Squire, 2004). Therefore, especially Brown (1992) and Brown and Campione (1996) started to argue that an understanding of why some educational innovation is sustainable across settings and times can be reached by investigating the local interpretations where learning takes place. That is, the research subjects' own explanations are taken into consideration and are situated in their learning context when drawing conclusions about the implementations and the experiment itself.

In DBR it is important to reflect the relationships among theory, designed artifacts, and practice. Even though in DBR the two essential parts are iterative development and authentic context, the purpose is not to overtake the formulated learning theories based on laboratory experiments. To deeply understand learning processes it is important that previous theoretical claims about learning are embodied in DBR research interventions. In addition, from results gained in DBR relevant factors affecting learning, which can be linked with theories derived from controlled laboratory experiments or randomized clinical trials can be identified (Brown, 1992). Reflection between these theories and findings gathered from DBR interventions can provide us a lens for understanding how theoretical claims about learning can be transformed into effective learning in various settings (The DBR collective, 2003).

This dissertation study follows the main ideas of the DBR research paradigm in the sense that in the three empirical research interventions improvements of previous interventions were taken into consideration in the following empirical interventions. In Figure 1 the general design path between the empirical experiments of the thesis is illustrated. Each of the empirical experiments and study approaches are described in more detail in Articles I-IV.

In the first empirical experiment the current dissertation's study contexts were grounded in terms of collaborative learning. In the interventions a questionnaire following the main ideas of the Experience-Sampling Method (Csikszentmihalyi & Larson, 1987) were developed in order to understand how individuals self explain their contributions to collaborative discussions in a computer-supported collaborative learning situation. The study showed that interpersonal evaluation of knowledge needs to be stimulated when new knowledge is expected to be constructed collaboratively in asynchronous computer mediated communication. For the second empirical intervention a pedagogical model was developed with the research group.

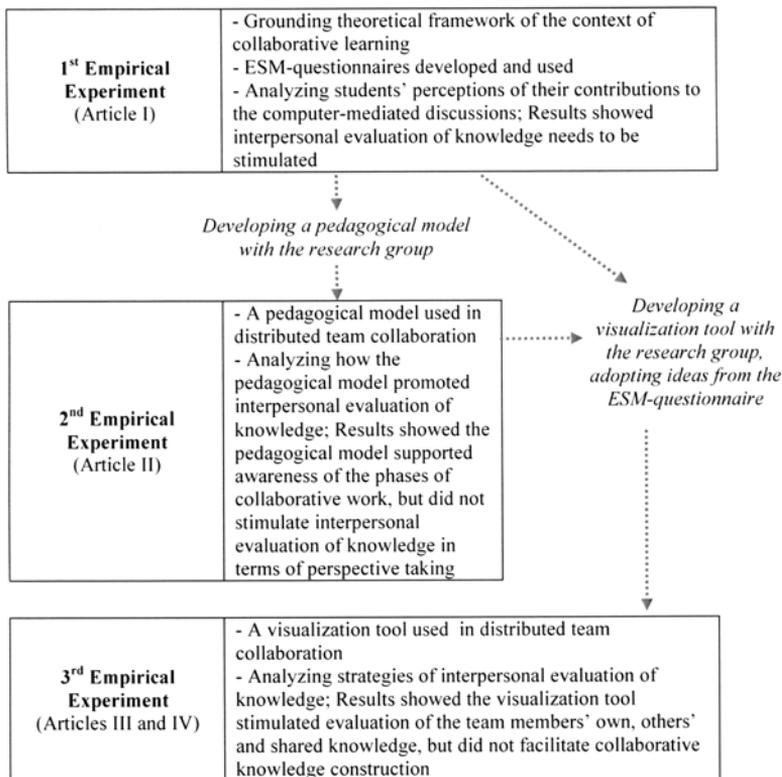


Fig. 2. Characterizing the current dissertation study as a design-based research study in terms of phases of the empirical experiments and designed tools to support interpersonal evaluation of knowledge.

The second empirical experiment was conducted with the distributed team which had to work collaboratively in order to reach a shared understanding of their shared task. The distributed team members used an asynchronous computer environment for communication. During their work they followed the pedagogical model which was aimed at increasing the awareness of collaborative work processes. The results showed that the pedagogical model supported awareness of the phases of collaborative work, but did not stimulate interpersonal evaluation of knowledge in terms of perspective-taking (Bromme & Nückles, 1998) or comparing an individual's own points of view to the others' (Leinonen & Järvelä, 2006).

Encouraged by the results gathered in the first and second empirical experiments, the visualization tool was developed to support individuals'

interpersonal evaluation of knowledge in distributed team collaboration. In addition, the tool was developed to more intensively study how individuals evaluate others' and shared knowledge. The main idea of the visualization tool was adopted from the Experience-Sampling Method (Csikszentmihalyi & Larson, 1987). Finally, in the third empirical experiment the tool was tested by two distributed teams. In short, the results showed individuals compare their own knowledge to others' knowledge when viewing the visualization tool, they evaluate others' knowledge on an individual level and they evaluate their common frame of reference when working collaboratively to achieve their common goal. In the next chapters the research subjects and the methods used for data collection and analysis are summarized.

4.2 Subjects and research settings

This thesis constitutes empirical experiments which were carried out in the contexts of inquiry-based CSCL and computer-supported distributed team collaboration. Altogether there were three research interventions: one in an elementary school context (Article I) and two in a workplace learning context of a global virtual team (Article II) two distributed teams from a municipal organization (Articles III and IV). What unifies these three contexts is that in each of them collaborative knowledge construction scenarios were conducted in computer supported situations in which communication was mainly asynchronous. In each of the studies the research subjects engaged in a goal-directed activity and sought shared understanding of their shared task at hand. The purpose was that the participating subjects had to try to gain new knowledge by sharing their own knowledge through contributing to discussions and working together with written documents. In each of the empirical experiments the discussions were all computer-mediated asynchronous discussions and none of the subjects had any specific roles during collaborative working periods. In addition, participating in these computer-mediated discussions was voluntary.

The subjects of the study reported in Article I were 20 upper elementary school students aged 15 or 16 years. The students worked with their literacy inquiry questions for seven weeks. They were experienced in doing literacy inquiries in the context of CSCL because they had had three inquiry-based literacy learning projects before the study. In other words, they were familiar with the ideas of collaborative learning and the technological environment Knowledge Forum

which was used to support knowledge sharing and constructing during the first empirical intervention.

In Article II a study is reported which was conducted in a global paper industry organization. From that organization one team's work as a distributed team was supported with a pedagogical model that was developed for the study after the first empirical intervention. The team constituted of 19 employees who worked in their local offices situated in six different sites across Africa, Europe and The United States of America. The team was used to work as a distributed team and its members were familiar with their shared www-based workspace, Discendum Optima. The task they were working with during the three-month data collection period demanded discussions and developing materials for their organization's forthcoming merger with a smaller organization. The team had a project manager who was responsible for the production of the team. However, none of the team members had any specific responsibilities in the project they were working with.

The subjects of the studies reported in Articles III and IV were 23 manager-level employees of two distributed teams from a municipal city organization. The teams were chosen to be part of the study because the team members have worked together as distributed teams before the study and they already knew the used technology. The team members participated in the computer-mediated discussions from their local departments which were located at seven different sites in the city area. The municipal organization was going through changes concerning re-organization of the departments. The teams' project tasks dealt with these organizational changes and the team members were expected to collaborate in order to answer the problems caused by the changes. To support the team members' interpersonal evaluation of knowledge during their collaborative work they were offered a visualization tool developed for the study. The tool was embedded in their www-based shared workspace.

4.3 Data collection and analysis

The current thesis consists of four articles in which three empirical experiments are reported. The main data collection methods were qualitative, namely questionnaires, stimulated recall interviews and analysis of the computer traces of the www-based workspaces. For analysis of these data sources qualitative content analysis methods were applied (Chi, 1997), especially the logic of Inductive Category Development (Mayring, 2000) were followed.

In the first empirical experiment (Article I), in order to reach the students' own explanations of their contribution to collaborative discussions, a questionnaire based on the principles of the Experience-Sampling Method (ESM) was used. ESM is intended to gather data in real-time and real contexts about research subjects' inner states such as their reasoning and engagement in the task they are working with (Csikszentmihalyi & Larson, 1987). Recent research has shown that ESM is a promising approach to studying an individual's intra-psychological states such as reasoning, emotions and engagement (Reed, Schallert & Deithloff, 2002) in such a way that the individuals are asked to respond immediately after something has happened, not later, when the participants might not recall what they were thinking and how they were feeling at the time of the incident (Stone, Schwartz, Marco, Cruise, Shiffman, & Hickox, 1998). The idea is to interrupt a student several times at unexpected, random times in natural settings.

In practice, the subjects were asked to fill-in the ESM-questionnaire once per lesson at a time chosen by the experimenter when working with the computer environment in which the students had their collaborative discussions. This paper and pencil questionnaire was the easiest way to conduct the questionnaire without disturbing students' inquiries too much. It took about three to five minutes to fill-in the questionnaire, which included both open questions and the Likert-scaled items measuring the dimensions of the student's perceived situation in a networked collaboration and the process of inquiry. The analysis of the open questions followed principles of qualitative content analysis (Chi, 1997).

In the second experiment (Article II) the distributed team members were presented the pre- and post-questionnaires which focused on clarifying their awareness of their shared collaborative working phases. This was conducted to understand how the model developed for the study affected the individuals' understandings of their collaborative working around the shared task. Finally, in the third empirical experiment, to understand how members of a distributed team explain knowledge which they assume to be shared an assessment tendency was investigated with the Assessment Scale Questionnaire. (Higgins, Kruglanski & Pierro, 2003). The theory of assessment tendency describes how alert an individual is to evaluate alternative goals or means to decide which are best to pursue in problem-solving. It is essential in collaborative learning and working, when new knowledge representations are expected to be constructed by viewing other's points of views reciprocally and contributing to discussions (cf. Shirouzu & al., 2002; Järvelä & Häkkinen, 2002; Fischer & Mandl, 2005). In analysis, it was investigated how members of a distributed team explain knowledge which they

assume to be shared and how an assessment tendency is associated to these explanations (Article IV).

In addition to the questionnaires, a stimulated interview method was used in the third empirical experiment (Ericsson & Simon, 1980) (Articles III and IV). Briefly, Ericsson and Simon have shown that with this method research subjects can give verbal expressions about their thoughts without much of an effect on their performance. When studying thinking in natural learning situations, it is known that using “think-aloud” methods may have effects on performance and thus will not reveal the same processes as those when research subjects are working alone. On the other hand, when using methods where subjects are asked their thinking processes afterwards, such as during an interview, memory biases may affect their recalls. Therefore, in this thesis during the interviews the research subjects were encouraged to recall their evaluations about the other team members’ and shared knowledge with the help of the visualizations presented in the virtual workspace. The stimulated recall materials were given to the research subjects in the beginning of the interviews.

In each of the three empirical experiments the research subjects were offered the www-based shared workspaces Knowledge Forum (Article I) or Discendum Optima (Articles II, III and IV) for their asynchronous discussions, document sharing and document editing. From both of the workspaces the research subjects’ activities were saved to the server computer. Based on the information it was possible to follow, for instance, how often and when the team members contributed to the asynchronous discussions, who has created, edited or saved documents to the environment and who has opened these document or discussion threads. Despite that from computer traces it can be seen who has accessed the documents or discussions threads, it cannot be shown whether the team member actually read the documents. Therefore, direct conclusions about the team members’ working cannot be made from computer traces. However, they showed how actively the distributed team members used the tools provided by the shared www-based workspace (Articles I, II and III).

In Table 1 a summary of the data collection and data analysis in relation to the articles of this doctoral thesis is presented. The table shows in detail the research topic, data sources and analyses of each of the studies reported in articles I-IV.

Table 1. Summary of the data collection and data analysis.

Article Research Experiment	Subjects	Research aim	Data sources	Analysis
Article I 1 st empirical experiment	Upper elementary school students	Students' interpretations of why they contribute to computer-mediated discussions in inquiry- based CSCL	A questionnaire following the ideas of ESM, computer traces of the www- based workspace	Qualitative content analysis, computer traces were followed
Article II 2 nd empirical experiment	Members of a distributed team	Developing a model for virtual collaboration and an individual's awareness of collaborative working	Pre- and post - questionnaires, computer traces of the www-based workspace, project documents	Qualitative content analysis, computer traces were followed
Article III 3 rd empirical experiment	Members of a distributed team	Evaluation of individual's own and others' knowledge	Interviews, computer traces of the www-based workspace	Qualitative content analysis, computer traces were followed
Article IV 3 rd empirical experiment	Members of a distributed team	Explanation of knowledge which was assumed to be shared	Interviews, assessment tendency questionnaires	Qualitative content analysis, analysis of questionnaires with non- parametric statistical tests

In this thesis qualitative analysis methods were used to analyze the evaluation strategies of others' knowledge from the questionnaire and interview data. With this approach the aim was to find how the distributed team members themselves interpret others' knowledge and behavior when they are expected to work to construct new knowledge as in a collaborative learning setting. The results of the qualitative analysis were combined with the analysis of the computer traces to get a more general overview of the distributed teams' actual working. In the third empirical experiment the team members' assessment tendencies were investigated as well, but with non-parametric statistics.

Because in the current thesis the empirical experiments were conducted in authentic distributed team collaboration contexts, there were no control groups which would have worked with the same tasks without designed research interventions described in articles II-IV. Therefore, based on the collected data and analysis methods no evaluation can be made of how much the team members of

the studies learned because of designed research interventions, and how much they are likely to construct new knowledge without these research interventions in their teams. However, as argued by Barab (2006), in design-based research experiments it is important to collect multiple types of theoretically relevant data and conduct ongoing data analysis in relation to theory. In this dissertation the aim has been to understand the interpersonal evaluation of knowledge in its context and find ways to facilitate this using multiple data collection methods. The results gathered with the experiments can be considered more as attempts to understand interpersonal evaluation of knowledge in distributed team collaboration in light of collaborative learning and work.

5 An overview of the empirical studies

This doctoral thesis is comprised of four studies. In Article I it is investigated what are the individual learners' interpretations of their contribution to collaborative learning activities. Articles II, III and IV focused on how evaluation of others' knowledge and explanations of shared knowledge can be supported during collaboration which takes place in distributed team work. In Article II how a pedagogical model supports awareness of the phases of collaborative working is presented and studied. In Articles III and IV the focus is more on the question of 'how distributed team members evaluate other individuals' knowledge and knowledge which they assume to be shared'. In the experiment described in articles III and IV, the developed visualization tool was used to support collaborative knowledge construction.

5.1 Article I

Leinonen, P., Järvelä, S., & Lipponen, L. (2003). Individual students' interpretations of their contribution to the computer-mediated discussions. *Journal of Interactive Learning Research*, 14(1), 99-122.

The study reported in Article I investigated how individual students self interpret his or her own contribution to computer-mediated discussions. The students of the study (N=20) used a www-based computer environment Knowledge Forum to share their knowledge and to inquire collaboratively their literacy problems. The analysis of how the students self reasoned as to why they contributed the collaborative computer-mediated discussions consisted of the analysis of two data sources. From the computer environment it was traced how actively the students read and wrote computer notes to the computer-mediated discussions. The students own interpretations of why they wrote their messages on the computer-mediated discussions were investigated with the questionnaires, which followed the ideas of the experience sampling method (ESM) (Csikszentmihalyi & Larson, 1987). In practice, the students answered the questionnaires in online situations, that is, when they were writing computer notes, and thus participating in the discussions. The answers to the open questions were coded into five categories which were derived from the data. The likert-scaled statements were not used as a data, because the content analysis of the open questions opened up the interpretations about the contribution to the computer-mediated discussions.

The results derived from the analysis of the written computer messages showed that the students' activity in reading the computer notes varied, and did not correlate with the writing activity. By using the computer environment Knowledge Forum it was predicted that the students would collaborate as expected in progressive inquiry learning. However, the computer messages showed that the students mainly answered their own research questions that they had constructed themselves. Article I shows that it is not obvious that all participating individuals share their own knowledge representations with others, or try to construct new knowledge collaboratively, even though they are provided with the tasks and tools to study in that way. The students' own interpretations of their contribution to the computer-mediated discussions mirrored their activity in the Knowledge Forum environment. In other words, a student who was an active contributor usually reported that she or he tries to share her or his own knowledge with the others. On the contrary, a non-active student did not present any interactive goals in his or her collaborative inquiry learning project. This finding was in accordance with the other studies (Lipponen & al., 2003; Guzdial & Turns, 2000) in which it has been shown that when individuals try to create new knowledge together, they have different activity roles which affect the reaching the goal of shared knowledge.

It is concluded that collaborative learning, as a process of participating in the construction of knowledge, is not an equal process for all individuals. To support different learners' individual learning processes, as pedagogical implications it is suggested that individuals could analyze their own contributions, when it is needed and how the others conceptualize the shared task. Pedagogical models and technological tools such as a visualization tool are presented as two possible ways to support construction of new knowledge in computer-mediated collaborative learning situations.

5.2 Article II

Leinonen, P., Järvelä, S., & Häkkinen, P. (2005). Conceptualizing the awareness of collaboration: A qualitative study of a global virtual team. *Computer Supported Cooperative Work*, 14(4), 301-322.

Article II focuses on the question of how modeling of the phases of the collaboration supports individuals' awareness of their collaborative working processes, when they work as a distributed team. A model for distributed team collaboration was designed to support an authentic global team's (N=19)

awareness of their collaborative working processes around their shared task. The model had four phases starting from negotiation of the aim of the project and ending with the evaluation of the project. Before the three-month distributed working period, the team members were introduced to the model developed for the study and the basic ideas behind it. Then the working model was embedded into the www-based shared workspace of the team and the team followed these phases during their distributed team collaboration.

Data was gathered with questionnaires, computer traces of the www-based shared workspace and company documents. The computer traces of the workspace and the company documents showed that, as in the study described in Article I, participation in distributed collaboration among the team members varied greatly, even though in this study the team members' collaboration was especially supported by the working model. Structuring the working processes did not prevent unevenness in participation in computer-mediated collaborative discussions. The study showed that an individual's goals and roles also play a remarkable role in distributed team working where new knowledge should be created collaboratively. However, beside the unevenness in participation in the computer-mediated discussions, the distributed team members followed their teams' collaborative working in the shared workspace. The qualitative analysis of the team members' answers to the open-optioned questions of the questionnaires revealed three awareness aspect of collaboration: awareness of the possibility of collaboration, awareness of the aims of the collaboration, and awareness of the process of collaboration. These aspects closely relate to the ideas of grounding (Beers & al., 2006), where shared common ground is seen as an important factor affecting the creation of new shared knowledge representations.

The study showed that modeling of the collaborative working phases supported the team members' awareness of their distance partner's working processes which dealt with the teams' shared task. It is relevant to stress that awareness of collaboration is more than awareness of a technically constructed environment where individuals work together. It is important for individuals to evaluate others' knowledge and shared working processes as well, and then situate their own knowledge in that shared knowledge (DeVires, 2000; Shirouzu & al., 2002). Based on this study, as an implication it is proposed that creation of new knowledge in collaborative learning and working situations, collaboration needs to be supported both from a cognitive aspect and from social aspects. To support individuals' evaluations of others' knowledge and their awareness of collaborative working processes, more attention should be paid to the social nature of

construction of new knowledge when designing of technological tools (Pea, 1993; Kirschner, Strijbos, Kreijns & Beers, 2004).

5.3 Article III

Leinonen, P., & Järvelä, S. (2006). Facilitating interpersonal evaluation of knowledge in a context of distributed team collaboration. *British Journal of Educational Technology*, 37(6), 897-916.

In article III the aim was to investigate how individuals evaluate their own and others' knowledge when seeking shared understanding in distributed team collaboration. The studies of collaborative problem solving (Roschelle, 1992; Shirouzu, & al., 2002) have shown that in order to reach shared understanding in collaboration, where a shared problem is to be solved together, the participating individuals have to evaluate the other participants' perspectives. Evaluation of others' knowledge was conceptualized in terms of diagnosis, when the evaluator tries to take the perspective of the other individual's knowledge (Chi, & al., 2004).

The study was conducted in an authentic team working context where the subjects (N=23) of the study were manager-level employees of a municipal organization. For this study, a tool which visualized the team members' knowledge to a figure, which was visible for each of the team members, was developed. The core idea of the tool was to facilitate evaluation of others' knowledge, but also to show to the distributed team members what issues they need to discuss more in order to reach shared understanding. With this tool how individuals evaluate their own and others' knowledge in distributed team collaboration was investigated.

The main data collection method was a stimulated recall interview (Ericsson & Simon, 1980). As an additional data set to follow how the visualization tool affected the distributed team collaborative working processes, the computer traces of the teams' shared www-based workplaces were collected. Qualitative analysis revealed that in distributed team collaboration interpersonal evaluation of knowledge included both evaluation of own knowledge and evaluation of others' knowledge. When the distributed team members tried to gain awareness of others' knowledge, they stressed their previous knowledge more in their evaluations than when evaluating their own knowledge. Evaluation of others' knowledge seemed to focus on the stable tendencies of others, such as expertise or professional status. This study showed that it is important to provide distributed team members with the possibility of externalizing their knowledge representations, even though all of

the individuals may not be as active as others, their knowledge of the shared task is also of interest to others trying to complete the shared task.

5.4 Article IV

Leinonen, P., & Bluemink, J. (2007). The distributed team members' explanations of knowledge they assume to be shared. Accepted for publication.

The last study, described in article IV, focused on the individual team members' explanations of the knowledge which they assumed to be shared between them. In collaborative learning studies (Shirouzu & al., 2002; Barron, 2000) it has shown that it is important that participating individuals try to take others' perspectives and assess how their own understanding is related to the knowledge presented in collaborative work. In addition, in research on social cognition (Derry & al., 1998; Fiore & Schooler, 2004) and communication (Clark & Marshall, 1981) it has been pointed out that evaluations about the knowledge which is already shared are also needed to construct new knowledge together. In order to construct knowledge collaboratively individuals have to evaluate what the others are thinking and what knowledge they share. However, in social psychological studies on self-regulation and cognitive goals it has been noted that individuals differ in their disposition to evaluate other individuals' knowledge, and they do not compare others' views to their own views in a similar way (Jost, Kruglanski & Nelson, 1998). Strivings to evaluate others' and shared understandings may depend upon one's motivational state and cognitive capabilities, such as assessment tendency (Higgins, Kruglanski & Pierro, 2003), and therefore there might be differences in individuals' evaluations of others' and shared knowledge in teamwork as well. In this study, in order to understand variations in explanations of shared knowledge, the distributed team members' assessment tendencies were investigated and compared to their explanations.

The data analyzed in article IV was part of the data which was collected during the third empirical intervention (see Articles III and IV). The analysis of the interviews considered in the forth study, however, the descriptions where shared knowledge was explained (for a detailed description for analysis, see Article IV). In addition, the assessment tendency questionnaires were analyzed and compared to the interview data.

The results showed that the explanations of shared knowledge considered the teams' common goals and teamwork activities, and not directly the contents of the

shared task. Explanations of common goals focused mainly to the two levels; the goals in which new knowledge was expected to be created, and, the goals when performing the shared task was stressed. When the team members assumed that they have shared knowledge about their teamwork activities, they explained their teamwork as collaborative activity or cooperative activity. Results also showed that the explanations of the common goals and teamwork activities were associated to the team members' assessment tendencies. The team members who were high assessors stressed that they have common goals to achieve and their distributed team collaboration was a reciprocal process, which demanded sharing of individual points of view to create new knowledge. This is to say that when working with computers collaboratively, an individual's disposition may affect how she or he endorses and contributes to collaborative learning activities in practice (Salomon & Perkins, 2005; Van den Bossche & al., 2006). For future studies this proposes, that as individuals in workplaces decide how they participate in collaborative activities and what they construct from their experiences, describing only their participation practices in teams may provide an insufficient understanding of how new knowledge is created in those settings. An instructional consequence would be to find ways to stimulate the distributed team members to share and evaluate others' knowledge, since each of them may not be highly predisposed to taking the perspectives of others into account.

6 Main findings

In this thesis the aim was to study interpersonal evaluation of knowledge in the context of distributed team collaboration. In an authentic teamwork team members have different backgrounds, they represent different experts with different working histories. This affects how others' perspectives are evaluated. This background information is taken into consideration when others' knowledge is evaluated, but their evaluation may not be presented in discussions considering the shared task (Bromme & Nückles, 1998; Chi & al., 2004).

The other aim was to investigate how interpersonal evaluation of knowledge can be supported in the context of distributed team collaboration using the working model and the visualization tool developed in this study. The pedagogical model and the visualization tool were developed based on the findings gathered from the first and the second empirical experiments. The model and the tool were tested in the experiments with distributed teams. In other words, this thesis builds on design-based research approach. The results showed that with the working model or the visualization tool it was possible to support only some strategies of interpersonal evaluation of knowledge at one time. The main findings are summarized below.

6.1 Findings related to interpersonal evaluation of knowledge in collaborative teamwork

6.1.1 Interpretations of contribution to the computer supported collaborative learning

The results showed that when the distributed collaborators presented reasons why they contributed to the discussions. They reported that their goal was to use collaborative discussions to support their personal inquiries, to ask questions, to share information, or they were asked to contribute to the discussions by the teacher. The first empirical experiment showed also that the students' interpretations of their contribution to their collaborative learning followed their activity in collaborative learning. When the student presented goals which stressed social interaction, she or he was more active also in collaborative learning. For instance, an active contributor reported that she had two reasons for contributing to collaborative discussions: she used the collaborative discussions as a tool to develop her personal inquiry process, but also to share information with other

students. It was possible to identify four different student types to describe differences in their collaboration activity: an active contributor, a non-active contributor, a central comment receiver and an isolated student (Article I).

The first empirical experiment showed also that it is not obvious that all participants begin to share their insights considering the shared task when they are offered a shared computer environment and a shared task which demands collaborative actions. Reading and commenting the other students' notes varied a lot, which indicated that the participants did not try to take others' perspectives into account in a similar way in collaborative learning (Article I).

As showed in the first experiment (Article I), in computer-mediated communication an individual does not necessarily have many possibilities to take others' perspectives into account and then contribute to the discussions with a new knowledge representation, since all of the participants may not be active, and if they are active, their computer messages may only briefly reveal their knowledge about the shared task. However, the second experiment showed that distributed team members have a need to be aware of their aims in the collaboration and their collaborative work processes (Article II). Therefore, more attention should be paid to the question of how to make the collaborating individuals more aware of their own and others' reasons for why they contribute to collaborative knowledge construction, and when they contribute. There is a need to develop tools to support evaluations of others' knowledge and shared knowledge. The findings about the varying goals and activities in collaboration (Article I) encouraged the development of the working model and the visualization tool, with which interpersonal evaluation of knowledge were studied in more detail.

6.1.2 Strategies of interpersonal evaluation of knowledge in distributed teamwork

The third study showed that interpersonal evaluation of knowledge is one of the core processes in collaborative teamwork. As noted also by Bromme and Nückles (1998), the third empirical experiment showed that perspective-taking is an essential cognitive process an individual has when working with different experts to solve a shared task. However, the results showed also that when the team members tried to take others' perspectives into account they evaluated their own task-specific knowledge. Then the other team members' knowledge was compared to an individual's own knowledge. Hence, comparing is used as one strategy to evaluate others' knowledge (Article III). Briefly, the results showed that within

distributed teams interpersonal evaluation of knowledge includes perspective-taking of others' knowledge about the shared task at hand and comparing these knowledge representations to an individual's own knowledge.

The results showed also that when they evaluated others' knowledge, they tried to understand the other team members' expertise or status in the organization (Article III). In other words, in collaborative teamwork the team members use the process of attribution as one strategy when they try to gain knowledge about others' thinking. This finding is in correspondence with Cramton's study (2002), which also showed that the dispersed locations bias evaluations of causes of behavior toward dispositional explanations rather than situational explanations (Cramton, 2002). In other words, when team members try to take others' perspectives into account, they stress previous background information, such as, expertise of professional status.

The empirical experiments conducted within three distributed teams also showed that distributed team members have a need to evaluate shared knowledge about their shared task (Articles II and IV). When the team members explained what knowledge they expected to be shared between them, they did not focus directly on the content or the outcomes of the project tasks. Instead, the third empirical experiment showed that explanations concerning shared knowledge considered common goals of the teams and knowledge about the shared work activities whether they are cooperative or collaborative. In addition, the results showed that especially those team members who were predisposed to evaluate and compare others' knowledge to one's own knowledge stressed that their distributed team collaboration was a reciprocal process, which demanded sharing of individual points of view to create new knowledge (Article IV).

The findings about the explanations of shared knowledge followed the findings of the collaborative learning studies (Rochelle & Teasley, 1995). In these studies it has been shown that in effective collaborative learning one of the solution-critical times is the goal setting and agreeing on the forthcoming work processes. In addition, the team members have a need to evaluate how working around the shared task is proceeding after the setting of the common goal during the collaborative work (Barron, 2003). The empirical intervention with the pedagogical model which was developed especially to support distributed teamwork indicated that a model developed from the collaborative learning point of views is useful in authentic teamwork situations as well. It encourages the distributed team members to evaluate their common goals and shared work processes.

Taken together, the results suggest that when we evaluate others' inert states and thinking, we probably use several cognitive reasoning strategies to create an image of what the other individual thinks about the certain task. The interpersonal evaluation of knowledge in distributed team collaboration focuses on evaluations of other individuals' knowledge as well as presumed shared knowledge. The findings of the empirical experiments indicate the processes of perspective-taking and comparisons to our own knowledge representations. In addition, in team working important processes are attribution and categorization. These evaluation strategies fulfill each other when we try to take the perspectives and shared knowledge of others into account. It can be concluded that interpersonal evaluation of knowledge includes complex cognitive processes. In everyday work situations we just may not be aware of these various cognitive reasoning processes with which we try to understand others' behavior and thinking (Jost & al., 1998; Bromme & Nückles, 1998).

6.2 Findings related to development of the working model and the visualization tool

6.2.1 The working model supported awareness of collaboration

The results of the research experiment with the working model indicated that modeling the distributed team's collaborative problem solving in their shared virtual workspace supported their awareness of collaboration in terms of the awareness of the possibility for collaboration, awareness of the common goals of the collaboration and awareness of the actual collaborative work process. Despite that the model was designed to be rather simple in order to avoid 'over-scripting' the team's collaborative work (Dillenbourg, 2002), the model supported their awareness of collaboration in a sense that collaboration was seen as a shared construction process of new knowledge by the team members (Article II).

There are promising results on how structuring supports collaborative problem-solving in computer-mediated learning situations. For example, Rummel *et al.* (2003) and Weinberger *et al.* (2005) have showed that with scripts university students can reach better learning outcomes in computer-supported collaborative learning. These studies and the findings of the second empirical experiment of this study (Article II) proposes that planning of work processes from the collaborative learning point of view is worthy of consideration in future studies. The results gathered with the working model suggest that it is not enough to support

workspace awareness with technological tools. Instead, awareness of collaboration needs to be taken into consideration when designing distributed teamwork settings.

6.2.2 The visualization tool stimulated interpersonal evaluation of knowledge

The visualization tool stimulated the distributed team members' evaluation of others' knowledge. The results of the third empirical experiment showed that when viewing the visualizations, the team members evaluated other individual team members' knowledge, but also tried to gain a group-level view (Article III). This means that they drew conclusions as to what knowledge is already shared and what is not between the team members. Noteworthy is that the distributed team members explained knowledge which they assumed to be shared knowledge, they focused especially to teamwork activities and common goals, and not directly to the content of the shared task, which was asked with the visualization tool (Article IV). Also in the studies of collaborative learning it has been argued that to coordinate collaboration the participants have a need to understand how collaborative their work activities are and what is their common goal (e.g. Barron, 2003). Thus, the visualization tool stimulated interpersonal evaluation of knowledge in an individual level, when some certain team members' knowledge was evaluated (Article III), but also in a group-level, when the team's shared knowledge was explained (Article IV)

Despite the explanations about the shared knowledge, the findings revealed that the visualization tool did not contribute to construction new shared knowledge about the shared task among the team members (Article III). The asynchronous discussions became less frequent after the visualizations. These results correspond with earlier work on collaboration with the visualisation tools, which have showed that graphical representations might change an individual's knowledge construction processes (e.g. Fischer, Bruun, Gärsel, Mandl, 2002), but may not facilitate the construction of shared outcome to the task at hand.

To sum up, the results showed that interpersonal evaluation of knowledge with the visualization tool included three strategies: evaluations of others' knowledge, comparisons between an individual's own and others' knowledge, and explanations of knowledge which was assumed to be shared. Even though the visualization tool stimulated these strategies, it can be concluded that visualisations of varying knowledge representations concerning the shared task do

not necessarily encourage working toward shared knowledge, nor do the spaces for discussions per se (Fischer & Mandl, 2005).

Since the ways in which we rationalize others' thinking and behavior seem to be complex processes, it is challenging to support with some specific tool. The results of the empirical interventions with the authentic distributed teams showed that with a working model or a visualization tool it was only possible to support some strategies of interpersonal evaluation of knowledge at the time (Articles II, III and IV). However, the results suggest that these complementary evaluation strategies are still able to be supported with pedagogically oriented models and technological tools.

7 Discussion

7.1 Interpersonal evaluation of knowledge – a multidimensional process

Several studies have been conducted from different theoretical traditions in order to understand interpersonal evaluation of knowledge. However, it is still challenging to explain the strategies which we use when we try to view some situation from others' perspectives. In cognitive research on individuals' perspective-taking strategies, the fact that learning takes place in a social context and communication is necessary, has not been paid too much attention. This is especially reflected when practical implications of collaborative learning and work environments are considered – there is a lack of practical suggestions or technological tools which are designed to support evaluation of others' points of views, for example when shared goals should be set in distributed teamwork. On the other hand, in studies following traditional socio-cultural research an individual's cognitive processes, which may not be externalized on a level of communication, are often overtaken. Those theoretical conclusions do not explain the 'hidden' strategies which are used when evaluating others' knowledge.

This thesis views the two theoretical traditions, cognitive and socio-cultural, as complementary. Interpersonal evaluation of knowledge is seen as a multidimensional process which is needed to construct new knowledge representations in a social learning situation. The dimensions which affect the evaluation of others' knowledge are externalized knowledge presented in communication, and, knowledge which may not be externalized in communication. In other words, knowledge which is presented in discussions, and an individual's conceptualizations about, for instance, others' expertise or status in the organization, which may not be presented directly in discussions, are both used when individuals try to view the situation from the perspective of others. It is suggested that future research conducted either from the cognitive tradition or socio-cultural tradition could enrich both points of view using the theoretical concepts from the other tradition, of course by carefully conceptualizing the used theoretical frames first (Derry & al., 1998; Akkerman & al., 2007). Different levels of analysis are needed to understand how interpersonal evaluation of knowledge is related to the interactions between team members and with technological resources in practice.

7.2 Methodological considerations

One intention of design-based research in learning sciences is to investigate broadly the nature of learning in a complex context (Brown & Campione, 1996). It can be seen as an interventionist rather than a naturalistic research approach (Confrey, 2006). According to the Design-Based Research collective (2003), DBR provides promises for exploring possibilities for creating novel learning environments, because researchers and other designers, such as team leaders or teachers, who are involved in a design process, understand the demands of real world situations. In addition, when a member from an authentic learning context participates in the design process of the educational innovation, the innovation can be adopted into that context more easily than if the innovation was received as an instruction from, for instance, policy makers (The DBR collective, 2003). To put it briefly, one of the main benefits of DBR is that research experiments are productive to create pedagogical innovations. However, because the pedagogical innovations are designed to a particular learning context, there is a need to consider how generalizable are the findings gathered in DBR experiments.

In this thesis a working model and a visualization tool was developed and embedded into the authentic contexts of distributed collaborative teamwork in order to support and conduct empirical interventions to investigate interpersonal evaluation of knowledge. The design of the model and the visualization tool based on the first empirical intervention (Article I) and on recent studies on collaborative learning (Barron, 2003; Beers & al., 2005; 2006). Even though intervention research approaches such as DBR can produce innovations to support learning in various contexts, it has been argued that the method has not been ideal for producing generalizable causal knowledge (Shavelson, Phillips, Towne & Feuer, 2003; Schwartz & al., 2006). If empirical experiments are conducted in authentic learning contexts, as in this study in the classroom and in the organizations with authentic distributed teams, classic experimental research methods, such as, random assignment and hypothesis testing statistically cannot be utilized directly. Considering this problem, Schwarz *et al.* (2006) have concluded that the design methodologies are high on the innovation development, but low on efficiency. This means that their goal is often discovery and the creation of novel practices, but they are poor at developing efficient tests and descriptions of a causal hypothesis about learning. Therefore, if one of the main intentions in design-based research is to refine generative or predictive theories of learning, then in future studies more attention should be paid to a balance between an innovation and

efficiency in terms of developing theoretical hypothesis about learning (Schwartz & al., 2006).

Considering the efficiency of empirical experiments conducted in this thesis, it is agreed that there are problems in producing generalizable causal theoretical hypotheses. The empirical interventions (Articles I-IV) were conducted in authentic learning and working contexts with the small number of subjects. This means that no statistical tests can be presented as supportive arguments for findings about the visualization tool or the working model. However, what advocates the DBR approach in this thesis is the ecological validity which was gained with the authentic research contexts, where interpersonal evaluation of knowledge was truly needed to solve the shared tasks at hand. Following the arguments presented by Brown (1992), it can be stated that the teams were 'messy' learning places where experimental control, even if possible to exercise, would have simplified the research settings to the point that ecological validity would have been lost. For example, the results gathered with the visualization tool showed how important it is in our interpersonal evaluation of knowledge to understand others' backgrounds such as professional expertise. In a controlled experimental setting, for instance with students representing the same discipline, this finding may have not been come out.

One important methodological issue in workplace learning studies concerns also the measurement of learning outcomes. The learning tasks, or in practice, the distributed teams' work tasks, were all ill-defined tasks. This means that it was not possible to use ready-made pre- and post-tests to measure the research subjects' learning achievement. Instead, qualitative content analysis method was used to find out the strategies which are used in distributed teamwork when team members try to take others perspectives into account.

The content analysis was used to analyse the open questions of the questionnaires (Articles I and II) and the stimulated recall interviews (Articles III and IV). In the content analyses systemic analysis procedures were used and the intersubjectivity agreements between two researchers were calculated, which are the two basic elements in qualitative research procedure when objectivity is searched (Neuendorf, 2002; Silverman, 2001). Even though this method showed the strategies of interpersonal evaluation of knowledge, the generalization of the findings is still limited, and the learning effects still remain unknown. Therefore, a future challenge is still to find methods with which generalizable theoretical hypothesis can be created. In workplace learning studies this could mean, for example, studying larger number of subjects.

A few more words about the limitations of the stimulated recall interview method need to be said. Nisbett & Wilson (1977) have argued that what is reported by the interviewees depends on their own perception of their understanding. It has been shown that if interviewees are unsure about the topic, which is asked in interview, they may choose to report nothing or give an alternative explanation that seems more plausible than the real explanation about what they are thinking about the topic. In addition, learning processes are also difficult to reflect (Nisbett & Wilson, 1977). The other problem deals with the fact that verbal reports, such as interviews, may cause changes to the distributed team members' performance (Nisbett & Wilson, 1977; Ericsson & Simon, 1980). In the third empirical experiment a stimulated recall interview method (Ericsson & Simon, 1980; 1998) was used in order to collect data, in which the distributed team members themselves verbalize their ongoing thoughts without changing their thought processes. The visualizations were used to stimulate the distributed team members to tell how they evaluate the other team members' and shared knowledge. The interviews were conducted in the end of the virtual working period (for a detailed description of the method see Article III). Even though this method opened up the strategies the team members used when they attempted to take others' perspectives into account, it is still relevant to ask whether the team members really used these strategies in practice during distributed collaboration. Therefore, it can be concluded that the validity of the findings gathered from the interviews would be better if traditional observational and experimental methods had been used as well. In future studies data collection methods could include, for instance, field observations and think-aloud methods with which more reliable conclusions about the strategies of interpersonal evaluation of knowledge can be reached.

7.3 Considerations for practical implications and future research

The continuous changes in our society and demands of knowledge work have proposed a question concerning whether formal education can provide individual team members the competences they will need in their work. In fact, it has been argued that in the future, both in formal education and in workplaces, the best way to cope through ever-changing environments and societies is an individual's and a community's continuous learning (Sawyer, 2006). However, one of the barriers to support, for instance, knowledge workers' learning in a distributed team, is the fact that there are no suitable and adaptive pedagogies for CSCL in workplaces. The technology seems to be ready for various different kinds of information sharing,

but engagement in effective learning practices seems to be more problematic. This fact forms the barrier against achieving effective and efficient asynchronous distributed learning groups. This is an important challenge for learning scientists who are looking for ways how to improve learning procedures and outcomes in these settings. Since the innovations in workplaces are characterized as more and more independent by their place and time, there is a challenge to find innovative instructional methods which make learning more effective, efficient and appealing (Kreijns & Kirschner, 2004). Briefly, there is a need to develop pedagogies for workplace learning activities as well (Billet, 2004).

One example of such a pedagogical intervention in workplaces could consider stimulating team members to move from monitoring to active engagement in collaborative knowledge construction. In a recent study on students' perceptions on constructivist learning environments, it was stated that if we aim towards some ideal about optimal learning then we should take more into consideration in regard to how the actual learners, such as team members, self perceive their learning environment and practices (Gijbels, Van de Watering, Dochy & Van den Bossche, 2006). Educational interventions will be less effective if we don't succeed to modify the learners' perceptions of the learning environment in the intended way, because participating in learning activities and learning outcomes follow their perceptions' about their learning environment (Gijbels & al., 2006). In other words, to strengthen team members' perceptions about a teamwork as collaborative knowledge construction, and consequently the outcomes of the team's work, they should be offered first hand experiences about such work practices, in addition to stimulating instructions and guidance about how to work as a part of a collaborative team. For instance, it is known that engaging team members in social knowledge construction situations is important for the forthcoming outcomes of a team (Prichard, Stratford, & Bizo, 2006). Therefore, they could be instructed about why it is important to take others' perspectives into consideration, and why it is important to engage in the process of collaborative knowledge construction in other ways than just monitoring. In summary, there is a need to further investigate the ways in which pedagogical models and instructions can be used to support innovative teamwork so that collaboration is still truly innovative leading to resolutions of complex problems.

In this study the two main 'innovations' to support learning were designed: the working model for virtual team collaboration and the visualization tool to support interpersonal evaluation of knowledge. One global team followed the working model for three months. However, since there is a possibility that the team

members will change their positions and projects will develop further, the intervention offered with this empirical study will not necessarily have a long lasting effect on the team's working culture. Therefore, scaling-up of workplace pedagogy requires the engagement of the team's key personnel in the pedagogical development of their work processes. To turn individual team members' learning within teams into continuous learning by teams, it is necessary to have an environment where construction of new knowledge and distribution of expertise are guided in the right direction by, for instance, a manager or a leader. Developing the teams' collaborative work culture demands the support of the entire work community.

Teamwork in distributed settings is increasing (Maznevski & Chuboda, 2000). However, it is still rare that shared virtual workspaces or technological tools instruct team members' in their collaborative problem solving, or that shared virtual workspaces are even designed to support some known mechanisms of collaborative learning, such as setting of common goals. Instead, most of the used computer environments or virtual workspaces focus on fluent knowledge sharing by means of document editing and knowledge managing. However, the findings of this study showed that more attention should be paid to development of tool packages, which provides information to the distributed team members of each other's working phases and solution-critical times. When considering development of such workspaces that would support this kind of awareness of collaborative work, experts from learning and computer sciences are needed. Therefore, for future studies dealing with technological tools which aim to support knowledge construction, it is suggested that the design and implementation of such tools should not be left to learning or computer scientists alone. Instead, joining their field of knowledge to create a learning technology that serves innovative teamwork in various contexts of learning can be fruitful (Kreijns, 2004).

In conclusion, this study showed that interpersonal evaluation of knowledge is one essential mechanism in collaborative knowledge construction. Individuals use several strategies when they attempt to gain insights into other team members' knowledge. However, an increasing amount of knowledge work is needed for further understanding of knowledge construction mechanisms in teamwork settings. There is also a need for practical implications to promote it. This study indicates that it is not enough that we only move from knowledge sharing towards knowledge construction when we organize work settings or spaces for teams. When considering practical implications for workplaces and especially for innovative team work, there is a need to consider how we can facilitate social

knowledge construction with pedagogical instructions and tools as well. It is hoped that this thesis contributes to the understanding of how individuals evaluate new ideas and relate them to conclusions, and furthermore, offers practical implications of how to support distributed teamwork.

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List of original articles

This thesis is based on the following articles, which are referred to in the text by their Roman numerals:

- I Leinonen, P., Järvelä, S., & Lipponen, L. (2003). Individual students' interpretations of their contribution to the computer-mediated discussions. *Journal of Interactive Learning Research*, 14(1), 99-122
- II Leinonen, P., Järvelä, S., & Häkkinen, P. (2005). Conceptualizing the awareness of collaboration: A qualitative study of a global virtual team. *Computer Supported Cooperative Work*, 14(4), 301-322.
- III Leinonen, P., & Järvelä, S. (2006). Facilitating interpersonal evaluation of knowledge in a context of distributed team collaboration. *British Journal of Educational Technology*, 37(6), 897-916.
- IV Leinonen, P., & Bluemink, J. (2007). The distributed team members' explanations of knowledge they assume to be shared. Accepted for publication.

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