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Designing and Investigating Pedagogical Scripts to Facilitate Computer-Supported Collaborative Learning

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Contents

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Abstract

Computer-supported collaborative learning (CSCL) appears as a promising social approach to foster learning. Thus, recent studies have indicated that when learners are left on their own, it is often difficult for teams to engage in productive interactions. Therefore, the use of collaboration scripts as instructional support has been presented as a possibility to trigger productive collaborative activities. This study explores collaboration scripts as a pedagogical method to facilitate group processes in virtual environments at authentic educational contexts. The study thus addressed three major aims: 1) To elaborate theoretical guidelines for design of macro-level (pedagogical) collaboration scripts. 2) To develop methodological tools to analyze group variations in macro-scripted collaboration. 3) To design four different pedagogical macro-scripts and examine how these scripts guide group activities and how the activity of different groups varies despite the same scripted environment.

This study implemented a design-based research approach. The study consists of four interventions (sub-studies; Articles II–V), which modify real-world settings by integrating a theory of computer-supported collaboration into the design of the collaboration macro-scripts. The empirical experiments were conducted to enhance an understanding of group collaboration in macro-scripted conditions. Macro-scripts aim to be flexible resources, which result in a richness of collaborative interactions between participants. Therefore, methods of analysis used in this study were based on the processes developed in socio-cultural studies and were further elaborated through the study in order to better understand what happens in macro-scripted collaboration contexts, and how groups vary despite use of the same scripts. The following general guidelines on qualitative analysis were made and four-step procedure may be used when analyzing groups collaboration in macro-scripted conditions: (1) verifying data, (2) examining whether the groups followed the structure of the script, (3) analyzing if the group work was collaborative or non-collaborative, and (4) comparing the main differences between groups, despite use of the same scripted environment.

In this study, previous research from collaborative learning formed basis for design of the scripts, and different theoretical guidelines (core pedagogical ideas) were used in each of the sub-studies (Articles III–V). There was an assumption that collaboration would be supported by the scripted tasks with the different core pedagogical ideas. The findings indicate that macro-scripts as external support can help students proceed in solving learning tasks. In all the studies, groups followed the script. However, none of the scripts could guarantee equal and high-level collaboration within the teams, and there was also considerable variation between the groups in this respect. The findings indicate that different groups acted differently, regardless of using the same pedagogical core idea and "ideal" scripts. The biggest differences occurred in collaboration (Articles II–V) and the roles assumed in a group (Articles IV and V). According to this study defining and introducing a core pedagogical idea is challenging because of the groups variations. Designing macro-scripts is more complicated than integrating core pedagogical ideas (based on the former research findings) into lesson plans. Findings assign that for different learning goals (learning concrete work skills vs. understanding theoretical concepts) there is a need for different kinds of core pedagogical ideas and external support through which scripts are expected to trigger collaboration. Aside from taking into account the learning goals, this study suggests that learners' characteristics and roles should also be considered in scripting.

This study is in line with the notion that collaborative learning is achieved under unique circumstances and its significance is determined ultimately by learners' interaction and cannot be directly predicted. There is a need to find an optimal level of scripting for different kinds of collaborative learning situations which allow for differences regarding different learners. In the optimal situation, core design principles, different roles assigned, and learners' characteristics (such as engagement, effort and focus) should intertwine. In the future, scripts should support group flexibility and collaboration. On the basis of this, the design of the macro-scripts should focus more on how to engage groups in productive collaboration and how to guide situated collaboration.

Keywords: Collaboration, computer-supported collaborative learning, collaboration scripts, design research

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List of publications

I Kobbe, L., Weinberger, A., Dillenbourg, P., Harrer, A., Hämäläinen, R., Häkkinen, P., & Fischer, F. (2007). Specifying Computer-Supported Collaboration Scripts. *International Journal of Computer-Supported Collaborative Learning*, 2, 211–224.

II Hämäläinen, R. (2008). Designing and evaluating collaboration in a virtual game environment for vocational learning. *Computers & Education*, *50*(1), 98–109.

III Hämäläinen, R., Oksanen, K., & Häkkinen, P. (2008). Designing and analyzing collaboration in a scripted game for vocational education. *Computers in Human Behavior*, *24*(6), 2496–2506.

IV Hämäläinen, R. & Arvaja, M. (2009). Scripted collaboration and group-based variations in a higher education CSCL context. *Scandinavian Journal of Educational Research.* (In press).

V Hämäläinen, R. & Häkkinen, P. (2008). Group variations in scripted collaboration: the case of the Grid script. (Submitted for publication).

In the texts, the original publications are referred to as "articles" with Roman numerals I–V.

The work reported in the three jointly authored empirical articles (Articles III–V) was primarily carried out by the first author. The first author had a significant responsibility in planning and design, conducting analysis and well as in reporting findings. The work reported in the jointly authored theoretical article (Article I) about specification of collaboration scripts has been conducted a joint effort with the CoSSICLE (and MOSIL) team. However, the first author of Article I (Lars Kobbe) was responsible for the co-ordination of the article and had a great impact on it.

1

Introduction and aims of the thesis

This study explores collaboration scripts as a pedagogical method to facilitate group processes in virtual environments at authentic educational contexts. Computer-supported collaborative learning (CSCL) (e.g. Koschmann, 1996) appears as a promising social approach to foster learning. However, computer-supported collaborative learning is a complex phenomenon and often difficult to implement in authentic educational settings (Häkkinen, Arvaja, & Mäkitalo, 2004). Traditionally, CSCL typically relies on "natural" interactions between team members, usually without predefined interaction structures (Strijbos, Kirschner, & Martens, 2004). Thus, recent studies (e.g. Arvaja, 2007; Vonderwell, 2003) have indicated that when learners are left on their own, it is often difficult for teams to engage in productive interactions. Therefore, the use of collaboration scripts as instructional support has been presented as a possibility to trigger productive collaborative activities (Dillenbourg, 1999).

Collaboration scripts aim to improve collaboration through structuring the interaction processes between learners (Kollar, Fischer, & Hesse, 2006). The main idea in scripted collaboration is to provide support and structure for groups in otherwise open learning environments. Scripts aim to foster collaborative learning by shaping the way in which learners interact with one another; for example by sequencing activities and distributing roles. Collaboration scripts are designed to trigger engagement in social and cognitive activities that would otherwise rarely occur, if at all (see, Article I of the thesis; Kobbe, Weinberger, Dillenbourg, Harrer, Hämäläinen, Häkkinen, & Fischer, 2007). However, the research field on scripting CSCL is still young, and theoretical development on scripting is still in its infancy. So far, research has concentrated chiefly on reviewing the connection between micro-scripts and individual learning (e.g. Kollar, Fischer, & Hesse, 2006; Schellens & Valcke, 2006; Weinberger, Stegmann, & Fischer, 2007), whereas much less is known about the effects of macro-scripts (see, Section 3.3.2) on collaboration within groups in authentic learning contexts. This study is one attempt to fill this knowledge gap, as it primarily focuses on macro-scripts as a pedagogical method to facilitate group collaboration in authentic educational settings.

The design of scripts is the crossroad of the educational sciences, psychology, and computer sciences. Yet, finding common ground for researchers from different research traditions has been problematic. Examples of collaborative efforts include The Kaleidoscope MOSIL-project (Mobile Support for Integrated Learning) (see MOSIL, 2004), aimed at integrating expertise from different research fields, and secondly, The Kaleidoscope European Research Team on the Computer-Supported Scripting of Interaction in Collaborative Learning Environments (CoSSICLE), which continued the work on integrating different research tradition in scripting collaborative leaning. CoSSICLE has established a joint research agenda on specification, formalization and implementation of CSCL scripts. The CoSSICLE team combines cross-discipline expertise in educational sciences, psychology, and computer sciences. The author of the thesis has been actively involved in both projects referenced above. The theoretical article (Article I in this doctoral thesis) about specification of collaboration scripts has been conducted as a joint effort with the CoSSICLE-team. This thesis approaches collaboration scripts from an educational science perspective and as a pedagogical method to facilitate learning. The general aims of the thesis are:

1) To elaborate theoretical guidelines for design of macro-level (pedagogical) collaboration scripts.
2) To develop methodological tools to analyze group variations in macro-scripted collaboration.
3) To design four different pedagogical macro-scripts and examine how these scripts guide group activities and how the activity of different groups varies despite the same scripted environment.

2

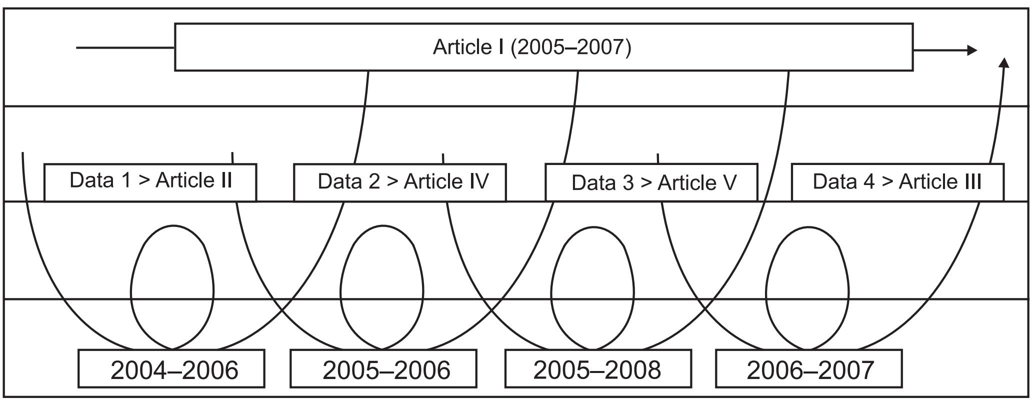
The structure and timeline of the thesis

This doctoral thesis will introduce theoretical guidelines, methodological tools and findings of the empirical sub-studies. Additionally, concluding remarks are made related to the main findings and future prospects for research are discussed. According to Dillenbourg, Järvelä and Fisher (2008), CSCL studies often lay in between an educational psychology oriented research perspective (cognitive studies of individual cognition) and socio-cultural oriented research perspectives (studies of group processes). This study is in between these two research perspectives. Indeed, the roots of the scripts used in collaboration are in cognitive psychology (see, Schank & Abelson, 1977), meaning that individuals' procedural knowledge guides them in specific routine situations. Next, scripts were adapted for studies on cooperative learning (O'Donnell & Dansereau, 1992), in which they were used as an external support to guide group work. Once CSCL researchers looked at new ways to promote collaborative learning, they adopted scripting as a form of supporting collaboration as well.

The aim of the scripts is to engage students in activities, a process which has been found to be effective for collaborative learning. Use of scripts differs from other collaborative learning approaches, chiefly in the fact that it focuses on the specific collaboration activities (for example, solving cognitive conflict) that a group of learners are expected to engage in (O'Donnell, 1999). Although the roots of the scripts are in a cognitively- oriented research tradition, the focus of my dissertation is in macro-scripts (group processes, see Section 3.3.2). From the aspect of collaboration, macro-scripts lie between socio-cultural approaches and instructional design (Dillenbourg & Tchounikine, 2007). Macro-scripts aim to be flexible resources, which result in a richness of collaborative interactions between participants (Dillenbourg & Tchounikine, 2007). Within macro scripts, the main focus is not the task output, but the process (e.g., what happened during the interaction), which differs greatly from settings where the produced output is most important (Tchounikine, 2008). In the other words, macro-scripts emphasize the interpretation of a socio-cultural approach that focuses on the role of mutual engagement and shared knowledge construction in collaboration (Lipponen, 2001). Methods of analysis used in cognitive and educational psychology, which aim to study the relationship between the cognitive aspects of student interaction and individual learning outcomes, were not suitable in the analysis of macro-scripts. The reason for this incompatibility is that macro-scripts aim to study group processes in an authentic learning context, and allow for flexible social interaction in the process of a group's knowledge construction. Therefore, methods of analysis were based on the processes developed in socio-cultural studies and were further elaborated through the dissertation study.

The first part of the thesis will introduce the theoretical background of scripting collaboration, particularly focusing on the kind of collaborative activities that were aimed for in the design of the empirical experiments (Chapter 3). We also present the kind of specifications that need to be conducted within collaboration scripts when integrating multiple perspectives from computer science, education and psychology (Article I). The second part of the thesis will present methodological tools and analytic approaches of the empirical sub-studies (Chapter 5). The third part will present four empirical sub-studies of scripting collaborative learning (Chapter 6; Articles II–V). There is a difference in the chronological order of the sub-studies and in the order of the articles (see, Table 1). Therefore, to increase

Table 1. *Timeline of the Articles and Empirical Data*



readability of the thesis, sub-studies will be referenced as articles II–V. These three sections of the thesis have been constructed in tandem as ongoing processes from 2004–2008 (see, Table 1). The empirical sub-studies were conducted at the same time as the collaborative work of the European Research Team (CoSSICLE) concerning specifications of collaboration scripts, from 2005–2007. Therefore, it has not been possible to take the conclusions made in Article I into full account in the empirical sub-studies of this dissertation.

3

Theoretical background

The roots of Computer-Supported Collaborative Learning (CSCL; Koschman, 1994, 1996) are in the integration of research areas focusing on collaborative learning and information and communication technologies (ICT) (Arvaja, Häkkinen, & Kankaanranta, 2008). According to Faulkner, Joiner, Littleton, Miell, and Thompson (2000), computers may have a unique role to play in facilitating shared collaborative activities although there is no unified theory of CSCL, a common feature is to focus on how collaboration supported by technology can facilitate joint construction of shared understanding, meaning, knowledge and expertise among the group or community (Arvaja, Häkkinen, & Kankaanranta, 2008; Dillenbourg, Järvelä, & Fisher, 2008; Littleton & Whitelock, 2005). This kind of sharing and knowledge distribution among the group, particularly within the frame of distant work over computer networks, will play an increasingly important role in the future, not only in the field of learning but also in working life (Beuschel, 2003; Leinonen & Bluemink, 2008). Therefore, in the context of education, there are great expectations for CSCL, and in work organisations, the same can be said for Computer-Supported Cooperative Work (CSCW; e.g. Dourish & Bellotti, 1992; Johnson, Johnson, Stanne, & Garibaldi, 1990).

Current research on collaboration and cooperation in virtual environments stems partly from earlier work on group-based learning approaches (Strijbos & Martens, 2001). Traditionally, research on collaborative learning lies at the crossroads of a research tradition based on Piaget´s (e.g. 1926, 1980) constructivist theory and Vygotsky´s (1978) socio-cultural approach. Thus, CSCL studies often lie in between educational psychology-oriented research perspectives (studies of individual cognition) and socio-cultural oriented-research perspectives (studies of group processes) (Dillenbourg, Järvelä, & Fisher, 2008; Dillenbourg, 2006). From an educational psychology perspective (tradition building upon the socio-cognitive processes), activities that foster social interactions are methods through which individuals construct knowledge (Fischer, Bruhn, Gräsel, & Mandl, 2002). This research perspective is based on assumption that the cognitive processes and outcomes of collaborative work are related (Arvaja, Häkkinen, & Kankaanranta, 2008), whereas a socio-cultural perspective emphasizes culturally organized social interaction and the process of group knowledge construction (Bredo & Mc Dermott, 1992; Cobb, 1994). According to the socio-cultural perspective, the social, cultural, interpersonal, and historical settings must be taken into account when studying collaborative knowledge construction (Arvaja, Häkkinen, & Kankaanranta, 2008; Wertsch, 1991). From a socio-cultural perspective, understanding collaborative learning requires making sense of the collaboration processes that students engage in and the tools that mediate their learning, as well as the qualitative differences in the communities where learners are participating (Arvaja, 2007; Cobb, 1994; Hmelo-Silver, 2003; Säljö, 1991). As previously stated, this study is in between these two perspectives. Although the roots of the scripts are in psychology (see, Schank & Abelson, 1977) and the cognitively oriented research tradition, this study focuses on macro scripts which are based on socio-cultural approaches and instructional design (Dillenbourg & Tchounikine, 2007). The aim, therefore, is to study macro scripts as a pedagogical method and flexible resource to facilitate group processes in an authentic learning context and to focus on what happened within the groups during the interaction.

3.1 Collaborative learning

In recent years, many researchers have reported on the beneficial effects of CSCL (e.g. Fischer, Bruhn, Gräsel, & Mandl, 2002; Koschmann, 1996; Schellens & Valcke, 2006). The potential of collaborative learning is that it combines individual and social processes (Dillenbourg, Järvelä, & Fisher, 2008; Dillenbourg & Self, 1995), through which groups can construct new understanding and knowledge (Stahl, 2005). According to Arvaja, Salovaara, Häkkinen, and Järvelä (2007), collaboration is defined as a shared knowledge construction in which it is not enough that participants cumulatively (Mercer, 1996) share knowledge together, but the *knowledge construction has to be built on others' ideas and thoughts*. Therefore, collaborative learning depends on interactions between group members (Arvaja, Häkkinen, & Kankaanranta, 2008). The participants are expected to solve complex problems by joining forces, contributing each team member's views and resources in a shared workspace (Weinberger, 2003). CSCL may generate learning characterized by interdependence between participants (Bereiter, 2002). As this is so, team members work in collaboration to construct an inter-subjective world of meanings as interpreted from their individual perspectives (Stahl, 2006). Within the context of this learning situation, each learner may have individual goals, but in successful collaborative learning one adopts new, *shared goals*; and shared goals may lead to a broader shared understanding (Puntambekar & Young, 2003). Collaboration is a complex phenomenon, and often in successful collaboration different aspects of learning, such as cognitive, social, developmental and motivational (Slavin, 1997) are intertwined. Thus, collaboration alone in an educational environment does not automatically produce high-level collaboration, where participants are engaged in cognitively high-level learning (Dillenbourg, 2002). Rather, learning is affected by the quality of interaction and whether a group is able to *build new and novel knowledge* through such interactions (Barron, 2003).

Since collaborative learning depends on interactions between group members, the definitions of collaboration typically describe the kind of interaction that takes place in successful collaborative activity (Arvaja, Häkkinen, & Kankaanranta, 2008). A widely used definition of collaboration describes it as a joint construction of shared meaning, understanding and knowledge (e.g. Fisher & Mandl, 2001; Littleton & Whitelock, 2005; Schellens & Valcke, 2006) through activities with others, where the participants are committed to, or engaged in, shared goals and problem solving (Dillenbourg, 1999; Littleton & Häkkinen, 1999; Roschelle & Teasley, 1995). The main idea of collaborative learning is that, through joint creation of understanding (Barron, 2003; Littleton & Whitelock, 2005; Puntambekar, 2006), collaborative co-construction (see, Reusser, 2001) of knowledge (e.g. Baker, 2002;), construction of common knowledge (e.g. Crook, 2002; Puntambekar, 2006), coordination (Barron, 2000), negotiation of shared meanings (e.g. Miell & Littleton, 2008; Pea, 1993), elaboration (e.g. Hamilton, 1997; Van Boxtel, Van der Linden, & Kanselaar, 2000), argumentation (e.g. Leitão, 2000; Marttunen, Laurinen, Litosseliti, & Lund, 2005), mutual explaining (e.g. Webb, 1989; Webb, & Palincsar, 1996) or reasoning (e.g. Bargh & Schul, 1980; Resnick, Salmon, Zeitz, Wathen, & Holowchak, 1993), a group builds new collaborative knowledge and creates something that exceeds what any one individual could achieve alone (Stahl, 2004). However, according to Arvaja and Häkkinen (2008), the core of all of these terms describes knowledge construction processes refer to a similar type of interaction.

Interaction in collaborative learning situations is predicated on activities occurring across various settings (e.g. classroom, home), social levels (e.g., individual, group, class), and media (e.g. with or without computers) (Dillenbourg, Järvelä, & Fisher, 2008). For example, in a CSCL situation, group size, combination of learning objectives, context, task-type and structures, as well as learners' characteristics as group members (e.g. Watson, Michaelsen, & Sharp, 1991) and group-dynamics, all affect collaboration (Dillenbourg & Self, 1995; Strijbos & Martens, 2001). According to Gillies and Ashman (1996), collaboration is also dependent on group management, understanding the material being studied, problem-solving processes, and personal communication skills. CSCL interactions may differ in the type and time of communication (Koschmann, 1994). Collaborative learning can also occur between small groups to hundreds of people (Dillenbourg & Self, 1995). In synchronous interactions, learners are expected to interact at the same time without technical or non-technical delay (e.g. Hämäläinen, Manninen, Järvelä, & Häkkinen, 2006), and in asynchronous communication non-technical delays between participants may appear (e.g. De Smet, Van Keer, & Valcke, 2008; Vonderwell, 2003). Collaboration can also take different forms depending on participants. For example, collaboration can emerge at the level of peer-peer, adult-child and professional-professional (Price, Rogers, Santon, & Smith, 2003).

Cooperative learning and collaborative learning are related, and many similarities in virtual working processes can be found. However, there is a need to understand the differences between collaboration and cooperation. Even though both perspectives focus on group learning, the main differences are typically in the division of labour and the position of task (and solving it). In a collaborative situation, participants are mutually engaged in a coordinating effort to solve problems and new knowledge has to be built on others' ideas and thoughts (Arvaja et al., 2007). A cooperative task, however, is often split into subtasks and each participant is responsible for a portion of the problem solving. In cooperation, learners often produce separated solutions afterwards (Aronson, Blaney, Stephin, Sikes, & Snapp, 1978; Dillenbourg, Baker, Blaye, & O`Malley, 1996; Roschelle & Teasley, 1995). In working life, cooperative work typically takes place between professionals, whereas in school settings there is a teacher who structures the activities and goals, and learners are likely novices in the field of study (Stahl, 2004). In this study, the aim was to design pedagogical scripts to support collaboration (knowledge construction built on others' ideas) in authentic educational contexts between novice learners.

3.2 Problems in computer-supported collaborative learning

Despite the advantages of collaboration described above, there are also several challenges in reaching successful computer-supported collaboration (e.g. Lipponen, 2001). Collaboration seems to be a complex phenomenon which includes elusive and unpredictable elements (Resnick, 1991). Researchers have pointed out various kinds of problems – cognitive, social, developmental and motivational – in virtually collaborative learning environments, especially in authentic educational settings. For example, studies evaluating collaboration, such as resolving cognitive conflict (Guzzetti & Glass, 1993), shared knowledge construction (Arvaja, Rasku-Puttonen, Häkkinen, & Eteläpelto, 2003), creating common ground (Mäkitalo, Häkkinen, Leinonen, & Järvelä, 2002), or motivation and goal achievement in learning (Volet & Järvelä, 2001), have indicated that high-level collaboration, where participants are engaged in cognitively high-level activities such as questioning, negotiating, reasoning and argumentation, is rare in virtual contexts (Järvelä & Häkkinen, 2002). In addition, the Web has been over-rated as a tool for collaboration, and the term itself is in danger of losing its meaning. Indeed, most Web facilities intended for correspondence or coordination across distances are now marketed as "collaboration tools" (Lipponen, 2001; Roschelle & Pea, 1999). Charles and McAlister (2004) argue that learning activities should not be simply transferred from a classroom setting into a virtual environment as such, but the virtual working methods should offer learners some added value. Therefore, there is a need to find out what kinds of environments and external support are beneficial for collaborative learning.

According to Barron (2000), since collaborative learning depends on interactions within the team, members either enable or prevent each other's learning. Persuading the participants to commit themselves to necessary collaboration processes is a challenge, because collaborative learning can irritate individual learners and arouse feelings that undermine confidence in fruitful teamwork (Barron, 2000). A typical problem might be that participants lack the necessary skills to collaborate effectively (Cartwright, 1968). Even learners with good communication skills may not be able to interact in a way that promotes learning in CSCL situations. Further, collaborative learning is often disturbed by the fact that in CSCL sessions participants may receive very little information about the group members with whom they are working (Cox & Greenberg, 2000) and, therefore, it can become difficult to reach common ground (e.g. Clark & Brennan, 1991; Baker, Hansen, Joiner, & Traum, 1999). In virtual environments, team members are often separated in space and time, which causes lack of everyday social communication compared to collaborative learning in the traditional classroom (Beuschel, 2003). A teacher's presence in CSCL situations is also more limited than in traditional collaborative learning (Stahl, 2002). Therefore, particular challenges in computer supported collaborative learning are finding ways to move beyond surface-level discussions, lack of engagement or unequal participation, and how to guide and help students towards cognitive goals, group collaboration and an openly communicative atmosphere (Arvaja, 2007; Dillenbourg, 2002; Strijbos, Martens, Jochems, & Broers, 2007).

3.3 Collaboration scripts as a form of pedagogical design

As evidenced in the previous chapter, CSCL is a complex phenomenon and often difficult to realise in authentic educational settings. Throughout the history of CSCL, different pedagogical models and systems have been developed to support collaboration (e.g. De Corte, 1996; Scardamalia & Bereiter, 1991, 1994). New technological applications offer tools for supporting collaboration within teams (e.g. Cobos & Pifarre, 2008; Fischer et al., 2002; Koschmann, 1996), and there have been many attempts to use network-based technology, for example, in virtual university courses (Strijbos, Martens, & Jochems, 2004) or in work-based learning contexts (Leinonen, Järvelä, & Häkkinen, 2005). The problem has been that in simply offering online learning environments, there is no guarantee that students will interact in a way that promotes cognitively high-level collaborative learning. Successful collaborative learning depends upon effective interaction amongst learners. However, when learners are left to their own devices, they rarely engage in productive interactions such as elaborative questioning, mutual explaining, justifying their opinions and reasoning, or elaborating and reflecting upon their knowledge (Barron, 2003; Article I; Kobbe et al., 2007).

Despite a lack of engagement in productive online interactions, communication typically relies on "natural" interactions between team members, usually without predefined interaction structures (Strijbos & Martens, 2001). However, evidence from empirical studies over the past half-century consistently indicate that minimally guided instruction is less effective than instructional approaches that emphasize the guidance of student learning processes (Kirschner, Sweller, & Clark, 2006). Knowledge of collaboration processes makes it possible to design new ways of promoting collaboration in computer-supported settings, which may in turn lead to better understanding and learning. Nowadays, research in CSCL has started to focus more on how to support collaboration and how to make collaboration more frequent and effective (e.g. Weinberger, Fischer, & Mandl, 2003). Moreover, studies have indicated that members of online communities benefit from support and structure in learning activities (De Laat & Lally, 2004; King, 1999; Lehtinen, 2003; Lipponen, 2000).

Structuring the interaction process may favour the emergence of productive interactions. Some amount of structuring may help to manage collaborative learning situations by emphasizing team-building to achieve effective collaboration. Structures are intended to facilitate collaborative learning processes and guide learners' activities. One way to structure interactions is to design predefined collaboration scripts for CSCL environments (Dillenbourg, 1999; Kollar, Fischer, & Hesse, 2003). Recently, researchers have adopted scripts as an instructional approach to support collaborative learning (Dillenbourg & Jerman 2006; Kollar, Fischer, & Hesse, 2006; Schellens, Van Keer, De Wever, & Valcke, 2007; Stegmann, Weinberger, & Fischer, 2007; Weinberger, Fischer, & Mandl, 2003).

Target of the scripts is to evoke interactions that have emerged from research findings for example in cognitive and educational psychology being strongly related to learning (e.g., Cohen, 1994; King, 2006; Webb & Palincsar, 1996). Scripting differs from other collaborative learning approaches chiefly in the fact that it focuses on the specific activities that learners are expected to engage in. By specifying a sequence of learning activities, together with designating appropriate roles for learners, collaboration scripts are designed to trigger engagement in social and cognitive activities that would otherwise occur rarely, or not at all. In this way, scripts will lead to higher-level interaction, and therefore, to better understanding and learning. For example, collaboration scripts are sets of instructions that prescribe for students how to form groups, what kind of materials and recourses they are expected to use, how they should interact with each other, what kind of roles they are expected to engage in, how they can solve a given problem together and/or what kind of phases exist during the work (Article I; Kobbe et al., 2007). According Kollar, Fischer, and Hesse (2006), based on their historical roots (in cognitive psychology see, Schank and Abelson, 1977), collaboration scripts can be deviated into an *external script* (the pedagogical scenario that students are asked to play) and *internal script* (the mental representation that students construct of the external scrip). In this study, all the designed scripts were external in nature.

3.3.1 Core design principles

The core design principle, through which the script is expected to trigger specific interactions, can vary. For different learning goals there are different kinds of design principles (script schemata) through which scripts are expected to trigger specific interactions. In CSCL environments, scripts may support, for example, the development of cognitive, social, developmental or motivational aspects of learning. Since scripts are typically designed according to the findings of former research, this section will generally portray the basics of the most well-known scripts and the core design principles (later referred to as core pedagogical ideas) employed in this study (see Chapter 6). Thus, the primary goal of these core pedagogical ideas (or schemata) is to trigger collaboration (knowledge construction built on others' ideas) so that the learners come up with innovative shared solutions to a problem (Brown, Collins, & Duguid, 1989; Fischer, Troendle, & Mandl, 2003).

One of the most well-known scripts is the Jigsaw, which has different variants (Aronson et al., 1978) that aim to form pairs with *complementary* information (e.g. Perkins, 1993); these pairs will then trigger dependency and complementary knowledge construction between the participants (e.g. De Laat & Lally, 2004; Kneser & Ploetzner). The basic idea of Jigsaw scripts is to provide members access to only a subset of the information necessary to solve the problem, and through that, create complementary knowledge construction, i.e. providing students with different pieces of information and/or distributing knowledge among students. Within this process, group members are dependent of each other, learners' activities are connected to the whole process, and each piece of work is meaningful for the group in regard to finishing the task at hand (Dourish & Bellotti, 1992; Haake & Wilson, 1992). When, for example, resources or expertise (Hermann, Rummel, & Spada, 2001) are distributed between the team members, teamwork is necessary. Since none of the group members has enough information/knowledge to solve the task alone, he or she needs to reason, explain and justify his knowledge or contribution to others. The member who receives a body of information has to first process it, to become an 'expert' on that sub-domain, in order to share it and to contribute to problem solving (e.g. Herbsleb, Mockus, Finholta, & Grinter, 2000; Strijbos & Martens, 2001; Perkins, 1993; Price et al., 2003). When expertise is distributed, the coordination of different perspectives is connected to the success of collaboration (Baker, 2002; Erkens, Jaspers, Prangsma, & Kanselaar, 2005; Malone & Crowston, 1994). As this is so, coordination involves personal responsibility, dependency between participants and control of an aggregate of individuals (Brown & Campione, 1994; Malone & Crowston, 1994). However, in distributing expertise there is a danger of oversimplifying a task. For example, if a reason for communication is only information sharing, the real benefits of collaboration fail to appear (Cohen & Levinthal, 1990; Paloniemi, 2006; Zeleny, 1989). Therefore, tasks should be complex enough to engage learners in mutual explaining (Arvaja, Häkkinen, Eteläpelto, & Rasku-Puttonen, 2000; Steiner, 1972; Webb, 1989; Webb, Troper, & Fall, 1995).

Scripts may aim to assign and alternate roles that foster *reciprocal activities* (see, Palincsar & Brown, 1984), such as questioning, mutual explaining or tutoring (e.g. Duran, & Monereo, 2005; Greenwood, Arrega-Mayer, Utley, Gavin & Terry, 2001; King, 1999; Webb, 1989). Within authentic learning problems (e.g., Brown, Collins, & Duguid, 1989; Lainema & Nurmi, 2006; Strijbos, Kirschner, & Martens, 2004; Zualkernan, 2006) the leading idea is to create a situation in which students have to use their abilities to handle uncertainty (e.g. Berger & Calabrese, 1975), commit to solving a task, and build shared understanding (Dillenbourg, 1999; Resnick, 1991; Schwartz, 1995) by mutually explaining their perspective on a task solution. In successful collaboration, shared goals may lead to shared understanding (Baker et al., 1999; Mulder, Swaak, & Kessels, 2002; Puntambekar & Young, 2003). In collaboration situations, learners' resources, cognitive representations and knowledge- transfer are interconnected with how well the group is able to build shared understanding (e.g. Fisher & Mandl, 2005). So, typically in CSCL situations learners must firstly build shared understanding of the goal/task, and then (for example through reciprocal activities) it is possible to create a shared task-solution.

The roots of *conflict*-oriented scripts are in Piaget's cognitive conflict theory (an individual's interaction with the concrete world) (Piaget, 1985), which was further developed to address socio-cognitive conflict by emphasizing the importance of social interaction (Doise & Mugny, 1986). The aim of conflict-oriented scripts is to trigger argumentation (e.g. Kollar, Fisher, & Slotta, 2008; van Bruggen, Kirschner, & Jochems, 2002; Weinberger, Ertl, Fischer, & Mandl, 2005) among group members by forming pairs of students with conflicting opinions (e.g. Tudge, 1992; Moscovici & Doise, 1994). This can be done by, for example, providing students with conflicting evidence or by asking them to play conflicting roles. In this way, scripts aim to promote solving a cognitive conflict (e.g. Huang, Liu, & Shiu, 2008;

Limón & Carretero, 1997; Moscovici & Doise, 1994). The rationale behind such a script is that conflicts may force learners to turn to new ways of constructing knowledge, thus, opening up the possibility that new knowledge will be created (e.g. Doise 1985; Posner, Strike, Hewson, & Gertzog, 1982). In conflicting tasks, the goal is to lead learners into negotiations (a process in which learners attempt to reach an agreement during problem-solving) to question their actions, and finally to solve a conflict and create a shared solution for the problem (Chan & Chan, 2001; Dillenbourg et al., 1996; McWilliam & Howe, 2004; Moscovici & Doise, 1994). In terms of learning effects, the crucial question is how are students able to solve their cognitive conflict, rather than just the conflict itself (Ayoko, Hartel, & Callan, 2002; Dillenbourg & Jerman, 2006; Limo´n, 2001).

3.3.2 Various kinds of scripts

There are different approaches to scripted collaboration, and the settings of scripted collaboration can differ. Scripts have been used in various settings, including face-to-face, Web-based, as well as in mobile contexts (Fischer, Kollar, Mandl, & Haake, 2007; MOSIL, 2004). The target of the script may vary from structuring specific synchronous, small-group interactions to introducing a time-frame or orchestration of collaborative and individual activities within the classroom over a longer period of time in an asynchronous setting (Dillenbourg & Jermann, 2006). Thus, collaborative core scripts are positioned within a didactic envelope; that is, pre- and post-structuring activities enable scripts to be optimally integrated into the lesson plan (e.g., introducing the topic, reflecting on what was discussed, etc.) and contribute to their effectiveness and consistency. Scripts can facilitate activities among collaborative learners, but may also flexibly integrate phases of classroom learning within a sequence of activities on different social planes (individual – group – classroom). Furthermore, scripts can enable integration of in-class or face-to-face activities and computer-mediated activities (Article I; Kobbe et al., 2007.) According to Dillenbourg and Jermann (2006), *integrative scripts* include individual activities and activities encompassing a whole class. The integrative aspect of scripts becomes evident in the case of computer-supported collaboration scripts, in which scripts integrate virtual and physical activities and manage the data flow between them (Dillenbourg & Jermann, 2006).

The target of scripting can also vary. Firstly, scripts may aim to facilitate learners in helping them to work on a specific learning task in a virtual environment (epistemic collaboration scripts). Secondly, scripts may instruct learners how to interact with each other and discuss their individual contributions in the virtual environment (social scripts) (Kollar, Fischer, & Hesse, 2003; O'Donnell, 1999; Weinberger, 2003; Weinberger, Fischer, & Mandl, 2003). Therefore, one needs to take into account not only the cognitive aspects of collaborative learning, but also the social dimensions of this form of student activity. Epistemic scripts aim to structure activities centred on individual-knowledge construction by providing learners with instructions and guidelines for actions, which in turn, may help them to achieve the intended learning outcome (Weinberger et al., 2005). According to recent studies, social scripting seems to improve learning outcomes (Stegmann et al., 2007). However, mere use of epistemic scripts has not lead to essentially better learning results, while scripting epistemic activities has also lead to better individual learning outcomes in unscripted conditions compared to scripted ones (Mäkitalo, Weinberger, Häkkinen, Fischer, & Järvelä, 2005). However, it should be noted that when scripts are used they may integrate epistemic and social guidance.

While all collaboration scripts aim to promote a productive interaction processes, there appear to be differences between establishing conditions for interaction and guiding interaction at a detailed level, which has lead researchers to distinguish macro- from micro-scripts (Dillenbourg & Jermann, 2006). Macro-scripts typically differ from micro-scripts in the level of granularity; in macro-scripts activities typically describe longer time segments compared to micro-scripts. On the one hand, macro-scripts set-up conditions in which favourable activities and productive interaction (for example argumentation) should occur, but leave the detailed aspects of interaction unconstrained. Micro-scripts, on the other hand, tend to provide a higher degree of scaffolding using sentence starters, question prompts or detailed descriptions that may gradually be faded out as learners become more competent (Dillenbourg & Jermann, 2006; Kobbe et al., 2007; Kollar et al., 2006). There is also a difference in research perspectives; macro-scripts are typically socio-culturally oriented and take a pedagogical approach to structuring interaction (emphasizing the orchestration of group processes), whereas micro-scripts take a more psychological approach (emphasizing the activities of individuals) (Kobbe et al., 2007). While the focus of research has been primarily on the connection between micro-scripts and individual learning (e.g. Schellens et al., 2007; Stegmann et al., 2007; Weinberger et al., 2005), we do not know much about the effects of macro-scripts on collaboration within groups in authentic learning contexts. This study is one attempt to fill this gap, and to study macro-scripts as external support for group collaboration.

Furthermore, there are various solutions in regard to the amount and type of technology used to support scripting, and therefore, scripts can be differentiated according to whether collaboration is supported by specific instructional means or by technology. In line with this notion, Lipponen (2001) has made a distinction between the collaborative use of technology (software alone does not scaffold collaboration) and collaborative technology (software designed to support collaborative knowledge construction). A script may be given prior to an activity as a form with a set of basic rules, or it may be given as a more formal worksheet containing sequences of instructions. On the other hand, scripting may be used throughout the duration of a long-term course and contain several different phases and forms. So, when scripts are programmed within specific environment, computers may then keep track of the students' position within the script sequence, alert or prompt students to engage in specific activities, and provide additional information and resources when needed. The advantages of programmed scripts are that once programmed, they can be re-used many times (Article I; Kobbe et al., 2007). Within this examination, two of the sub-studies (Articles IV and V) focused on collaborative use of existing technology (by sequences of instructions), while two other sub-studies (Articles II and III) aimed to develop collaborative technology in a game environment. At their best, these kinds of "edu-games" (Articles II and III) may enrich learning and the pedagogical use of technology (de Freitas & Oliver, 2006; Dickey, 2006; Gros, 2007; Kiili, 2005; Ravenscroft & Matheson, 2002; Ravenscroft, Sagar, Baur, & Oriogun, 2008). Indeed, the goal of these games was to trigger collaboration through scripts, build overlaps between domains of professional practice (Delwiche, 2006) and facilitate interesting behaviours and unexpected outcomes (Price et al., 2003), as compared to traditional learning methods.

3.3.3 Overview of specifying computer-supported collaboration scripts (Article I)

Script design is currently at the crossroads of educational sciences, psychology and computer sciences. The problems with collaboration scripts have been, firstly, that different research traditions have not been able to find common ground, and secondly, many computer-supported collaboration scripts suffer from the problem of being restrained to a specific learning platform and learning context (Kobbe et al., 2007). Therefore, there was a need for negotiating shared understanding and constructing shared concepts of key script elements between different research perspectives (to increase transferability of the scripts for different learning settings). To begin, the MOSIL-project (Mobile Support for Integrated Learning) (see, MOSIL, 2004) aimed to integrate expertise from different research fields. Similarly, the COSSICLE-project continued work on integrating different research traditions in scripting collaborative leaning, and concluded that the core pedagogical idea of scripts should be transferable to different learning settings in order to make scripts more widely applicable. The author of the thesis has been actively involved in both the MOSIL and COSSICLE projects. However, this framework has been constructed in tandem with the empirical sub-studies (see, Table 1) and, therefore, it has not been possible to fully account for this framework in the design of the empirical sub-studies (Articles II–V). This section will, therefore, portray the main conclusions framed by the COSSICLE team (see, Article I). The COSSICLE team has framed the level of abstraction in scripts, which allows for the adaption of different scripts in different learning contexts. Subsequently, this framework defines script *components* and *mechanisms*. Components refer to *participants, activities, roles, resources* and *groups* that are needed in the script, while mechanisms introduce *task distribution, group formation* and *sequencing* of the script.

Scripts typically have certain requirements regarding the total number of participants they can handle, sometimes given as a variable range or as a multiple of another script component (e.g., two participants per text book). Scripts may also take into account specific participant characteristics, such as individual opinion or knowledge of a domain. Participants can be grouped in terms of common features, such as gender, age, nationality; or they can be distributed into new groups based on certain criteria, such as desired group size, amount, or composition. While some groups exist simply by definition (e.g., gender groups such as men and women) other groups must be formed by a particular procedure or principle. Groups generally form a hierarchical structure, with larger groups composed of one or more smaller groups. Participants can also become members of multiple and overlapping groups (Article I: Kobbe et al., 2007.).

Activities, roles, and resources are also intertwined. For example, roles foster particular learning activities, such as a scientist is offered certain resources which are expected to promote planning, observation and drawing conclusions. Activities can be described from different angles; firstly, they can mean the mode and outcome of an activity (which is especially useful from a computational point of view) and, secondly, from the point of the cognitive processes underpinning the activity (e.g. the type of activity students are expected to engage in). Activities form a hierarchical structure in which any greater activity can be decomposed into lesser, more fine-grained activities; while any lesser activity can be subsumed by greater, more coarse-grained activities. For instance, a discussion can be decomposed into explaining, questioning, etc. Moreover, activities include different degrees of scaffolding. When learners are assumed to be proficient in a specified activity, a much lower degree of scaffolding (down to none) is needed than when they are not proficient with certain activities (Article I: Kobbe et al., 2007). However, it should be noted that in macro-scripted collaboration, students may use a variety of different activities, such as reading and discussing (reasoning, arguing and explaining), while solving a task. For example, in a sub-study reported in Article III, the fourth phase of the script is aimed at enhancing students' ability to reason and explain a hazardous situation (danger of fire) based on the different roles, resources and activities of the avatars players were able to use. Thus, no specific guidance was given for how students were to argue or explain (see, Section 6.1.2).

A simple function of roles in collaboration scripts is to refer to specific participants when assigning activities or allocating resources. As roles are closely tied to learning activities, the title of a role is usually predictive of the activities a participant is allowed, obliged or expected to engage in. Participants may assume one or more roles at any given time, and can exchange these roles with other participants. Resources are also important in the context of scripts because they often constitute a common object of or reason for interaction. Resources in general are comprised of virtual or physical objects that can be allocated to script participants. Some resources may be predefined objects offering important information (information sources like websites, articles, etc.) or functionality (tools like calculators, online dictionaries, etc.), whereas others may be created or significantly modified throughout the script (editable products, such as fill-out questionnaires and written notes). (Article I: Kobbe et al., 2007.) For example, in a sub-study reported in Article V, recourses were distributed within the group, along with complementary knowledge (see, Section 6.2.1).

Script mechanisms help to describe the distributed nature of scripts; that is, how activities, roles, and resources are distributed across participants (task distribution), how participants are distributed across groups (group formation) and how both components and groups are distributed over time (sequencing). Each of these mechanisms features particular principles that are important for issues of scalability (e.g. for applying the same script to a varying number of participants) and later for technical implementation of the scripts. The sequence is typically designed according to a theoretical model or to the findings of former research (e.g. establishing conflict). Script sequences are often divided into distinct segments, referred to as phases, which provide a helpful point of reference for students and teachers, and are frequently used for managing time. Scripts are not limited to a strictly linear sequence of activities, but may also feature complex sequential arrangements with loops and branches. In most cases, group formation is very simple, such as forming groups based on number of participants. Some scripts make use of more complicated principles that do not only take into account group numbers and size, but also the composition of each group and the overall balance among the groups. The distribution of the task is often related to resources, such as providing participants with only one piece of necessary information in order to foster an exchange of knowledge with one another. Decomposable activities can also be distributed in such a way that one learner engages in a cognitive activity while the other learner engages in a supportive metacognitive activity (Article I: Kobbe et al., 2007).

3.3.4 Flexibility in scripts

The process of collaboration is not easy to structure. First, the central idea in collaboration is creative interaction between learners, which is not predictable. Next, collaboration produces the best results when participants employ a variety of cognitive mechanisms (e.g. Barron, 2000; Pirchard, Stratford, & Bizo, 2006). In scripted collaboration, different variations of each script can be identified according to the goal of the script, how the groups understand the script and what actually happens during the learning period. Initially, there is an *ideal script* meaning, e.g. particular learning activities the teacher expects a script to produce. Secondly, there is a *mental script*, which is a social and mental representation created by the group performing the script. Finally, there is an *actual script* which is the emerging pattern, i.e. what really happens in a scripted learning situation (Dillenbourg & Jermann, 2006). There are several features which may harm scripted collaboration, such as learners not interacting in an expected way, not committing to the shared task solving, or there may be roles which prevent collaboration.

Scripting collaborative interactions is a complicated challenge that can be hindered with either too much or too little guidance. If there is not enough guidance, students may not reach the goals set for interaction, or in the worst case there is no real interaction at all. If there is too much guidance, it may limit the richness of natural collaboration (Dillenbourg & Tchounikine, 2007) or structuring can become counter-productive (Tchounikine, 2008). There is also a risk of over-structuring learners' interactions so that natural interactions and problem-solving processes may be disturbed, interactions may become too didactical or distracted from the actual goal, and finally the cognitive load for the learners may increase too much (Dillenbourg & Jermann, 2006). Under such circumstances, instructional scripts can also have negative motivational effects by oversimplifying the task and reducing its challenges (Dillenbourg, 2002). Therefore, in the optimal situation, scripts could be faded in or out depending the needs of learners. Fading refers to features that are gradually added (faded in) or removed (faded out) from a script and are often used to gradually increase or decrease the degree of scaffolding in activities (Kollar, Fischer, & Hesse, 2006; Kobbe et al., 2007). However, this kind of optimal scripting is a challenge, and future research is needed in order to perceive benefits of scripting in authentic learning contexts.

4

Aims of empirical studies

The aim of empirical studies is to explore macro-level collaboration scripts as a pedagogical method to facilitate collaborative learning. The empirical studies (see, Table 1) were constructed and carried out while the framework of collaboration scripts (Article I) was in the process of being created and, therefore, it has not been possible to fully account for it in the empirical studies. *The aim of empirical studies is to integrate empirical research on computer supported collaboration into the design of the collaboration scripts* (Dillenbourg & Tchounikine, 2007). This integration brought about a distinction between the collaborative use of technology (software alone does not scaffold collaboration) and collaborative technology (software designed to support collaborative knowledge construction) (Lipponen, 2001). Firstly, two of the sub-studies (Articles II and III) aimed *to develop collaborative technology* and *investigate the kinds of activities players were drawn into* at the scripted environment. Secondly, two of the sub-studies (Articles IV and V) focused on scripted collaboration combined with collaborative use of existing technology. The aim of these sub-studies (Articles IV and V) is *to investigate the difference between the ideal script* (the particular learning activities that the script was expected to produce, Kobbe et al., 2007) *and the actual, realised script*, referring to emerging patterns, i.e. what really happens in a scripted learning situation (Dillenbourg & Jermann, 2006). Furthermore, in all the sub-studies (Articles II–V) the aim is *to explain how the activity of different groups varied, despite using the same scripted environment*.

Within this general framework there were specific aims and tasks for each of the sub-studies, as reported in Articles II–V. Article II combines the technological possibilities of game environments with recent research on CSCL. The first goal of the Article was to develop a game environment as a means of simulating the work context of the vocational design process of surface treatment, and to describe the game and design process by means of scripted tasks. The second goal was to investigate how the scripted game environment influenced learning processes and players' actions. In addition, an additional goal was to find out what kinds of collaboration occurred during game play. Finally, the study describes how groups varied in their activities despite using the same scripted environment.

Article III integrates the technological possibilities of a gaming environment with research on collaboration scripts. The first goal was to develop a game environment that simulates certain practical issues of work safety in a vocational context. The second goal was to investigate what kinds of activities were generated among the players in the scripted game environment and how the least and the most successful groups differed.

Article IV explored how the Case script – designed to support students' collaborative processes – guided groups' activities while working in a Web-based environment. In addition, the goal was to find out what kinds of differences existed between the groups as they worked through the script, and how these differences were shown in the collaborative activities of various groups.

Article V explored the difference (by means of a Grid script) between an ideal script, and an actual, realized script, referring to emerging patterns, i.e. what really happened in a scripted learning condition. The aim was also to find out how collaboration varied between groups. Special interest was paid to group processes and the kinds of roles the students adopted.

5

Method

5.1 Design-based research

This study implemented a design-based research approach. Design-based research has become widely used in educational sciences, especially in the domain of computer-supported collaborative learning (e.g. Hoadley, 2002). Design-based research is a promising way to integrate traditional instructional design (ID) (e.g. Enkenberg, 2001; Herrington & Oliver, 2000) or instructional system design (ISD) and research on shared processes, in which different types of expertise enable reciprocal development on theory, implementation of the virtual environments, and practice in the education field (Wang & Hannafin, 2005; Kester, Kirschner, & Corbalan, 2007). The main idea is to carry out research to test and refine educational design based on theoretical principles (Collins, Joseph, & Bielaczyc, 2004). The advance of design-based research is that it allows a full articulation of the role of technology as a mediating tool for intellectual and social development, instead of seeing technology as an organisational "means" to deliver traditional learning (Ravenscroft, Sagar, Baur, & Oriogun, 2008). Design-based research is a series of approaches with the intent of producing new artifacts, theories, and practices that account for and potentially impact learning in authentic settings (Barab & Squire, 2004; Sandovall & Bell, 2004). Design-based research typically integrates different fields of expertise (e.g., educational sciences, psychology, computer sciences, and filed-practice) and, therefore, there are also different perspectives on design-based research approaches such as design-based research (e.g. Hoadley, 2004; Kong, 2008; Sandoval & Bell, 2004; Strobel, Jonassen, & Ionas, 2008), design experiments (e.g. Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Hawkins & Collins, 1992), design research (e.g. Collins, Joseph, & Bielaczyc, 2004; Edelson, 2002; Shavelson, Phillips, Towne, & Feuer 2003), development research (e.g. van den Akker, 1999; Reeves, Herrington, & Oliver, 2004), developmental research (e.g. Richey, Klein, & Nelson, 2003) and formative research (e.g. Reigeluth & Frick, 1999).

Design-based research is originally centred on a combination of design experiments, in which new theoretically constructed models aimed at supporting learning are designed and tested in authentic learning contexts (Brown, 1992) and the idea of educational research as a "design science" that requires a methodology to systematically test design variants for effectiveness of learning (Collin, 1992). The central concept of design-based research is to integrate the empirical research of learning and teaching with particular designs for instruction. Software design may also be combined with studies in education (Hawkins & Collins, 1992; Hoadley, 2002). Design-based research simultaneously aims to develop effective learning environments and use such environments in authentic settings as a way to study learning and teaching (Sandoval & Bell, 2004). Design experiments attempt to carry experimentation into authentic settings in order to find out what works in practice. However, this means giving up a psychological research tradition in which results are based on the notion of controlling variables (Collins, 1999).

Design-based research is an interactive process in which theoretical knowledge, designed artifacts, and filed-practice are combined to reflect each other (Sandoval & Bell, 2004). According to The Design-Based Research Collective (2003), design-based research typically includes five characteristics. First, the central goals of designing learning environments and developing theories of learning are intertwined. Second, development and research are on-going processes through continuous cycles of design, enactment, analyses and re-design (e.g. Cobb, 2001). Third, research on designs leads to theories that help communicate relevant implications for other educational designers and practitioners. Fourth, research must be transferable to different authentic learning settings. Finally, the development relies on methods that can connect and document processes of enactment to outcomes of interest. Design-based research aims to go further than merely designing and testing particular interventions. The aim is to understand and reflect the relationships that exist between theory, designed artifacts and practice. Thus, at their best, research interventions can also contribute to theories of learning (The DBR collective, 2003).

According to Shavelson, Phillips, Towne and Feuer (2003), DBR settings are often complex and occur in multileveled settings (e.g. linking classroom practices in the structures of the school or community). The critical aspects of DBR are that studies should be *iterative* (involve linked design-analysis-re-design cycles), *process focused* (seek to trace in learning practices by understanding reasoning and learning), *interventionist* (design and modify real-world settings), *collaborative* (take place in naturalistic contexts and depend on collaboration with practitioners), *utility oriented* (intent to improve instructional tools to support learning) and *theory-driven* (test and advance theory through the design-analysis-redesign of instructional activities and artifacts) (Barab & Squire, 2004; Shavelson et al., 2003).

5.2 Research design of empirical studies

This section will describe the research design of empirical experiments and generally portray the environments of the four sub-studies (Articles II–V). The study consists of four interventions (sub-studies; Articles II–V), which design and modify real-world settings by integrating a theory of computer-supported collaboration into the design of the collaboration scripts. The empirical experiments were conducted to further develop an understanding of group collaboration in macro-scripted conditions. These four contexts are unified in the sense that the sub-studies (Articles II–V) were all aimed to improve instructional tools (by the use of collaboration scripts), to support learning, and through that, to modify an authentic learning setting. This study follows the iterative structure of design-based research (continuous cycles of design, enactment, analysis, and redesign) in the sense that in the four empirical research interventions, the improvements of previous interventions were taken into consideration in the following empirical interventions (e.g., in designing aims and pedagogical core ideas as well as methods for data collections and analysis). These four sub-studies (Articles II–V) were constructed in tandem as an on-going process from 2004–2008 (see Table 1). For each sub-study (Articles II–V), a unique pedagogical script with different phases was designed based on theoretical knowledge about CSCL (see, Section 3.3.1, core design principles). All of the sub-studies (Articles II–V) were conducted with small groups, in collaboration with teachers, and in authentic educational settings, although an authentic classroom was partly modified in two of the empirical experiments (cameras and recording systems were set). The sub-studies (Articles II–V) differed in terms of the participants, the timing of the communication (synchronous and asynchronous) and technology used. In two of the sub–studies, new synchronous game environments were created in vocational learning contexts (Articles II and III). In two different sub-studies, previously-existing asynchronous web-based learning environments were used (Discendum Optima) in a higher education setting (Articles IV and V). This is in line with Lipponen's (2001) notion of *collaborative technology* (games designed to support collaborative knowledge construction) and the *collaborative use of technology* (Discendum Optima alone does not scaffold collaboration, but was utilized in establishing collaboration).

5.2.1 Research design of empirical studies in vocational learning contexts

Two of the sub-studies (Articles II and III) were conducted in vocational learning contexts. The aim of these sub studies was to create new game environments based on the needs of authentic contexts of vocational education. The philosophy behind the game design was to offer game play in a virtual environment that allows such practice that would otherwise be almost impossible, or at least very costly to arrange. Games were also expected to offer learners some added value in comparison to the traditional vocational learning processes (e.g. Charles & McAlister, 2004; Gee, 2003; Ravenscroft, 2007). The aim of both games was to use collaboration scripts and different game levels in a way that supports pedagogical goals. Both of the games use synchronous communication and include different types of puzzles; some can be solved individually, but others require effort and commitment from the whole team for successful completion. The different levels of scripts follow the progression of the game, where higher levels can be reached by solving problems set for the players. Thus, the scripts guided the students step-by-step and also offered necessary material, but did not give instructions for student interaction (e.g. how they should argue) (see more detailed description of core design principles in Section 3.3.1, and of scripts in Section 6.1.1. and 6.1.2.). The pedagogical idea of the scripts was designed by the author of the thesis, while the content of the scripts was primarily designed in a vocational institute, and technological environments were implemented by a small company called Korento Ltd. However, these three areas were constructed through intensive collaboration between these three parties. Based on the experiments (Articles II and III), new and unique game environments were created to meet the needs of authentic contexts. For example, in both games, the teacher has an active role in after-game reflection, though this role is not supposed to intervene during the actual game session.

Both empirical experiments were conducted in an authentic classroom setting that was partly modified (cameras and recording systems were set) in order to capture all the required data from the experimental game sessions. The first sub-study (Article II) was organized among vocational students (N = 20) divided into five groups of four persons playing the game, "Mustakarhu". The idea of the game design is to simulate the work context of a vocational design process, which involves the vocational task of designing four different customised hotel rooms. Mustakarhu is a virtual 2D/3D online game for four players. The goal of the game is authentic task-solving, and the story consists of 14 different phases which aim to facilitate collaboration (knowledge construction built on others' ideas) between team members. Due to the limited duration of the experiment, the game provides approximately 45 minutes of goal-oriented activities. Role management and player-to-player communication are supported by chat or voice-over-IP speech systems, which allow free dialogue between the players.

The second sub-study conducted in a vocational educational setting (Article III) was organized among 16 groups of four persons (N =64) playing the game, "Secure". Secure is a virtual 3D game for four players. The goal of the game is task solving in the area of work safety. The game's story consists of five different phases of activities, four of which (phases 2–5) are designed to promote particular collaborative activities (solving an open problem (e.g. Brown, Collins & Duguid, 1989), distributing expertise (e.g. Price et al., 2003), solving a cognitive conflict (e.g. Moscovici & Doise, 1994) and coordination of activities (e.g. Brown & Campione, 1994)). Although problems are set in strict order, teams may create different ways to solve the problems. The game provides approximately one hour of goal-oriented activities. Role management and player-to-player communication are supported by the chat function.

5.2.2 Research design of empirical studies in higher education learning context

Two of the sub-studies were conducted in a higher education context (Articles IV and V). The leading idea in these sub-studies (Articles IV and V) was to use pre-existing technology and pedagogical design for guiding learners' activities. Scripts were given to students as sequences of written instructions in an asynchronous setting. Both of the sub-studies (Articles IV and V) were conducted in a higher education context and were composed of the same seven groups of first-year teacher education students (N = 30) who were taking courses in the pedagogy of pre-primary and primary education. Sub-studies (Articles IV and V) involved structuring the student groups' collaborative activities by means of a pedagogical model (script), whilst they were working in an asynchronous web-based learning environment (Discendum Optima) for about two months. For this purpose, two different pedagogical models or scripts (called "Case" and "Grid") were designed. The pedagogical ideas of the scripts were designed as a joint effort by two research groups (see, Häkkinen, Järvelä, Arvaja, Bluemink, Hämäläinen, Järvenoja et al. 2005), while the content of the script was designed by the teacher (an expert with a doctoral degree in education and many years teaching experience). Thus, the scripts guided the students step-by-step through the task, and also offered necessary material, but did not give detailed instructions for student interaction. During the Case and the Grid exercise the students were supposed to proceed through five different steps. Moving from one stage to the next stage presupposed that the previous task was completed. The students were not penalised in any way, however, should they fail to go through all the steps in the script. In the Case script, the main idea is to solve an authentic learning problem (e.g. Kester, Kirschner, & Corbalan, 2007) with different theoretical background knowledge (distributed expertise), complementary knowledge construction (Perkins, 1993) and reciprocal teaching (Palincsar & Brown, 1984). The basis of the Grid-script used in this study leaned on the combination of "Concept Grid" (see, Dillenbourg & Jermann, 2006) and ideas about cognitive conflict (e.g., Doise, 1985).

5.3 Data sources

Certainly, design-based research is an interactive process (Sandoval & Bell, 2004). In these four sub-studies (Articles II–V), a variety of data sources was collected to find out how different scripts guided a group's activities and how different groups varied despite using the same scripted environment (see Table 2). There were three main reasons for the variety of data sources: various means of data collection were used in order to capture, in a systemic manner, the complex relationships and dynamics between different variables within the diverse data (Salomon, 1997); the nature of the study context influenced the data (e.g., videotaping game contexts); and experiences from the data collection and analysis of the previous sub-studies were taken in account to improve the gain of the collected data.

Table 2. *Data Sources of the Sub-studies*

Name of the script	Mustakarhu (Article II)	Secure (Article III)	Case (Article IV)	Grid (Article V)
Data sources	N = 20	N = 64	N = 30	N = 30
Videotape	x	x		
Audio recording of discussions	x			
Written discussions	x	x	x	x
Logged data	x	x	x	x
Observation notes	x	x		
Interviews	x			
Questionnaire		x	x	x
Final productions	x		x	x

The first sub-study (Article II) was organized in 2004 among vocational students (N = 20) divided into five groups of four persons. During the experiment the students played the game and had a simulated recall interview immediately after. Data were gathered by videotaping each group, recording their discussions and/or logging chat conversations (822 utterances) and player activities during the game. Other sources of data included observation notes, simulated recall interviews and the final productions created in the game.

The second sub-study conducted in the game environment (Article III) was organized in 2006 among vocational students (N=64, 49 male, 15 female) divided into 16 groups of four persons. During the experiment, the students played the game and had a test immediately after. Data were gathered by means of observation notes on the game process, an electronic questionnaire (with multiple-choice and open questions) immediately after the game session, videotaping nine groups (video feed from one player screen), logging chat conversations (3841 utterances) and logging all player activities (e.g. Time: 2006-05-09 13:16:38 – Action: Antti shows object P2 gloves1) of all groups during the game.

In the sub-studies conducted in the higher education context (Articles IV and V), the data were collected in 2005 in conjunction with a university course (pedagogy of pre-primary and primary education) of the same students (N = 30). Process-oriented data sources included material used and produced in the computer-based activity, log data on student activities, asynchronous Web-based discussions during the task, seven final productions accomplished by the groups in each script, a shared plan for personal curriculum in a Case-script, and final statements in the Grid-script. The Web-based discussions took place in a virtual learning environment over a period of about four weeks for each of the scripts (about eight weeks together). A total of 271 postings were sent during the Case-script, and a total of 352 postings were sent during the Grid-script. Both sub-studies (Articles IV and V) also included a self-report questionnaire (Järvenoja, Järvelä, & Volet, 2008), which prompted the students to rate their experience and the challenges they faced in different tasks. This information was elicited by means of 12 questions and written feedback. In this study, the self-report questionnaires were used as background data to describe the overall satisfaction of the students in regard to the group activity.

5.4 Analytic framework

In DBR, different methods of analysis may be used (Bereiter, 2002). As research traditions in CSCL are at a crossroads of educational psychology and socio-cultural research perspectives, the methods of analysis have been typically based on one of these traditions. However, according to Beers, Boshuizen, Kirschner, and Gijselaers (2007), CSCL research has also typically developed varying analysis methods, all with specific goals, units of analysis and for specific types of data. Avouris, Dimitracopoulou, and Komis (2003) have presented three periods in the analysis of CSCL. Firstly, the main objective was to explore the effectiveness of collaborative learning by controlling different independent variables. Secondly, empirical studies started to focus on understanding the role of variables in mediating interaction. Thirdly, research on CSCL seems to exploit the previous results and is oriented not only to the design of appropriate systems, activities and settings, but also to establish effective analysis and evaluation methodologies. However, there is still a need to find new methods to better understand the quality of group collaboration and its relation to learning. According to Arvaja (2007), studies in collaborative learning have typically focused on (individual) learning outcomes (Fischer et al. 2002; Weinberger, Stegmann, & Fischer, 2007) and its relation to the cognitive quality of discussion (e.g., Kanuka, Rourke, & Laflamme, 2007; Schrire 2006). However, the problem is that this type of analysis reveals little about the process of collaboration (Arvaja, 2007). Using this type of analysis also makes it difficult to capture the variations between the groups and their activities, in relation to the design of collaboration. There is still need to find more methods to understand collaboration (e.g. Baker, Andriessen, Lund, van Amelsvoort, & Quignard, 2007; Stahl, 2006; Strijbos & Fischer, 2007), especially as it pertains to macro-scripted conditions.

Research on scripting computer-supported collaborative learning is young, and typical methods of analysis used in CSCL studies have mainly focused on individuals' learning outcomes in specific learning environments (e.g. Kollar, Fischer, & Hesse, 2006; Schellens et al., 2007; Stegmann, Weinberger, & Fischer, 2007; Weinberger et al., 2005). There seems to be a lack of empirical research with a qualitative approach on how groups work in scripted conditions. Since macro-scripts lie between the socio-cultural approaches and instructional design highlighting the process of collaboration, (Dillenbourg & Tchounikine, 2007), methods of analysis that focus on the outcomes of learning are not suitable for illustrating the nature of group collaboration in the macro-scripted conditions. That is, outcomes do not tell enough about the process itself, and even less about its setting. In this study, the aim is to further develop methods of analysis in order to better understand what happens in scripted collaboration contexts and how groups vary despite use of the same scripts.

In each sub-study (Articles II–V), different phases of the scripts provided the basis for analysis. In the following section, methods of analysis are presented in a chronological order to illustrate the development process of the analysis used throughout this doctoral thesis (see, Table 1).

5.4.1 Phases of the scripts as a grounding of the analysis

The first sub-study (chronological order, see Table 1), conducted in the vocational education setting (Article II) aimed to use partly theory-driven and partly data-driven data classifications. The goal of the sub-study (Article II) was to find out how the game environment influenced the collaboration processes, how scripting affected players' actions, what kind of collaboration took place during the game play, and how groups varied in their activities despite using the same scripted environment. After the game experiment, all the data were verified, interviews and conversations during game play were transcribed, observation notes were sorted into relevant categories (collaboration, goal definition, task solution, social organisation, or interest/motivation) and evaluations of the groups' final plans were conducted. A qualitative analysis across the whole variety of data was carried out using data classifications. The first classification was based on the key points (later referred to as phases) scripted into the game environment. At this stage, the teams were analysed in terms of the collaboration processes or teamwork they achieved during the play. Collaborative groups that built knowledge based on the ideas of others used, for example, elaborative questioning, and made sure that all team members were able to participate and negotiate (see, Arvaja, 2007), more so than groups which preferred teamwork (e.g. participants were responsible for a portion of the problem solving and simply used communication to share information as they moved through tasks). At the second stage of classification, the groups were examined in more detail to find out what kind of individual activities players applied to solve problems, and how important these were for the game play. For example, collaborators made sure that all team members were able to participate, produced new knowledge for final plans and experienced teamwork as fruitful. Within these first two stages, cross-summarizations between the groups were also conducted to find out group-based differences occurring despite the similar scripted environment. And finally, the analysis focused on how the environmental elements affected collaboration. Cross-comparisons of sets of research materials collected by various methods were performed to improve the reliability of the research results (Cohen, Manion, & Morrison, 2001).

5.4.2 Determining activity levels and prototypical roles

In the second sub-study (chronological order, see Table 1) phases of the scripts remained as the basis for analysis, the methods of analysis sharpened and the analysis focused in more detail on differences between groups. This sub-study (Article IV) was conducted in the higher education setting of the "Case-script". The focus of the sub-study (Article IV) was to determine how the collaboration scripts guided the group processes of different groups, how different groups interpreted the script, what kind of roles the students adopted and what kind of differences existed between the groups as they worked through the script. The analysis involved two stages. At the first stage of analysis, data were verified and categorized. At this stage, all the material was read through several times, redundancies were omitted (such as double entries in documents or repeated messages) and different types of data occurring in the same context were taken under cross-analysis. Next, students' activity levels were categorized in terms of a) the overall activity of all the students during the Case exercise, b) the activity for the five steps of the script, and c) the activity level of individual participants. Since students' activity levels in a virtual environment does not necessarily illustrate collaboration (e.g. Pöysä, 2006), students' activity levels were determined not only by the frequency of their contributions within different steps of the script, but also considering how meaningful these contributions were with respect to the shared knowledge construction of the group. At this stage, the analysis was modified from the analysis of the prototypical roles in CSCL (see, Strijbos & De Laat, 2007), in which students' roles in asynchronous higher education settings were investigated. According to Strijbos and De Laat (2007), students' roles in collaborative learning situations can be identified on three dimensions: *group size, student orientation and effort*. In this study, all the groups were small-sized groups. First, students' orientation during group work was categorized as either oriented towards individual goals or towards the group goals. Second, the effort and impact that students invested in the group work were investigated. It should be noted that effort is not the same as impact: one's influence within a group is not directly dependent on the amount of one's contributions. Finally, we identified if the prototypical roles of "Free rider", "Ghost", "Over-rider" or "Captain" emerged (see, Strijbos & De Laat, 2007).

The second stage of analysis concentrated on how well the groups proceeded through the different phases of the script from the collaboration (knowledge built on others' ideas) point of view, and the main characteristics of the different groups. This analysis was based on the phases scripted into the environment as well as the individual roles identified in the previous level of analysis. At this stage, different teams were identified by the quality of their collaboration. In each group, different roles were taken under cross-summarization in view of the different steps of the script, and the degree to which each group succeeded in their collaboration. Groups that were found collaborative did not have roles that prevented collaboration, were active in high-level discussions (built knowledge on others' ideas) and did not skip scripted steps. Such engagement was demonstrated, for example, in elaborate questioning, explaining and reasoning (e.g., Mercer, 1996; Van Boxtel, Van der Linden, & Kanselaar, 2000). The contributions for collaboration were discussed to ensure that interpretations of the activities were neither misreadnor inferred by a single message, but were in fact based on a consistent pattern throughout the entire collaboration (Strijbos & De Laat, 2007).

5.4.3 Defining the difference between "ideal" script, and "actual, realized script"

In the next sub-study (3rd in chronological order, see Table 1), conducted in the higher education setting (Article V), the analysis was based on the method used in the previous sub-study. However, the method was further elaborated to better understand the difference between an ideal script and an actual, realized script, referring to emerging patterns, i.e. what really happens in a scripted learning condition and on how groups differ despite using the same scripted environment. The following four steps were taken: (1) verifying data, (2) examining whether the groups followed the structure of the script, (3) analyzing if the group work was collaborative or non-collaborative, and (4) comparing the main differences between groups, despite use of the same scripted environment.

At the beginning of the analysis, all the data were verified as in earlier sub-studies (Articles II–IV). Whether students were active during the script and the degree to which they followed the script were examined. This was done by categorizing students' rate of participation (Part 1: Amount of Activity) in terms of a) the overall activity of all students during the Grid exercise (how many students were active in each phase of the script) and b) the rate of participation of individual students in each phase. The goal of examining whether the groups followed the structure of the script (Part 2: Quality of Activities) was completed after analyzing collaboration within different groups (see the next section) by examining if the script generated a resolution for cognitive conflict and mutual explanations, as expected in the core pedagogical idea of the script.

In addition to the amount of activity, it was essential to discern whether or not students followed the script in collaboration (built knowledge on others' ideas). Therefore, the groups were identified as collaborative and non-collaborative. This was defined based on how the students participated and in what kind of activities. Finally, an investigation was done to see the types of differences between the groups despite use of the same scripted environment. In order to decipher the main differences, groups were compared according activity level, collaboration, prototypical roles and students' personal experience of the group work. Each group was examined as a sum of its participants' group processes. At this stage, different data sources (activity levels, number of messages, content of the messages (with researcher's interpretation), the final statements of each group, the self-report questionnaire and written feedback about the group work) provided corroborative evidence in addition to information obtained by other means (Cohen, 1994).

5.4.4 Analysing collaboration in the scripted 3D-game environment to understand group differences

The last sub-study (chronological order, see Table 1) was conducted in the Secure-game environment (Article III). The methods of analysis were further developed based on the needs which emerged in the first sub-study (Article II) of the vocational setting, and had some influence on the sub-studies conducted in the higher education context (Article IV and V). However, the aim of this sub-study (Article III) differed from higher education sub-studies (Articles IV and V) in terms of the scripted roles and focus of the analysis. As a scripted game story guided the roles of the players (Article III) more precisely than the scripted environment in the higher education settings (Articles IV and V), the players followed these roles. Therefore, the analysis of prototypical roles was not applied. The aim of the analysis was to understand the kind of activities that the scripted game environment generated among the players, and to what extent the least and most successful groups differed. This sub-study (Article III) utilized both qualitative and quantitative methods to cover larger groups of students and to make results more widely applicable. After the game experiment, all the data were verified, videos were watched and discussion entries, logged during the game, were read several times. The test results and time used in the game were examined, and groups were classified according to their test results and time used on the game. Then, the discussions were analyzed according their functional roles (see Table 3).

Table 3. *Functional Roles of Interaction and Subcategories According to the Detailed Functions of Interaction*

I Providing Information	II Questions	III Management of Interaction	IV Other Inputs
I.1. Explaining own situation	II.1. Questions	III.1. Group organisation	IV.1. Off task – Not related to game
I.2. Piece of advice		III.2. Planning upcoming activity	IV.2. Humour
I.3. Describing technical problems			IV.3. Motivating others
			IV.4. Downplaying others

According to Kumpulainen and Mutanen (1999), functions of interaction must be defined on a situational basis. In this sub-study (Article III), each player's utterances were categorised by type and quantity for each phase of the game (open problem, distributed expertise and mutual dependency, conflict situation and coordination). Each utterance was placed into one category based on its dominant character, and the categorisation was validated and cross-checked by two researchers. First, all the utterances were categorized, according to their functional roles, (Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001) into four main groups (Providing information, Questions, Management of interaction and Other inputs) (see, Table 3). According to Beers, Boshuizen, Kirschner, and Gijselaers (2007), theory-based code definitions are a good starting point for categorization, but typically a great deal of communication does not fit into predefined categories. Therefore, there is a need to develop new categories for a number of cases in order to enable the classification of all communication. In this sub-study (Article III), the utterances were data-driven and sorted into ten different subcategories according to the detailed functions: questions, pieces of advice, explaining own situation (for example explaining reasons for own actions), describing technical problems, group organisation, planning upcoming activity, motivating others, humour, downplaying others and off-task inputs. These discussion data were then examined at the group level to find out how different functional roles were distributed within different groups. Next, we checked to see if there was any correlation between the quantity of discussion and the test scores of the group, or a correlation between the time used in the game and the test scores of the group. Finally, detailed functions of interaction were compared between the groups with the highest and lowest final test scores.

Because the functional roles of discussion, time used on the game and scores of the final test could not give a full picture about collaboration in the 3D-game environment, a more detailed analysis was conducted across the entirety of the data. There were two main reasons for this qualitative analysis. First, avatars may serve as a means of communication, and second, the functional roles of discussion differed in terms of the quality of discussions (e.g. high quality of providing information included explaining, reasoning or elaborating, while low quality was characterized by scanty discussion). The classification was based on the phases of the game; open problem, distributed expertise and mutual dependency, conflict situation and coordination. Then, the groups were scrutinized for each phase: what was happening on the video and in light of the logged data, and how these observations were related to the findings gained from the electronic questionnaire and direct observation notes to get a picture of the groups' collaboration processes (including, for example, elaborative questioning and ensuring that all team members were able to participate, but also non-collaborative features such as an individualistic approach with minimal communication). Cross-comparisons of research material-sets, collected by various methods, were performed to improve the reliability of the research results. This comparison was done to ensure that the findings of this qualitative analysis were based on indicators from at least three different data sources (Cohen, Manion, & Morrison, 2001). To improve the reliability of the results, video feeds were watched, discussion entries were read and classifications (interpreter reliability in classifications; after discussion between two researchers percent agreement was 98%) cross-checked by two researchers. However, as stated in the evaluation of this study (see, Section 7.4), lack of classification of the functional roles of interaction did not specify the quality of collaboration well enough, and categories for classifications were rather simple and easily agreeable.

5.4.5 Concluding remarks on the analysis of the group processes in authentic macro-scripted collaboration contexts

Based on the findings of this study (see, Chapter 6), despite the macro-scripted environment there are variations between the groups. Therefore, there is a need to better understand group variations in order to support collaboration, for example with the use of macro-scripts. As described in the above sections, all the sub-studies (Articles II–V) had different aims and methods of analysis. However, all the sub studies (Articles II–V) also involved common features focusing on group processes in authentic macro-scripted collaborationcontexts. One aim of the thesis was to further develop methods of analysis in order to better understand what happens in macro-scripted collaboration contexts, and how groups vary despite use of the same scripts. In conclusion, as far as the methods of analysis are concerned, this study serves as an example of qualitative analysis of group processes in authentic macro-scripted collaboration contexts. To draw some general guidelines for such analyses, the following four-step procedure can be used:

1) Verify data.
2) Examine the extent to which the groups follow the structure of the script (Part 1: Amount of activity, Part 2: Quality of activities).
3) Analyze collaboration (how students are participating).
4) Compare group differences.

In *data verification* it is essential to go through the material several times and omit redundancies. In the context of this study, omitting redundancies meant reading through discussions, watching videos and logging double entries. Phases of the scripts give grounding for examination of whether the groups follow the structure of the script. There are two dimensions (participation activity and quality of activities) in examining whether the groups follow the structure of the ideal script. Firstly, there is a need to categorize students' rate of participation in terms of a) the overall activity of all students during the exercise (how many students were active in each phase of the script) and b) the rate of participation of individual students in each phase. Secondly, there is a need to analyze the quality of collaboration to understand if the groups follow the core pedagogical idea (for example solving cognitive conflict) of the script.

In this study, several methods were used to analyze quality of collaboration. There were two different types communication modes (synchronous in vocational contexts and asynchronous in a higher education context), and therefore, methods for analyzing the quality of collaboration differed as well. In design experiments, a theory-based data analysis (Berger & Calabrese, 1975; King, 1999; Webb, 1989) gives a good starting point for data classifications. However, there is often need for data-driven (Beers, Boshuizen, Kirschner, & Gijselaers, 2007) analysis as well, because in understanding collaboration and reasons behind group variations, certain amounts of data may not fit theory-driven categories. In the first sub-study (Article II), the teams were identified in terms of the collaboration (knowledge built on others' ideas) processes or teamwork they achieved during game play. The analysis was conducted by cross-comparing observation notes, evaluations of the final plans, interviews and conversations during game play. However, there emerged a need to further develop the method of analysing the quality of collaboration to make the analysis more reliable. Therefore, in the sub-studies conducted in a higher education context (Articles IV and V), the participation was examined in terms meaningfulness with respect to the groups knowledge construction in a particular learning task. At this stage, the analysis was modified from the analysis of the prototypical roles in CSCL (see, Strijbos & De Laat, 2007). In the last empirical experiment, the methods of analysis were further developed based on the needs emerging in earlier sub-studies (Articles II, IV and V), especially based on the experiences of the first sub-study in a vocational context (Article II). In the last sub-study (Article III), collaboration was analysed according to the functional roles of discussions (e.g. Kumpulainen & Mutanen, 1999), other means of communication (e.g. use of avatars), achievement on the test and time used in a play. As described above, there is no single way to analyse a group's activities to understand the quality of collaboration in scripted conditions, rather the methods of analysis must be defined on a situational basis.

Comparing the main differences between groups can be based on different types of data and/or findings of the previous phases of analysis. Groups can be compared, for example, in terms of activity level, collaboration, prototypical roles, students' personal experience, functional roles of discussions, test results, or time used in the activities. However, phases of the scripts can constitute the basis for analysis, in which different methods (e.g. methods of analysing prototypical roles) can be integrated. At this stage, different data sources provide corroborative evidence in addition to information obtained by other means (Cohen, 1994), and there is typically a need to use different data sources (see, Cohen, Manion, & Morrison, 2001) to understand the differences in collaboration between different groups. In this study, data classifications and analysis were cross-checked by two researchers in the two sub- studies (Articles III and IV) to improve the reliability of the results. While in two of the sub studies (Articles II and V) only the first author was familiar with data and conducted analysis. However, as each coder has his/her own capacities of understanding a coding (Beers et al., 2007), it would be optimal to use more than one researcher for the purpose of crosschecking.

6

An overview of the empirical studies

This study explores CSCL macro-scripts as a pedagogical method to facilitate learning. This section will portray four different macro-scripted settings and the main findings of each sub-study reported in the published articles (see, Appendices; Articles II–V).

6.1 Different game levels as a setting for scripts

In the sub-studies (Articles II and III) conducted in a vocational learning context, game environments were developed based on the needs of authentic learning contexts. The philosophy behind the designs of Mustakarhu and Secure games was to offer the kind of game play in a virtual environment that allows such practice that would otherwise be almost impossible, or at least very costly to arrange. Games were expected to offer learners some added value in comparison to the traditional vocational learning processes. The aim of both games was to use collaboration scripts and different game levels in a way that supports pedagogical goals. The different phases of the scripts follow the progression of the game levels, where higher levels can be reached by solving problems set for the players. Although problems are set in strict order, teams may create different ways to solve the problems. Both of the games include different types of puzzles; some can be solved individually, but others require effort and commitment from the whole team for successful completion.

6.1.1 Added value of visual communication for collaboration (Article II)

There were two aims in this sub-study (Article II). The first aim was to develop a game environment to simulate the work context of a vocational design process of surface treatment. The second aim was to answer the following questions on the basis of empirical study: 1) How did the game environment influence learning processes? 2) How did scripting affect players' actions and the kind of collaboration that took place during the game play? 3) How did groups vary in their activities despite the scripted environment?

The script of the Mustakarhu game was designed to encourage students to make decisions together. The main idea in the game design was to simulate the work context of a vocational design process, which involves a vocational task of designing four different customised hotel rooms. The game includes 13 sets of vocationally- oriented problems, 6 of which are mathematical. During the game, students are expected to design the rooms, calculate the areas and costs of the materials (within a team budget of 4000 euros), answer a quiz about materials, and finally write a report about the design process. Different modes of collaboration and cooperation are required and the game integrates individual work with collaboration (e.g. the costs of floor materials for each room needs to be calculated and the sum affects the team budget).

The findings show that a scripted game environment enriched studying by enabling aspects of collaboration that would not have been possible in traditional classroom settings. Afterwards, all the students felt that the game environment had offered added value by visual outlining a task as compared to the traditional classroom methods. A new form of collaboration emerged during the game, as all players used visual communication. Groups spent long periods of time comparing different materials. During that time, group members did not speak or write, but they were highly concentrated on browsing through different options for materials until they found ones that suited the needs of the group. In the game, students used the illustrative 3D model to view the rooms from different angles. In analysing the data, it turned out, however, that besides this illustrated point of view, some players used the model as a chance to take a break when the cognitive load started to build up too much. All five groups followed the scripted task order and completed the game successfully. So, the script guaranteed that all teams were able to complete the game. However, the analysis also revealed that the students' game processes varied a great deal despite the same scripted environment. The groups differed in terms of the outcomes of the design process, the time spent on the game (from 27 to 55 minutes) and collaboration shown.

The biggest differences between the groups emerged in their use of individual work, teamwork and collaboration. Group 1 used collaborative working processes throughout the game and moved through each task as a team. This group kept track of each other both by spoken dialogues and by visual communication, and they also made sure that all members understood each other. They used a lot of questioning, but mostly at a very practical level. In Group 2, the players started the game working individually so that their completion times for the first mathematical problem showed a range of over six minutes, which indicated they did not solve the task together. After this, however, the group realised that collaboration paid off, and accordingly resorted to this strategy through the rest of the game. The time spent on each phase increased after Phase 5, while the group started to use more elaborative questioning and negotiation, which led to a higher level of interaction. This group used a great deal of visual communication when it came to the choice of materials. Group 3 went for teamwork, but never reached collaboration. The level of cognitive activities was lower in Group 3 than in other groups; the students seldom negotiated but went for the simplest possible solutions. In Group 4, players were inexperienced and quite dependent on each other. They made sure that all members were able to solve problems, shared information, and everyone took part in the different activities. This group used a lot of humour and their completion times for the phases were equal. This group was collaborative, but instead the high elaboration collaboration was orientated toward practical task solving. Group 5 resorted to individual work as much as possible. Within this group, the completion times for individual phases varied up to 15 minutes. In the simulated recall interview, three of the group members stated that they preferred individual working methods as compared to collaborative ones. Within this group, only the tasks (material choices) that forced the team to work together made them ask questions and use visual communication. Interestingly, when collaboration was needed, this group was able to negotiate, make elaborative questions, listen to each other and build a task solution together. These students had experience from authentic work-life situations. They found the experiment easy and felt that they would have benefited from more complicated tasks within the game. To conclude, this study indicated that collaboration scripts can be integrated into different game levels. Ultimately, this kind of integration has the potential to make learning more efficacious. However, despite the scripted environment there were differences between the groups in regard to their game play and collaboration.

6.1.2 Group differences despite the scripted game environment (Article III)

The aims of the sub-study (Article III) were twofold. Firstly, the aim was to develop a game environment to simulate certain practical issues of work safety in a vocational context. Secondly, the aim was to answer the following questions on the basis of an empirical study:
1) What kind of activities did the scripted game environment generate among the players?
2) How did the least and the most successful groups differ in this respect, despite using the same scripted game environment?

The aim of Secure games is task solving in the area of work safety. The game story consists of five different phases (macro-script) of activities, four of which (phases 2–5) are designed to promote particular collaborative activities. In the first phase of the game, players get instructions from the forewoman, solve an individual task about a construction plan, and thereby gain access to the next level of the game. In the second phase of the game, the teams are supposed to cast the substratum for a hut (an open problem). There is also a certain order in which players have to act within their predetermined roles, and the players are not aware of each other's roles. Thus, the primary idea is to create a situation in which students have to use their abilities to handle uncertainty, commit to task solving and build shared understanding by explaining their understanding about the task solution. The main goal is for players to figure out the task and come up with innovative solutions for the problem. In the third phase, the teams are to make a construction of wood and prefabricated units on top of the substratum. The leading idea is to facilitate distributed expertise so that different types of tools are distributed between the team members, which in turn, makes shared task solving (e.g. explaining and reasoning) necessary. In the fourth phase, the aim is to enhance students' learning by offering them a task in which they have to reason and explain. In this phase, players work with conflicting tasks, which brings about a hazardous situation (danger of fire). The goal is to lead the players into discussions, to question their actions, and finally to solve a conflict and create a shared solution for the safety problem. In the final phase of the game, the players have to finalize the hut and coordinate the perspectives of four different players. This phase involves four important principles of collaboration: personal responsibility, dependency between participants, combining different skills, and control of an aggregate of individuals. Most importantly, none of the players are able to solve the problems without other players.

The findings of this sub-study (Article III) are in line with the previous sub-study (Article II) in a vocational context. Indeed, the findings indicate that in order to induce collaboration between players, it is crucial to construct tasks that compel them to work together, and further, that the scripted game environment enriched the learning activities by enabling aspects that would not have been possible in traditional classroom settings with regard to dealing with an authentic fire emergency situation, for instance. Overall, every group followed the scripted task order, and 12 of the 16 groups completed the game, while the remaining four groups suffered from some technical problems in the last game session. Students' game processes varied a great deal during the sessions despite the same scripted environment. Groups differed in terms of their results in the final test, time spent on the game and collaboration processes (the discussions, and non-verbal communication through the avatars). There were differences regarding the time used on the game, which varied from about 58 minutes to 94 minutes, with an average of approximately 71 minutes. Faster playing groups did better in the final test than slower playing ones. Also, the amount of discussion differed between the groups. Some of the groups played the game through with very little discussion (Group 12: 58 utterances), while the most active group in this respect, Group 8, sent 507 utterances. There was no statistically significant correlation between the groupwise test scores and discussion activity, i.e. number of utterances (r=.002, p=.990).

During the game, the 16 groups sent a total of 3.841 utterances. On average, more than forty per cent of utterances related to providing information. In terms of the detailed functional roles, most of the utterances during the game consisted of questions, explanations of own situation (for example explaining reasons for own actions), and pieces of advice. The category of "off task" (which could be characterized as miscellaneous, off-topic) accounted for about 20% of all utterances. Humour had a quite significant role in discussions, and there was only one group without any utterances in the humour category during the game. In the discussions and non-verbal communication, there were differences between different phases of the game. Most of the discussions, 56.9%, took place in the first two phases of the game (intro and open problem), whereas the non-verbal communication through the avatars gained ground throughout the game. At the beginning of the game, most utterances involved establishing different roles, questions and offering pieces of advice which were related to the logic of the game and practical operations, such as moving in the game environment using avatars. The amount of discussion decreased in the third phase (distributed expertise and dependency between participants). This was the most inactive part of the game in terms of discussion, and accounted for only 11.3% of the utterances. A technical deficiency in the game implementation allowed the players to work individually. In the fourth phase (conflict), the storyline involved a danger of fire if the players did not work as a team, which activated collaboration again, so that 18.4% of the utterances were sent in this phase; non-verbal communication through avatars was also active during this phase. However, four teams managed to avoid the fire, although in some cases it broke out several times (four times in Group 8). The last phase of the game comprised 13.4% of the utterances, and they were mostly related to coordination or description of the player's own situation.

The biggest difference in test results was between Group 1 (130 points) and Group 12 (108 points). There were also striking differences in the amount of their utterances; Group 1 sent 251 utterances, whereas Group 12 sent only 58 utterances. However, as far as the percentage of distribution across the interactional functions is concerned, these groups were quite similar in the categories of providing information and questions. Yet, the reactions and activities differed greatly between these two groups. While Group 1 used shared task solving, characterized by high quality of interaction and contributions, Group 12 based their work on individual contributions, with little or no feedback from the other team members. The players in the high-achieving Group 1 explained and reasoned their own situation, and guided each other during the game process. For example, in "explaining own situation" -utterances, a high-level was characterized by detailed explanations and reasoning own situation and actions. In contrast, the low-achieving Group 12 was characterized by their typically scanty discussions; the players simply informed each other about their actions, but without describing their current situation. There were also differences in the management of interaction and other inputs as well. While the low-achieving Group 12 used 12.1% of their utterances in managing their group activities, in Group 1 only 1.2% of utterances fell into this category. A typical feature of Group 12 was that their activities were dispersed and the group never reached shared task solving.

To sum up, this sub-study (Article III) indicated that all the groups followed the scripted task order; the game environment guided players towards shared problem solving (Johnson, Johnson, Stanne, & Garibaldi, 1990) and helped them to proceed through the different phases. However, there were great variations within different groups, especially in the quality of collaboration. The sub-study (Article III) also revealed that in order to induce collaboration between players, it is crucial to construct tasks that compel them to work together, because within the game experiment most players first attempted to carry out the tasks on their own, joining forces with the other players only when they realized that it was necessary to do so to solve a problem.

6.2 Differences between "ideal" script and "actual, realized script"

The aim of the sub-studies conducted in a higher education learning context (Articles IV and V) was to develop and study macro-scripts as a pedagogical method to facilitate collaborative learning.

6.2.1 Roles in scripted collaboration (Article IV)

The aim of the sub study (Article IV) was to examine how the Case script – designed to support students' collaborative processes – guided groups' activities while working in a Web-based environment. In addition, the aim was to study how different groups interpreted the script, what kinds of roles students adopted and what kinds of differences there were between the groups in working through the script.

In the Case script, the main idea was to solve an authentic learning problem with different theoretical background knowledge (distributed expertise), complementary knowledge construction (Perkins, 1993) and reciprocal teaching (Palincsar & Brown, 1984). Learners worked in small groups to prepare an individualized teaching plan for one particular learner (Matti and Timo). Matti and Timo have different kinds of needs with respect to the teaching plan. The Case script is comprised of five steps. First, the students need to familiarize themselves with an authentic learning problem concerning learning readiness (of two different learners, Matti and Timo). At this step, each group reads a comic where the characters Matti and Timo are working together. Half of the groups are to focus on Matti's case, while the other half concentrate on Timo. Second, they should read the theoretical background material about such cases. Third, they are to enter a group Web discussion about constructing a shared plan for Matti or Timo's personal curriculum. Fourth, based on this discussion, the students are to proceed to accomplish a shared plan as a group. Finally, the student groups are expected to comment on other groups' curriculum plans and to evaluate how realistic the plan is with regard to supporting the learning readiness of the learner in question.

The results of the sub-study (Article IV) indicated that scripting guided student collaboration at a general level, ensuring that all groups were able to accomplish the task; but it did not guarantee "high-level" participation within the groups. All groups followed the Case script, although 10 of the 30 participants skipped one or more of the steps included in the script. Nonetheless, each group eventually produced a shared plan. With regard to the time limits, the script kept the students well paced, so that all groups completed their work on time within a range of three days. The activity level of individual participants varied between the different steps of the script. In the first step, where the students were supposed to familiarize themselves with an authentic learning problem, all 30 students were active. From the second step (reading theoretical background material) we did not get any exact participation rate, but 18 of the students referred to the reading material in their discussions. The Web discussion was the most activating section of the script, as all 30 students participated in shared discussion. Based on discussion data, 21 students were actively involved in the actual writing process (by editing or revising) of the final document. In addition, everyone took part in constructing the document through the Web discussion. Regarding the final step of commenting on other groups' work, 20 students sent at least one comment to another group.

The groups differed in terms of the number, length and content of their activities, satisfaction with the group work, the degree of collaboration, roles assumed and attitudes displayed in the group. A total of 271 postings were sent during the course, but the number of postings varied across the groups from 24 messages to 60 messages. While in the Case script, all participants were involved in discussion, three of the groups also included so-called "free riders" (members seeking maximum benefit from the group task with minimum personal input) (Kerr & Bruun, 1983) or "ghosts" (members with a high individual learning goal, but a passive attitude towards group work) (Strijbos & De Laat, 2007), who hampered collaboration in their group. There were three main types of group-work profiles. First, there were three groups with unequal participation. Two of these groups had some members who reached higher levels of collaboration (built knowledge on others' ideas), whereas the third group did not reach higher levels of collaboration. Second, there were two groups with practically-oriented working methods, which showed in structured discussions around the main theme. Even the work that was partly collaborative task solving, was practically- oriented instead of creative (Craft, 2001) and high-level elaboration. Third, there were two groups with shared knowledge construction that were clearly dominated by one member. However, these two groups showed opposite effects of such dominance: while Group 5 experienced uncomfortable work situations and suffered from the "over-rider" (member dominating the group work), Group 7 had a supportive "captain" who facilitated teamwork and increased team cohesion. To sum up, findings indicate that within this sub-study (Article IV) all groups completed the task successfully and came up with respective shared plans for the particular case. However, the Case script could not guarantee equal and "high-level" collaboration within the teams (see, e.g. Baker, 2002). The Case script was quite open with respect to assigning or allocating roles, and there were different roles among students. Despite the script and shared background knowledge, some learners would have needed more support or supervision.

6.2.2 Too strict guidance hinders collaboration (Article V)

The aim of the sub-study (Article V) was to examine the difference (by means of a Grid script) between the "ideal" script (the particular learning activities that the script is expected to produce, Kobbe et al., 2007) and the "actual, realized script" referring to emerging patterns, i.e. what really happens in a scripted learning situation (Dillenbourg & Jermann, 2006). The aim was also to find out how collaboration differed between different groups in the same scripted condition.

The basis of the Grid-script used in this sub-study (Article V) employed the combination of "Concept Grid" (See Dillenbourg & Jermann, 2006), aiming at mutual explanation (Webb, 1989), and the idea of resolving cognitive conflict (e.g., Doise, 1985). In this experiment, modifications were made to the original "Concept Grid", and instead of concepts, the students were expected to work on a conflicting education policy topic concerning whether pre-primary education should be organized at school or at kindergarten. During the Grid script, the groups received different theoretical background information (for each participant), which the students themselves allocated within the group. The aim of this procedure was to create interdependence among group members by producing opposite but complementary resources for the students. In the second phase, each student read his/her theory material and made a visit to a related pre-primary education learning centre (school or kindergarten). The aim of this phase was to offer authentic experiences and add meaning to the personal roles established in the first phase. In the third phase, each student filled in a table stating his/her views and definitions based on the background information provided and their visit (different views aimed for conflict). The aim of this phase was to make the opposite sides and opinions visible and clear for the group members. In the fourth phase, each group had a shared discussion in which students had to formulate final statements around the topic, heeding the opposite points of view (at this phase conflict between opposite views was expected to occur). In the final phase, each group had an analytic discussion about how well they had been able to construct the task and complete the final statement.

The Grid script ensured that all groups were able to complete the task, and that all participants indicated some activity during the work. The course began with a total of 30 students, but two of them eventually dropped out without finishing the script. With regard to the time limits, six groups kept pace with the one-month timeline set by the script, whereas one group exceeded it by over a week. The participation varied between the different phases in terms of the modes of individual participant activity. Of the seven groups, four can be characterized as collaborative and three as non-collaborative. The groups differed in terms of the number, content, and length of messages posted, as well as in the roles assumed, attitudes and personal features displayed by their members. A total of 352 postings were sent, but the number of messages varied between the groups, ranging from 29 to 92 messages. Thus, at the end of the script, all groups were able to formulate their final statements. The Grid script required individual efforts from each student, which meant that all the students either contributed to some work or failed to go through the script and dropped out the course, and there was only one "free-rider" within all groups. Despite this positive effect, some critical issues did arise. The biggest problem concerned the differences in individual learners' contributions at each step of the script. Six of the groups had members who were hindering, rather than promoting, collaboration.

The findings indicate that there was a difference between the ideal script (reaching the core pedagogical idea) and the patterns that emerged with different groups in the scripted collaboration. In the first three phases, students followed the ideal script. In the first phase, in which students received different theoretical background information all the students (28) were active. From the second phase on, we could not get exact participation rates for students regarding reading of theoretical background material, but 27 of the students made a visit to a relevant learning centre. In the third phase, 27 students filled in a table and also argued for their respective points of view. Differences between the ideal script and students' activities emerged in the last two phases. The fourth phase (Web discussion) was a very active part of the script, and all 28 students participated in shared discussion and formulated the final statements. However, participation differed from the ideal script, firstly, because active conflict situations with critical argumentation (which were expected in the ideal script) were rare in all groups, and secondly, mutual explaining did not occur within all the groups, due to the use of copy-pasting text from individual tables to conversation. This was especially true in Groups 1 and 4, who both included high use of copy-pasting text. However, the influence of copy-pasting differed; Group 1 integrated copy-pasting into the discussion, whereas for Group 4, task solving was non-dialogic copy-pasting of text from their individually filled tables to the Web-discussion. The findings also indicate that a task that would create a conflict in a face-to-face situation does not necessarily apply to a virtual environment. It may be that in virtual environments, students do not enter conflict situations as easily as in face-to-face discussions (Baker, 2003). In the final phase, 24 students took part in discussion. However, in this phase of the script, students' discussion tended to be very simple, without analytic reflection. A particular problem with phases 4 and 5 was that six of the groups had students who used very simplistic arguments and resorted to extensive copy-pasting of text from individual tables to the conversations.

To sum up, according to the findings, the Grid script ensured that all the groups were able to complete the task, and all participants indicated some activity during the work. The Grid script required individual efforts from each student, which meant that all the students either contributed to some work or failed to go through the script and dropped out the course. Despite this positive effect, also some critical issues did arise. The biggest problem concerned the quality of collaboration, which was hampered by the differences in individual learners' contributions at each step of the script, and six of the groups had members who were hindering, rather than promoting, collaboration.

7

Main findings and general discussion

This study was inspired by the finding that revealed when learners are left on their own in CSCL it is often difficult for teams to engage in productive collaboration in authentic educational settings (Häkkinen, Arvaja, & Mäkitalo, 2004). One solution may be to design collaboration scripts into CSCL environments (Dillenbourg, 1999). This study explored macro-scripts as external support for CSCL, and elaborated theoretical guidelines for design of (pedagogical) collaboration scripts. As described earlier, CSCL scripts lie in between micro-scripts with typically educational-psychology oriented research perspectives (cognitive studies of individual cognition) and macro-scripts with typically socio-cultural oriented research perspectives (studies of group processes) (Dillenbourg, Järvelä, & Fisher, 2008). While the focus of research has primarily centred on the connection between micro-scripts and individual learning, the effects of macro-scripts on collaboration within groups in authentic learning contexts are still largely unexplored. This study was one attempt to fill this gap and to study macro-scripts as a pedagogical method to facilitate learning in authentic educational contexts. Since studies of scripting have been largely based on the methods used in cognitive studies of individual cognition, the aim of this study was also to develop methodological tools to analyze groups and variations between them in macro-scripted collaboration. The aim of the empirical part of this study was to design four different pedagogical macro-scripts and to examine how these scripts guided group activities and how group activity varies despite use of the same scripted environment.

7.1 Shaping the meaning of the core pedagogical idea within macro-scripts

In designing scripts, the multi-disciplinary expertise of the educational sciences, psychology, and computer sciences are needed. However, finding common ground for researchers from different traditions has been problematic. Therefore, there was a need for negotiating shared understanding and constructing shared concepts for key elements of the script between different research perspectives. COSSICLE-team concluded that, in order to make scripts more general, the core pedagogical idea of scripts should be transferable to different learning settings and frame the level of abstraction (defining components and mechanisms) in scripts, which would in turn allow for the adaption of different scripts for different learning contexts (Article I).

From the pedagogical perspective, the leading issue in scripting is the core design principle, through which the script is expected to trigger collaboration (knowledge construction built on others' ideas). Therefore, the aim of this study was to elaborate different theoretical guidelines for design of (pedagogical) collaboration scripts, which support the development of cognitive, social, developmental or motivational aspects of learning. In the first sub-study (Article II) the core pedagogical idea, how to tiger collaboration, was tentative. However, the findings indicated that in order to induce collaboration between students, it is crucial to construct tasks that compel them to work together, as most students first attempted to carry out the tasks on their own, joining forces with other learners only when they realized it was necessary to solve a problem (Articles II and III). These results are in line with the notion that shared knowledge construction typically occurs in situations were the task itself triggers collaboration (Arvaja, 2005). Based of the findings of this study, the meaning of the core pedagogical idea (or core design principle) became evident as a reason to introduce collaboration between learners.

In this study (Articles III–V), previous research from collaborative learning formed basis for design of the scripts, and different core pedagogical ideas were used in each of the sub-studies (Articles III–V). There was an assumption that collaboration would be supported by the scripted tasks with the different core pedagogical ideas (an authentic learning problem (e.g. Kester, Kirschner, & Corbalan, 2007), solving cognitive conflict (e.g. Doise, 1985), distributed expertise (e.g. Price et al., 2003; Dillenbourg & Jermann, 2006), complementary knowledge construction (e.g. De Laat & Lally, 2004) and reciprocal teaching (Palincsar & Brown, 1984). Findings indicate that defining and introducing a core pedagogical idea is challenging because, in macro-scripted conditions, groups acted differently, despite using the same core pedagogical idea and an ideal script. These results are in line with the notion of Dillenbourg and Jermann (2006), who state that differences emerge between an *ideal script, mental script* (a social and mental representation created by the group performing the script) and an *actual script* (the emerging patterns, i.e. what really happens in a scripted learning situation). Within two of the sub-studies (Articles II and III), in which new synchronous game environments were created in vocational learning contexts, core pedagogical ideas came true and students followed the ideal script more precisely than in the sub-studies conducted in higher-education contexts (Articles IV and V). This might be because in the game environment, there were more concrete learning tasks, and also because the game's story supported students' roles more than a textual environment.

Based on this study, one can surmise that designing macro-scripts is more complicated than integrating core pedagogical ideas (based on the former research findings) into lesson plans. Findings assign that for different learning goals (learning concrete work skills vs. understanding theoretical concepts) there is a need for different kinds of core pedagogical ideas and external support through which scripts are expected to trigger collaboration. Aside from taking into account the learning goals, this study suggests that learners' characteristics and roles (Hare, 1994) should also be considered in scripting (for a more detailed discussion, see Section 7.3).

7.2 Games as a setting for scripting

In this study, there was an assumption that virtual games could support learning (Kirriemuir & McFarlane, 2003; Ravenscroft & Matheson, 2002; Ulicsak, 2005). This study is the first attempt to integrate research on design of collaboration scripts and different game levels. Findings indicate that the potential for this kind of integration as one way to support collaboration. In two of the sub-studies (Articles II and III), in which new synchronous game environments were created, the environment supported collaboration more than in the sub-studies conducted in higher-education contexts in a textual environment (Articles IV and V). The major benefits of the scripted game environments were, firstly, the possibility to visualize authentic work conditions in a manner that would have been unlikely in a traditional classroom setting, and secondly, the possibility to create new ways to collaborate (Articles II and III). The game process generated new forms of collaboration, as the students were able to use visual communication (Article II) and non-verbal communication with the aid of avatars (Article III). Findings suggest that this kind of integration of the script and game levels seems to be a promising way to support collaborative leaning. These findings are in line with Manninens' (2004) argument that virtual game environments enable new forms of collaboration. Based on this study, different levels of the game can ultimately enable motivating scripts, and are one way to integrate different social levels (individual and collaborative) of learning into the game story (Dillenbourg & Hong, 2008). This is especially true in vocational education, where learning is based on authentic tasks; better ways to visualize such learning tasks are needed to address motivational challenges. Illustrative presentation of occupational situations through game-like applications seems to be one potential way to improve vocational learning and respond to the changing needs of working life.

Findings (Articles II and III) indicate that despite the scripted environment, there were variations in collaboration, and the game environment itself does not guarantee high-level collaborative learning (see, Barron, 2003). Rather, games can be seen as one way to integrate pedagogically designed collaboration scripts into technical environment. Therefore, designing pedagogically meaningful virtual environments for specific contexts is a challenging task that calls for close cooperation between the technical game developers and specialists with pedagogic and domain-specific expertise (from both teachers' and learners' point of view). Designing scripted games for a specific context is even more complicated than designing scripts. Script design teams have to be able to take into account the needs of learning in authentic contexts, the possibilities of technical applications and the latest research findings. Even though this study suggests that, at their best, scripted games can support collaborative learning in a vocational context, future research should focus on the possibilities and limitations of scripted game environments as a setting for collaborative learning.

7.3 Macro-scripts as external support for collaboration

The findings of the sub-studies (Articles II–V) indicate that macro-scripts as external support can help students proceed in solving learning tasks. In all the studies, groups followed the script. However, none of the scripts could guarantee equal and high-level collaboration within the teams (see, e.g. Baker, 2002), and there was also considerable variation between the groups in this respect. The findings of the all the studies indicate that different groups acted differently, regardless of using the same macro-scripts. The biggest differences occurred in collaboration (Articles II–V) and the roles assumed in a group (Articles IV and V). In all the sub studies (Articles II–V), there were collaborative and non-collaborative groups. Although interaction in this study occurred across various settings, (Koschmann, 1994; Dillenbourg, Järvelä, & Fisher, 2008), the differences in settings did not explain the quality of collaboration. There was no single reason for quality of collaboration. In this study, aside from students´ collaboration skills (Cartwright, 1968), high-level collaboration depended on learners' willingness and effort towards collaboration (e.g. Article II) and taking responsibility for personal roles (e.g. Articles IV and V). As far as the roles were concerned, the main problem for collaboration was unequal participation in the group work. For example, the roles of the "free-rider", "ghost" and "over-rider" did exist (Strijbos & De Laat, 2007). In contrast, high-level collaboration (knowledge construction built on others' ideas) seemed to be connected to students' equal interaction, in which they were explaining, reasoning and questioning their own and their peers' actions or views (Baker, 2002; Barron, 2003).

Learners' efforts towards group work and skills to collaborate were meaningful for collaboration. Findings indicate that a student's high activity level did not automatically indicate good collaboration (Articles III and IV). Article III showed that the number of utterances did not correlate with achievement in the final test, and Article IV demonstrated that a high amount of activity does not necessarily promote collaboration. This is also supported by the findings of the most structured script "the Grid" (Article V), which ensured that all the groups were able to complete the task, and all the participants indicated some activity during the work. The Grid script required individual efforts from each student, which meant that all the students either contributed to some work or failed to go through the script and dropped out of the course. However, the cycle of higher education sub-studies (Article IV and V) demonstrates the notion that too much guidance disturbs the richness of natural collaboration (Dillenbourg & Tchounikine, 2007) through which new knowledge is built on others' ideas and input (Arvaja et al., 2007). This is in line with Dillenbourg and Jermann's (2006) notion that scripts should be seen as a flexible recourse for collaboration.

In two sub-studies (Article IV and V) the same students proceeded through two different scripts. The advantage of more detailed control was that it prevented free riding, but the negative effect was that since some students were forced to participate, six of the groups had members who were hindering rather than promoting collaboration (Article V). Since collaboration in macro-scripted conditions depends on the learners' willingness to work together; the script should not be seen as a way to force students to participate in collaboration. If students are forced to participate (without motivation and engagement), there is a risk that, while scripting may increase the quasi-activity of some students who are not really committed to the actual group work, it may lead to simplistic discussion or even prevent more active members' collaboration. This poses interesting challenges to script design. One such challenge is deciphering the core design principles that awoke students' motivational high-level engagement (e.g. Järvelä, Veermans, & Leinonen, 2008; Volet, Summers, & Thurman, 2008) in collaborative knowledge construction. A further challenge is deciding how to assign individuals in such a way that they will recognize and balance their collaborative behaviours in quest of optimal group processes. Based on the findings, this is more complicated than helping students recognize their participation, which indicated that unequal participation in collaboration was recognized both by some active members of the group and by some less active members (Article IV). Even though the problem was recognised, those members still remained inactive. With regard to this aspect of scripted collaboration, a future challenge is to find ways to engage the whole group in the collaboration process (Fredricks, Blumenfeld, & Paris, 2004; Volet, Summers, & Thurman, 2008), while still leaving space for participants' own ideas and creativity (Amabile, 1983; Gall & Breeze, 2008; Vass, 2002). In this regard, it might be useful to combine knowledge of students' self-regulation (Boekarts, Pintrich, & Zeidner, 2000), on the one hand, and of collaborative scripts, on the other hand.

7.3.1 Assigning roles in macro-scripted collaboration

Two of the sub-studies (Article IV and V) focused on the roles assumed in a group. By opening up the process of each group's shared activity, this study aims to offer tools for detecting possible reasons for differences. Optimally, this knowledge could be used in identifying critical points for re-structuring scripting in response to the specific needs of a particular context. Article IV demonstrates three main types of group work. First, there were three groups with unequal participation. However, unequal participation did not automatically spoil other members' collaboration (knowledge construction built on others' ideas). Two of these groups had some members who reached higher levels of learning and collaboration, whereas the third group did not reach higher levels of learning. Second, there were two groups with practically-oriented working methods, which showed in structured discussions around the main theme, and a main interest in solving the task. Even though the work was partly collaborative-task solving, it was practically-oriented instead of shared-creativity (Craft, 2001; Vass, 2002). Third, there were two groups that were clearly dominated by one member (Strijbos, Martens, Jochems, & Broers, 2004). However, these two groups showed opposite effects of such dominance: while Group 5 experienced an uncomfortable working situation and suffered from the "over-rider", Group 7 had a supportive "captain" who facilitated teamwork and increased team cohesion.

The cycle of higher education sub-studies (Article IV and V) demonstrates that among the same students, the roles and main characteristics of the group work did not remain the same. In the next sub-study (Article V), there were four collaborative groups with shared task solving, one group with high use of copy-pasting text (Group 4), and two groups whose discussions tended to be simplistic, lacking elaborative questioning, mutual explaining and reasoning. This poses a challenge for future research concerning deciphering the kind of support different groups need in their collaboration processes (which cannot be directly predicted) and how to assign different roles to support collaboration (knowledge construction built on others' ideas) in different groups. One way to further understand the meaning of roles (Strijbos et al., 2004) in collaboration processes using macro-scripted conditions would be longitudinal empirical studies in authentic large-scale settings, which follows same groups throughout different scripts. This kind of research would offer new insight, which could then be used in assigning different roles as external support for collaboration. This is in line with the assumption of Rourke and Kanuka (2007), who state that well-structured learning activities with clearly defined roles and assessment of students' participation may ease the difficulties of uncritical discourse in collaboration. Ideally, this kind of knowledge could be used for helping students recognize disturbing activity (such as over-riding) and offer them tools to turn their activity towards participation which facilitates collaboration.

7.3.2 Macro-scripts as flexible and situated resources

The findings of this study are in line with Stahl's (2006) notion of re-conceptualizing scripts to be situated resources for knowledge construction rather than implementable action plans. In the optimal situation, core design principles, different assigned roles, and students' engagement, effort, and focus should intertwine. Therefore, future research is needed in order to find out what kinds of core pedagogical ideas support the cognitive, social, developmental, or motivational aspects of group collaborative learning in different authentic learning contexts. More attention must be paid to what kinds of scripts (with explicit design principles) are able to trigger collaboration with different learners and how scripts further various kinds of interactions in different learning situations. One way to do this might be to observe the differences between an *ideal script*, a *mental script*, and an *actual script* (Dillenbourg & Jermann, 2006). Methodologically, this would mean further development of the methods used in this study (determining if the groups follow the structure of the script and analyzing the quality of the collaboration) in order to comprehend a group's understanding of the mental script. This could mean, for example, longitudinal empirical studies on macro-scripts in authentic large-scale settings, as well as conducting micro-level analysis to understand why ideal, mental, and actual scripts differ.

Another solution may be to pay more attention to the role of the teacher as one who orchestrates and supports students' knowledge construction in macro-scripted collaboration (Fischer & Dillenbourg, 2006; Rasku-Puttonen, Eteläpelto, Häkkinen, & Arvaja, 2002). In scripted conditions, it may be useful to increase the role of the teacher, not only during collaboration, but also beforehand – such as in forming groups, for example, since different groups seem to benefit from different group composition – to find optimal scripts for different groups of learners (e.g., Denessen & Veenman, 2005; Van Keer, Schellens, De Wever, & Martin Valcke, 2008). Furthermore, future research on scripting should intertwine with research on students' contextual resources, such as prior knowledge (for detailed descriptions of contextual resources, see Arvaja, 2007). Scripts, group composition, and contextual resources could then be used as tools to positively impact continual, group-based knowledge construction activities. The use of such scripts would mean that heterogeneous groups, with respect to knowledge, could be offered material that creates common ground and a shared conceptual space (Kopp, Schnurer, & Mandl, 2006; Roschelle & Teasley, 1995). Furthermore, these activities would allow the participants to utilize the collaborative value of different perspectives and grant learners the possibility of asking for help from participants in heterogeneous groups (e.g., Van Keer et. al., 2008). In contrast, the reason for the script in homogeneous groups is to offer material that creates different perspectives (e.g., to create cognitive conflicts) or knowledge between participants (e.g., through assigning participants different material) (Dillenbourg, 2002; Miyake, Masukawa, & Shirouzou, 2001).

7.4 Evaluation of this study

7.4.1 Evaluation of methodology

Lipponen (2001) has argued that the findings of the successful CSCL laboratory experiments are not necessarily achieved in ordinary classrooms. The advantage of this study is that it focuses on group collaboration in macro-scripted authentic learning contexts, which we do not currently know much about. Another benefit of the study is that it simultaneously aims to develop macro-scripts for collaborative learning and uses such scripted environments in authentic settings to study learning and teaching (Sandoval & Bell, 2004). Through this, the study attempts to carry experimentation into authentic settings in order to find out what works in practice. The study enhances the knowledge of how groups work in macro-scripted conditions and develops a qualitative approach in order to capture variations between the ideal and actual script by highlighting the process of group collaboration in which methods of analysis that focus on learning outcomes are not suitable. However, such an approach is also a limitation of this study. Authentic settings and qualitative analysis mean abandoning a psychological research tradition (from which collaboration scripts are typically investigated) in which results are based on the notion of controlling variables in large-scale settings (Collins, 1999). Only the last sub-study (Article III) utilized both qualitative and quantitative methods to cover a larger group of students and to make results more widely applicable. Therefore, the limitations with regard to the usability of the findings of the individual sub-studies are, firstly, the lack of individual perspective in learning a process; it is not possible to evaluate an individual's learning based on this study. Secondly, the experiments are designed for a particular learning context and for a small number of subjects. Therefore, the findings of the individual sub-studies are not usable for grand generations (Shavelson et al., 2003). Although the individual sub-studies comprised rather small number of participants, which restricts possibilities for generalisation, the findings of all these sub-studies (Articles II–V) gave consistent evidence both for the positive effect of macro-scripts and the variations between groups. Therefore, the findings of the thesis can be considered indicative of groups' collaboration in macro-scripted conditions and may serve as a foundation for future studies.

The advantage of this study is that it is the first attempt to integrate scripts and different game levels. This is in line with the notion that, at its best, design-based research can create innovations for learning (The DBR collective, 2003). However, despite this advancement there are also limitations when the findings of these game studies are considered, especially in the methods used in the analysis. This is especially true in the first sub-study (Article II), as the methods of analysis were rather undeveloped, and there was only the aim to use partly theory-driven and partly data-driven data classifications. Both of the sub-studies (Articles II and III) conducted in game contexts revealed that discussion data, i.e. the type and quantity of utterances, did not give a full picture of the collaboration process, because the players were also able to collaborate through visual communication (Article II) and avatars (Article III). In the course of the game, the use of non-verbal communication seemed to be an essential role. However, even though there was an attempt to capture this non-verbal collaboration, the method of analysis was strongly based on methods developed for textual environments, and compared to analysis based on test results, time and functional roles of discussion, the analysis of the non-verbal collaboration was vague and a poor representation of non-verbal collaboration. Another limitation was that classification of functional roles of discussion did not bring about the quality of collaboration to a suitable level, and categories for classifications were rather simple (Article III). Therefore, in the future there is a need to pay more attention to developing methodological tools, not only to capture non-verbal collaboration in game environments, but also to understand differences in the quality of collaboration.

This study explored the meaning of the core pedagogical ideas in the pedagogical design of scripts. Thus, a critical aspect of this study was that even all the sub-studies (Articles II–IV) were theory-driven and aimed at testing different theoretical ideas through the design-analysis-redesign of instructional activities and artifacts as outlined in DBR (see, Barab & Squire, 2004; Shavelson et al., 2003). However, a limitation was that use of the core pedagogical ideas is in its infancy. The four cases were iterative and focused on using collaborative macro-scripts to enhance learning. However, they are not iterative within the same content. The assumption that collaboration would be supported by the scripted tasks, with different core pedagogical ideas, was not followed systematically throughout this study. In the first sub-study (chronological order), conducted in the vocational education setting (Article II), the use of the core pedagogical idea and script was undeveloped, and there was only an aim to use theory-driven design in the game. In the following sub-studies (Articles III–V) the core pedagogical idea was developed further, but there were still weaknesses. In the Case-script (Article IV), the core pedagogical idea and script was so loose that it allowed unequal participation and did not engage students well enough in task solving. The problem of the core pedagogical idea of the Grid-script (Article V) was that it activated students, but the reason was too external, as the Grid-script was not able to motivate students to engage in joint-creation of new knowledge. Another limitation of the Grid-script was the possibility of copy-pasting text from individually filled tables, which in turn caused a lack of reciprocal discussion. In the last sub-study (Article III), the pedagogical core idea(s) were most theory-based and triggered collaboration more than in the previous studies. However, in the last sub-study, there were still approximately 20% "off task" utterances, and therefore, there is a need to find better ways to engage students in collaborative learning tasks.

When considering the critical aspects of DBR (see, Chapter 5; Barab & Squire, 2004; Shavelson et al., 2003), the advances of this study are as follows: the truly collaborative nature of the sub-studies is important to point out, as all of them took place in naturalistic contexts and depended on collaboration with practitioners; all of the sub-studies designed and modified real-world settings; the intent of the sub-studies was to improve instructional tools to support learning (as new scripted game environments were developed in two of the sub-studies (Articles II and III) and new macro-scripts were developed in two of the sub-studies (Articles IV and V)); throughout the development of new macro-scripts, this study sought to trace learning practices and understand collaborative learning in its technological contexts; and this study followed the iterative nature of DBR as all the sub-studies linked design-analysis-re-design cycles (see, Table 1 and Section 5.2) to develop a new understanding of macro-scripted collaboration and group variations, as well as more effective methods for data collection and analysis (see, Chapter 5).

In summary, the advances of this study were the authentic nature of a macro-scripted setting, and integration scripts and different game levels, which we do not currently know much about. The limitations of this study concerned the use of pedagogical core ideas and methods investigating group collaboration in macro-scripted settings. Therefore, in the future, there is a need for more systematic empirical research (which focuses on the difference between *the ideal*, *mental* and *actual script*, especially emphasizing the use of core pedagogical ideas). Additionally, since research on scripting computer-supported collaborative learning is still young, more theoretical development of scripts and empirical studies are needed to uncover possibilities and limitations of macro-scripts as external support for CSCL in authentic educational settings.

7.4.2 Evaluation of ethical issues

Within this study, the research ethics guidelines of the National Advisory Board on Research Ethics (2002) and the Academy of Finland (2003) were followed. This study followed modes of action endorsed by the research community, that is, integrity, meticulousness and accuracy in conducting research, in recording and presenting results, and in judging research and its results (see the more detailed description of reporting in Articles (I–V) and of evaluation in Section 7.4.1). As regards data collection, also ethical issues were taken into consideration: all of the participants were volunteers; they were free to choose alternatively a traditional working method for this course and even change over to that option during the study (as took place in the higher education setting, see Article V). Prior to the experiment, participants were thoroughly informed about what would happen during the experiment. All participants were also told the aims of the study, data collection methods and methods of reporting. All of the participants' were asked to sign written permission for their participation (including parent/guardian permission with students under 18 years old). None of the participants were given extra credit or paid for their participation. Privacy issues were also considered, and therefore, it is not possible to identify students based on reporting of the study (pseudonyms were used in reporting). The collected data will be archived at the Finnish Institute for Educational Research, University of Jyväskylä.

Other researchers' work and achievements were referred to with good scientific practice. The sources of financing and other associations relevant to the conduct of research were made known to participants of the study and reported in published articles (see, Articles I–V) and in the summary of the study. To sum up, this study was planned, conducted and analysed (see, Summary and Articles I–V) according to the standards set for scientific knowledge (National Advisory Board on Research Ethics, 2002; The Academy of Finland, 2003).

7.5 Conclusion

To conclude, as distributed or distant working over computer networks will play an increasingly important role in the future – not only in the field of learning but also in working life – new pedagogical methods are needed. Furthermore, since free-form collaboration does not systematically facilitate productive collaborative learning, learners need tools and models to structure and manage their collaborative situations. Collaboration scripts offer a promising way to support and foster productive collaborative learning. Indeed, the findings of this study corroborate the notion that well-designed macro-scripts can enhance the use of educational technology. This study demonstrated that macro-scripts support collaboration by introducing the reason (core pedagogical idea) for interaction and by helping students to proceed in solving learning tasks. However, macro-scripts did not guarantee high-level collaboration. This study indicated that different groups acted differently despite using a similar script and, therefore, it seems evident that different groups need different kinds of support in their interaction. This study is in line with the notion that collaborative learning is achieved under unique circumstances and its significance is determined ultimately by learners' interaction and cannot be directly predicted (Arvaja, 2007). In the future, there is a need to find an optimal level of scripting for different kinds of collaborative learning situations which allow for differences regarding different learners. Therefore, in the optimal script, learners' characteristics and interactions during collaboration should influence the scripting. Scripts could offer hints and prompts to increase the likelihood that productive collaboration will occur. In the future, scripts should support group flexibility and collaboration, depending on learning goals, learners´ characteristics and roles assumed in a group. On the basis of this, the design of the macro-scripts should focus more on how to engage groups in collaboration and how to guide situated collaboration. More attention needs to be paid regarding how to engage students in productive collaboration (knowledge construction built on others' ideas) as well as how to form groups and distribute roles among different learners in different learning contexts.

Yhteenveto

Tämän tutkimuksen kolme päätavoitetta olivat: 1) Selvittää tietokoneavusteista yhteisöllistä oppimista tukevan vaiheistamisen lähtökohtia. 2) Löytää metodologisia välineitä tutkia ryhmien yhteisöllistä toimintaa vaiheistetuissa ympäristöissä. 3) Suunnitella neljä erilaista tapaa vaiheistaa tietokoneavusteista yhteisöllistä oppimista sekä tutkia yhtäältä, kuinka vaiheistetut ympäristöt ohjasivat ryhmien toimintaa, ja toisaalta, millaista vaihtelua ryhmien välillä esiintyi vaiheistamisesta huolimatta.

Tutkimus koostuu kolmesta osiosta, joihin liittyy viisi artikkelia. Tutkimuksen ensimmäinen osa avaa tietokoneavusteisen yhteisöllisen oppimisen teoreettisia lähtökohtia ja vaiheistamisen (skriptien) suunnittelun pedagogisia lähtökohtia. Tämän lisäksi artikkelissa I kasvatustieteen, tietoteknologian ja psykologian tutkijat ovat rakentaneet yhteistä pohjaa vaiheistamiselle. Tutkimuksen toinen osa esittelee työssä kehitetyn metodologian, jonka avulla ryhmien vaiheistettua yhteisöllistä toimintaa voidaan tutkia. Tutkimuksen kolmas osa koostuu neljästä empiirisestä artikkelista (artikkelit II–V), joissa raportoitujen osatutkimusten avulla selvitettiin, kuinka yleisen makrotason vaiheistaminen ohjasi ryhmien toimintaa ja millaista vaihtelua ryhmien välillä esiintyi vaiheistamisesta huolimatta.

Teoreettiset lähtökohdat

Tutkimustulokset tietokoneavusteisten oppimisympäristöjen käytöstä ovat osoittaneet, että parhaimmillaan onnistunut teknologian hyödyntäminen voi luoda puitteet sekä oman ajattelun että sosiaalisesti jaetun osaamisen kehittämiseen (Fischer, Bruhn, Gräsel, & Mandl, 2002; Schellens & Valcke, 2006). Onnistunut tietokoneavusteinen yhteisöllinen oppiminen (Computer Supported Collaborative Learning = CSCL) (Koschmann 1996) voi olla tiimien ja verkostojen yhteisöllistä tiedon luomista, koordinoitua yhdessä työskentelyä, sitoutumista asetettuihin tavoitteisiin ja toiminnan jaettua arviointia (esim. Baker, 2002; Barron, 2000; Littleton & Whitelock, 2005; Pea, 1993). Tällöin yhteisöllinen työskentely synnyttää positiivisen riippuvuuden toimijoiden välille, jolloin virtuaalisen vuorovaikutuksen seurauksena ″saavutetaan jotakin enemmän kuin mihin toimijat yksinään kykenisivät″ (Stahl, 2004, 2006).

Vaikka yhteisöllistä verkko-oppimista tutkinut tiedeyhteisö on todennut monet tutkimusalueen periaatteet varsin lupaaviksi, on laadukas yhteisöllinen verkko-oppiminen kuitenkin haasteellista toteuttaa (Arvaja, 2007; Lipponen, 2001; Vonderwell, 2003). Viimeaikaisten tutkimustulosten mukaan täysin vapaa yhteinen työskentely ei systemaattisesti edistä oppimista, joten tuloksellisen vuorovaikutuksen aikaansaamiseksi ja oppimisen tehostamiseksi on oppijoiden työskentelyprosessia tarpeellista ohjata (Dillenbourg 2002; Kirschner, Sweller & Clark, 2006). Yksi tapa edistää yhteisöllistä oppimista on vaiheistaa tai strukturoida skriptien eli käsikirjoitusten (vrt. näytelmäkäsikirjoitus) avulla (engl. *collaboration script*) ryhmien yhteisöllistä toimintaa (Dillenbourg, 1999; Kobbe, Weinberger, Dillenbourg, Harrer, Hämäläinen, Häkkinen, & Fischer, 2007).

Yhteisöllisen toiminnan käsikirjoittamisen erityisinä etuina pidetään mahdollisuutta virittää sellaisia kognitiivisia prosesseja, joita ei yleensä muuten ilmenisi, ja vähentää ei-toivottuja ryhmäprosesseja, joita yhteisöllisessä verkko-oppimisessa helposti syntyy (O`Donnell, 1999). Tavoitteena on lisätä sellaisen yhteisöllisen toiminnan todennäköisyyttä, joka laukaisee tietoa tuottavaa vuorovaikutusta kuten konfliktien ratkaisemista, selittämistä tai yhteistä säätelyä. Käytännössä vaiheistaminen (skriptit) voi olla esimerkiksi ohjeistuksia siitä, kuinka muodostaa ryhmiä, kuinka toimia yhdessä tai kuinka ratkoa ongelmia yhdessä (Dillenbourg, 2002; Kobbe, et al., 2007). Yksi yhteisöllisten verkko-oppimisympäristöjen suunnittelun ydinkysymys on, kuinka paljon yhteisöllisiä prosesseja voidaan ja kannattaa ohjata. Tästä on olemassa kaksi erilaista näkemystä. Vaiheistamisen suunnittelu ja tutkimus voidaan jakaa yleisemmän makrotason vaiheistukseen (macro-scripts) ja oppijoiden vuorovaikutuksen tarkkaan mikrotason vaiheistukseen (micro-scripts) (Dillenbourg & Jermann, 2006). Toistaiseksi empiiriset tutkimukset ovat keskittyneet lähinnä mikrotason vaiheistuksen ja yksilön oppimistulosten välisen yhteyden selvittämiseen (esim. Kollar, Fischer, & Hesse, 2006; Schellens & Valcke, 2006; Weinberger, Stegmann, & Fischer, 2007), minkä vuoksi makrotason vaiheistuksen vaikutuksista ryhmien yhteiseen tiedonrakentamiseen on olemassa vähän tietoa.

Metodit

Tutkimus on design-tutkimus (esim. Brown, 1992; Design-Based Research Collective, 2003), joka koostuu neljästä empiirisestä osatutkimuksesta autenttisissa oppimistilanteissa (artikkelit II–V). Osatutkimukset toteutettiin syklisenä kokonaisuutena vuosina 2004–2008. Jokaista tutkimusta varten suunniteltiin uusi makrotason vaiheistus, jossa otettiin huomioon aiemmista tutkimuksista saadut kokemukset. Kaksi osatutkimuksista toteutettiin ammatillisen koulutuksen opiskelijoilla (artikkelit II–III) ja kaksi osatutkimusta korkeakouluopiskelijoilla (artikkelit IV–V). Osatutkimukset poikkesivat toisistaan käytetyn tekniikan, vuorovaikutuksen (synkroninen ja asynkroninen) sekä osallistuvien oppijoiden suhteen. Kahdessa osatutkimuksessa toteutettiin uusi teknologinen peliympäristö ammatillisen oppimisen tarpeisiin (artikkelit II–III). Kaksi osatutkimusta hyödynsi olemassa olevaa teknologiaa (Optima- ympäristö) pyrkien vaiheistamisen avulla tukemaan yhteisöllistä toimintaa (artikkelit IV–V).

Ensimmäisessä ammatillisessa koulussa toteutetussa osatutkimuksessa viisi neljän hengen ryhmää (N= 20) pelasi noin tunnin mittaisen pelin, jonka aikana he suunnittelivat ja toteuttivat tilaustyönä neljän erilaisen hotellihuoneen kokonaisuuden. Koko ryhmällä oli käytössä 4000 euron budjetti kokonaisuuden toteuttamista varten. Tehtävät etenivät pedagogisen vaiheistuksen (käsikirjoituksen) mukaisessa järjestyksessä, ja niissä vuorottelivat yhteisölliset ja yksilölliset tehtävät. Tehtävän onnistunut ratkaiseminen siirsi pelin seuraavalle tasolle. Tehtävänä oli laskea kattojen, seinien ja lattioiden pinta-alat, valita niihin sopivat materiaalit, laskea materiaalien kustannukset sekä vastata materiaalivalintoihin liittyviin kysymyksiin ja kirjoittaa työstä loppuraportti asiakkaalle. Pelin aikana opiskelijat pitivät yhteyttä toisiinsa joko chat- tai reaaliaikaisen puheyhteyden kautta. Tutkimusaineisto koostui pelissä tapahtuneista toiminnoista (lokitiedosto), videoiduista pelitilanteista, chat- ja puhekeskusteluista, pelin aikana suoritetuista observoinneista ja pelin jälkeen suoritetuista stimulated recall- ryhmähaastatteluista.

Toisessa ammatillisessa koulussa toteutetussa osatutkimuksessa 16 neljän hengen ryhmää (N=64) pelasi noin tunnin mittaisen pelin, jonka aikana ryhmät ratkoivat työturvallisuuteen liittyviä ongelmia. Ryhmän jäsenillä oli tehtävien suorittamisen kannalta tärkeitä tietoja, joita yhdistäen heidän tuli suoriutua tehtävistä. Peli koostui viidestä erilaisesta makrotasolla vaiheistetusta tehtäväkokonaisuudesta ja perustui neljään (tehtävät 2–5) aiemmissa tutkimuksissa esiin tulleeseen tietokoneavusteista yhteisöllistä oppimista edistävään toimintoon: autenttinen avoin ongelma (esim. Vanderbildt ym, 1993), tiedollinen riippuvuus (esim. Strijbos & Martens, 2001), kognitiivinen konflikti (esim. Chan & Chan, 2001) ja hajautettu asiantuntemus (esim. Price, Rogers, Scaife Stanton, & Neale, 2003). Pelin aikana opiskelijat pitävät yhteyttä toisiinsa chat-yhteyden kautta. Tutkimusaineisto koostui pelissä tapahtuneista toiminnoista (lokitiedosto), videoiduista pelitilanteista, chat-keskusteluista, pelin aikana suoritetuista observoinneista ja kyselystä, johon oppijat vastasivat pelin jälkeen.

Korkeakoulukontekstissa (artikkelit IV–V) toteutetut osatutkimukset koostuivat seitsemästä esi- ja alkuopetuksen opiskelijaryhmästä (N=30), jotka suorittivat Optima- ympäristössä kaksi oppimistehtävää noin kahden kuukauden aikana. Oppimistehtävien taustalle oli suunniteltu kaksi makrotasolla vaiheistettua käsikirjoitusta (makroskriptiä; Case ja Grid), jotka kumpikin koostuivat viidestä vaiheesta. Case-tehtävän lähtökohtana oli autenttisen ongelman ratkaiseminen (esim. Kester, Kirschner & Corbalan, 2007) hajautetun ja toisiaan täydentävän tiedon (Perkins, 1993) sekä vastavuoroisen opettamisen avulla (Palincsar & Brown, 1984). Grid-tehtävä pohjautui yhdistelmään tiedollisen riippuvuuden "Concept Grid" -skriptistä (katso, Dillenbourg & Jermann, 2006) ja ajatukseen konfliktin ratkaisemisesta (esim. Doise 1985). Tutkimusaineisto koostui käydyistä keskusteluista, suoritetuista tehtävistä, tehtävien jälkeen kerätyistä palautteista ja ympäristön käyttötiedoista.

Vaiheistetun tietokoneavusteisen yhteisöllisen oppimisen tutkimus on uusi tutkimusalue, ja tutkimusmenetelmät ovat toistaiseksi pohjautuneet pääasiassa menetelmiin, joissa yksilöiden toimintaa säädellään tarkasti mikrotasolla ja oppimista tarkastellaan mittaamalla yksilöiden oppimistuloksia. Makrotason vaiheistamisesta on toistaiseksi olemassa vähän tietoa, mistä johtuen myös menetelmien kehitys niiden vaikutusten arviointiin on ollut vähäistä. Makrotason vaiheistamisen tavoitteena on tukea ryhmän yhteistä tiedonrakentamista, jolloin yhteisöllisen toiminnan laadun tarkastelu on keskeistä (Tchounikine, 2008). Tämän vuoksi on tarpeellista kehittää menetelmiä, joilla voidaan arvioida ryhmien yhteisöllistä tiedonrakentamista (Arvaja, 2007; Baker, Andriessen, Lund, van Amelsvoort, & Quignard, 2007; Stahl, 2006; Strijbos & Fischer, 2007).

Tässä tutkimuksessa on kehitetty yksi menetelmä makrotasolla vaiheistetun tietokoneavusteisen yhteisöllisen oppimisen tutkimiseen. Menetelmä koostuu neljästä vaiheesta. Sen avulla voidaan tutkia, saiko vaiheistaminen aikaan yhteisöllistä toimintaa, ja vertailla ryhmien välillä ilmeneviä vaihteluita. Ensimmäisessä vaiheessa *aineiston laatu tarkistetaan.* Toisessa vaiheessa keskitytään siihen, *noudattavatko ryhmät vaiheistettua tehtäväjärjestystä ja saako vaiheistettu ympäristö aikaan toivotunlaista toimintaa* (esimerkiksi konfliktin ratkaisemista). Tällöin osallistumista tutkitaan ensin määrällisesti osallistumisaktiivisuuden kautta, minkä jälkeen arvioidaan, suuntautuiko toiminta ennalta suunnitellun käsikirjoituksen mukaisesti. Tämä edellyttää *yhteisöllisen toiminnan laadukkuuden arviointia* ryhmän yhteisöllisen tiedon tuottamisen näkökulmasta. Laatua arvioidessa voidaan soveltaa useita erilaisia tutkimusmenetelmiä. Tässä tutkimuksessa hyödynnettiin osallistujien roolien määrittämistä (Strijbos & De Laat, 2007) (artikkelit IV ja V) ja keskusteluanalyysiä (Kumpulainen & Mutanen, 1999) (artikkeli III). Analyysin viimeisessä vaiheessa *ryhmien eroja verrataan* esimerkiksi roolien, keskustelujen ja oppimistulosten suhteen.

Tulokset ja johtopäätökset

Tutkimustulosten mukaan vaiheistetut ympäristöt ohjasivat ryhmien toimintaa ja auttoivat ryhmiä saamaan tehtävät suoritetuiksi (artikkelit II–V). Vaiheistamisen etu oli, että kaikissa osatutkimuksissa ryhmät tiesivät, mitä heidän tuli tehdä. Työskentelyn vaiheistamisen etuna voidaankin pitää yhtäältä, mahdollisuutta ohjata ryhmiä toimimaan yhteisöllisesti, ja toisaalta, mahdollisuutta raamittaa ja jaksottaa erityisesti verkossa tapahtuvaa työskentelyä sekä integroida paremmin normaalisti erillisenä pidettyjä toimintoja. Vaiheistamisen avulla voidaan nivoa yhteen kasvokkaistilanteita ja verkossa tapahtuvaa toimintaa sekä ennalta suunniteltuja vaiheita (esim. artikkelit IV ja V). Toisaalta kaikki osatutkimukset osoittivat, ettei makrotason vaiheistaminen (makro-skriptit) taannut korkeatasoista yhteisöllistä toimintaa. Kaikissa osatutkimuksissa ilmeni vaihtelua erilaisten ryhmien välillä yhteisöllisen toiminnan määrän ja laadun suhteen (artikkelit II–V). Tämän lisäksi oppijoiden erilaiset roolit vaikuttivat ryhmän yhteisölliseen toimintaan (artikkelit IV ja V).

Tämä tutkimus osoitti, että yleisellä tasolla vaiheistetuissa tietokoneavusteisen yhteisöllisen oppimisen ympäristöissä pedagogisen ydinajatuksen suunnitteluun tulisi kiinnittää erityistä huomiota. Oppijoiden yhteisöllinen toiminta poikkesi toiminnoista, joita vaiheistamisen avulla tavoiteltiin (artikkelit IV ja V). Tutkimus myös osoitti, ettei yhteisöllinen toiminta ollut luonnollisin tapa ratkaista ongelmia, vaan oppijat turvautuivat siihen yleensä vasta, kun he huomasivat yhteistyön olevan välttämätöntä tehtävän ratkaisemiseksi (artikkelit II ja III). Ammatillisessa koulutuksessa toteutetuissa osatutkimuksissa (artikkelit II ja III) vaiheistamisen pedagoginen ydinajatus toteutui paremmin kuin korkeakoulukontekstissa toteutetuissa osatutkimuksissa (artikelit IV ja V). Tulevaisuudessa onkin keskeistä tutkia, millaiset makrotasolla vaiheistetut ympäristöt tukevat uuden tiedon luomista ja jaetun ymmärryksen muodostumista tarjoten samalla välineitä ajattelun ulkoistamiseen, vaihtoehtoisten ratkaisujen tutkimiseen ja kokeiluun, kysymiseen, selittämiseen, perustelemiseen, itsearviointiin ja toiminnan jaettuun arviointiin (Barron, 2003; Dillenbourg 1999; Pea, 1993; Scardamalia & Bereiter 1996).

Tutkimus osoitti, että verkkotyöskentelyn pedagoginen vaiheistaminen on haasteellinen tehtävä, johon liittyy monia ongelmia. Korkeakoulukontekstissa toteutetut osatutkimukset osoittivat, että pahimmillaan vaiheistamisen seurauksena luonnollinen vuorovaikutus häiriintyi (artikkeli V). Liian tarkasta työskentelyprosessin vaiheistamisesta aliprosesseihin ja rajattuihin vaihtoehtoihin seurasi ns. ylistrukturoinnin ongelma (Dillenbourg 2002; Dillenbourg & Jermann, 2006; O`Donnell 1999; Tchounikine, 2008). Tutkimuksessa ilmeni, että mikäli vaiheistaminen edellytti osallistumista, mutta oppija itse ei ollut sitoutunut yhteisölliseen toimintaan, myös muiden ryhmäläisten yhteisöllinen toiminta estyi. Ongelmallista ulkopuolisen ohjauksen ja oppijan oman ajattelun välisessä ristiriitatilanteessa oli, että ympäristön ohjaus pakotti oppijan mekaanisesti toteuttamaan tehtävää vaiheistetussa järjestyksessä, vaikkei hänellä ollut omaa kiinnostusta aitoon yhteisöllisyyteen muiden kanssa. Tämän seurauksena myös yhteisöllisesti toimivien ryhmäläisten vastavuoroinen ongelmanratkaisu estyi (artikkeli V). Toisaalta on kuitenkin huomioitava, etteivät oppijoiden yhteisöllistä toimintaa estävät roolit kuten ″vapaamatkustajat″ (katso, Kerr & Bruun, 1983; Strijbos & De Laat, 2007) automaattisesti pilanneet muiden ryhmäläisten yhteisöllistä tiedonrakentamista (artikkelit IV ja V).

Yhteenvetona voidaan todeta tämän tutkimuksen osoittaneen, että parhaimmillaan yleisellä tasolla vaiheistetuilla ympäristöillä voidaan tarjota lisäarvoa tietokoneavusteiseen yhteisölliseen oppimiseen sekä peliympäristöissä että perinteisemmissä oppimisympäristöissä. Vaiheistamisen etu on, että ryhmät tietävät, mitä heidän tulee tehdä. Vaiheistamisen avulla on mahdollista ohjata ryhmiä yhteisölliseen työskentelyyn, joka sisältää tietoa tuottavia toimintoja esimerkiksi oman toiminnan selittämistä. Tutkimuksen perusteella voidaan kuitenkin todeta erilaisten ryhmien vaativan erityyppistä tukea sekä vaiheistusta suunniteltaessa että toiminnan aikana. Tulevaisuudessa tietokoneavusteisten yhteisöllistä oppimista tukevien ympäristöjen suunnittelun kannalta on keskeistä miettiä, millaisissa tilanteissa niillä saavutetaan todellista lisäarvoa oppimiselle. Virtuaaliympäristössä oppimisen ei tule olla irrallista viihtymistä vaan päämäärätietoista ja älyllistä ponnistelua edellyttävää toimintaa, jota voidaan tukea etukäteen suunniteltujen vaiheiden avulla.

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