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Experienced and described challenges in pre-service teachers' collaborative learning

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Luokanopettajaopiskelijoiden kohtaamia ja kuvailemia haasteita yhteisöllisissä oppimistilanteissa (Kaisa Manninen)

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Tässä pro gradu -tutkielmassa tarkastellaan haasteita, joita luokanopettajaopiskelijat kokevat ja tunnistavat matematiikan yhteisöllisissä oppimistilanteissa. Aiempi tutkimus on osoittanut, että ryhmien voi olettaa olevan ongelmanratkaisussa yksilöitä tehokkaampia. Toisaalta yhteisöllisesti työskenteleminen voi olla kognitiivisesti ja emotionaalisesti haastavaa. Tämän työn tarkoitus on selvittää, millaisia haasteita luokanopettajaopiskelijat kokevat yhteisöllisen oppimistilanteen aikana ja kuinka he kuvailevat haasteitaan vaiheistetun, oppimista tukevan keskusteluohjeistuksen eli skriptin avulla.

Tämä pro gradu -tutkielma on osa PREP21 -tutkimusprojektia (Preparing teacher students for 21st century learning practices). Tutkielmani aineisto koostuu ensimmäisen vuoden luokanopettajaopiskelijoista (N = 20), joiden työskentelyä neljän hengen ryhmissä kolmen yhteisöllisen matemaattisen tehtävän parissa videoitiin. Osallistujat suorittivat ensimmäistä matematiikan didaktiikan kurssia suomalaisessa yliopistossa.

Tulosten mukaan ryhmät kokivat tehtävätyöskentelynsä aikana 1) sisältöymmärrykseen liittyviä kognitiivisia, 2) tehtävännäköiseen liittyviä kognitiivisia, 3) kommunikaatioon liittyviä, 4) emotionaalisia ja motivationaalisia ja 5) työskentelyyn liittyviä haasteita. Opiskelijat eivät keskustelleet kaikista kokemistaan haasteista skriptikeskusteluiden aikana, vaan he kuvailivat ainoastaan kognitiivisia, emotionaalisia ja motivationaalisia sekä työskentelyyn liittyviä haasteita. Aineistosta ilmeni, että opiskelijat eivät kuvailleet haasteita yksityiskohtaisesti. Toisaalta opiskelijat saattoivat mainita skriptikeskusteluiden aikana sellaisia haasteita, joita he eivät olleet ilmaisseet työskentelyn aikana. Näin skriptikeskustelut tarjosivat mahdollisuuden käsitellä asioita, jotka olivat työskentelyn aikana mahdollisesti jääneet käsittelemättä.

Tämä tutkielma on merkityksellinen erityisesti yhteisöllisestä oppimisesta kiinnostuneiden sekä luokanopettajaopiskelijoiden näkökulmasta. Yhteisöllisen oppimisen haasteisiin liittyvän ymmärryksen syventäminen on tärkeää kehitettäessä toimivia oppimisympäristöjä ja valmistautuessa tulevaisuuden yhteisölliseen koulukulttuuriin.

Avainsanat: yhteisöllinen oppiminen, haasteet, luokanopettajaopiskelijat, videoanalyysi

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Experienced and described challenges in pre-service teachers' collaborative learning (Kaisa Manninen)

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This master's thesis provides an overview of challenges that pre-service teachers experience and describe during collaborative learning in mathematics. Previous research has indicated that groups can be expected to be more effective in solving problems than individuals. On the other hand, working collaboratively can be hard work both emotionally and intellectually, leading to challenges that can potentially hinder learning or ideally improve it if appropriately addressed. The purpose of this work is to examine what kinds of challenges pre-service teachers experience during collaborative learning situations and how do they describe their challenges during discussions, which were prompted by a script designed to support collaborative learning.

This master's thesis is part of the PREP21 -research project (Preparing teacher students for 21st century learning practices). The sample for this work is first-year pre-service teachers (N = 20) who studied in groups of four during three collaborative mathematical tasks. Participants were attending their first course in mathematics education at a Finnish university.

The results show that groups had 1) cognitive challenges related to content understanding, 2) cognitive challenges related to task understanding, 3) communication challenges, 4) emotional and motivational challenges, and 5) working challenges. The students described cognitive, working, and emotional and motivational challenges during script discussions. All types of challenges that were experienced during group work were not described during scripts. In general, the data showed that students did not describe their challenges in detail. On the other hand, there were challenges that were not expressed until scripted discussions. Thus, scripted discussions gave opportunities to bring up issues that were not spontaneously mentioned during group working.

The significance of this work falls upon people who are interested in collaborative learning especially concerning pre-service teachers. Identifying this subject is paramount for constructing deeper understanding about challenges in collaborative learning, which is needed in creating functional learning circumstances and preparing for collaborative school culture.

Keywords: collaborative learning, challenges, pre-service teachers, video data analysis

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## 1 Introduction

This master's thesis is a part of the PREP21 -research project (Preparing teacher students for 21<sup>st</sup> century learning practices). PREP21 is a longitudinal follow-up study of four years. The project investigates factors that affect the development of teacher students' strategic learning and collaborative problem-solving skills and students' competencies towards the use of ICT in teaching and learning. In my master's thesis, the focus of the analysis is on the challenges in collaborative learning in mathematics.

Finland's new core curriculum places strong emphasis on the learning process, collaborative school culture, and communal models of studying. At its best, according to the curriculum, learning can awaken positive emotional experiences, joy in learning itself, and can become a creative activity that will inspire the students' development of their own expertise. (Vahtivuori-Hänninen, Halinen, Niemi, Lavonen & Lipponen 2014.) When starting to utilize collaborative learning more and more extensively at schools, identifying possible challenges in it and ways of addressing those challenges in groups is a prerequisite for successful teaching and learning. Because of the significance of the core curriculum in Finland, it is important to deepen understanding about collaborative learning. According to Häkkinen, Virtanen, Pöysä-Tarhonen, Niilo-Rämä, Näykki, and Järvelä, (submitted), in order to update 21<sup>st</sup> century learning skills for teacher education, research should recognize and elaborate the challenges that students have when learning as a group.

Collaborative learning research has indicated that groups and teams can be expected to be more effective in adequately solving problems than individuals. The effectiveness of group working is particularly related to the opportunities that it creates for sharing and constructing new knowledge and understanding. (Van den Bossche, Gijssels, Segers & Kirschner 2006.) On the other hand, successful collaborative learning does not always occur and not all group work leads to a high level of learning and understanding (e.g. Baker 2015; Burdett 2003; Häkkinen & Arvaja 1999; Järvenoja & Järvelä 2009; Volet, Summers & Thurman 2009). Working collaboratively means making significant changes to conventional ways of learning and can be hard work both emotionally and intellectually (Burdett 2003). Students do not automatically become more involved, thoughtful, tolerant, or responsible when working with others (Blumenfeld, Marx, Soloway & Krajcik 1996).



Research examining challenging episodes in collaborative learning has been proposed as a critical and current theme for research (Hadwin, Järvelä & Miller 2017). The purpose of this master's thesis is to complement and extend previous empirical research by examining what kinds of challenges pre-service teachers experience during group work and how do they describe their challenges. Small group activity has not been studied as extensively as whole-class setting (Littleton & Howe 2010), which makes this point of view necessary. Furthermore, according to Häkkinen et al. (submitted), teachers have not had much training for 21<sup>st</sup> century skills yet. My aim is to explore pre-service students' actions and thoughts in the context of collaborative learning and present new perspectives. Thus, the significance of this master's thesis falls not only upon people who are interested in collaborative learning but especially upon pre-service teachers and their educators.

I got interested on the topic when I was working as a research assistant in the PREP21 -research project. While working amongst video data, I noticed that pre-service teachers experienced different kinds of challenges in their group work and disagreements came up during collaborative problem solving, when completing tasks in mathematics. There seemed to be both more and less severe challenges that influenced group members' actions and interactions. According to Hadwin, Järvelä and Miller (2017), there is the lack of research investigating social aspects of learning at key points when encountering and resolving challenges. I was curious to find out more precisely what happened in those challenging situations during group work activities.

In addition to observing experienced challenges, I wanted to find out how thoroughly the students describe their possible challenges during the script discussions. Collaboration scripts structure the interactive learning partners, and aim to function as scaffolds that improve collaboration (Fischer, Kollar, Stegmann & Wecker 2013). With the help of scripts, learners in small groups can engage, plan, monitor and evaluate their problem solving process possible in a more strategic manner than without scripts (King 2007).

I was interested in exploring how efficient scripts are to get students aware of their learning process and possible challenges in collaboration. This is important because there is a lack of empirical research to investigate how learners appropriate and implement the scripted processes in learning situations (Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen & Häkkinen 2017). According to Hämäläinen and Häkkinen (2010), there is not enough knowledge about the effects of scripts on collaboration within groups in authentic learning contexts. The mathe-

mathematical context provides an interesting perspective for this work. Reflecting on mathematical learning situations offers opportunities for pre-service teachers to become aware also of their mathematical identity, thus helping them build a more positive future identity (Lutovac & Kaasila 2014).

## **2 Theoretical framework**

In order to preface the general topic of this master's thesis, I first work towards the definition of collaborative learning. Second, I consider the challenges that can be expected to arise during collaborative group work and factors that hinder successful collaboration. Third, I inspect the definition of script as a scaffold for collaborative learning.

### **2.1 Collaborative learning**

According to Roschelle and Teasley (1995), collaboration is coordinated and synchronous activity that results from a continued attempt to construct and maintain a shared conception of a problem. Collaboration can be shown, for example, in mutual explanation, elaborative questioning, and knowledge built on others' ideas (Hämäläinen & Häkkinen 2010). Dillenbourg (1999) reminds that the word "collaboration" is often used abusively for more or less any kind of group activities, and that can cause problems. It is nonsense to talk about the cognitive effects of collaborative situations if any peer or group situation can be labelled collaborative. Furthermore, various authors can use the same word very differently. Dillenbourg (1999) lists four aspects for collaborative learning: situation, interactions, processes and effect, and states that the key for understanding collaborative learning is in the relations between those four items.

Dillenbourg (1999) presents that collaborative learning is neither a mechanism nor a method. It is not one single mechanism, because peers do not learn because they are two, but because they perform some activities which trigger specific learning mechanisms. Moreover, collaborative learning cannot be seen as a method, because the specific types of interactions e.g. reciprocity and interdependency are only predictive, and there is no guarantee they will occur. (Dillenbourg 1999.)

Panitz (1999) presents several principles in which collaborative learning is based. He describes that in collaboration, working together results in a greater understanding than would likely have occurred if one had worked independently. Spoken and written interactions contribute to this increased understanding. Through classroom experiences, there is an opportunity to become aware of relationships between social interactions and increased understanding – even though some elements of this increased understanding are idiosyncratic and unpredictable.

ble. Panitz (1999) adds that participation is voluntary and must be freely entered into. (Panitz 1999.)

When a class is divided into groups, a new social context is created in which students have the opportunity to share individual cognitions with their peers and come to a conclusion based on the sum of those cognitions (Summers, Gorin, Beretvas & Svinici 2005). Working collaboratively means making significant changes to conventional learning styles as learners come to grips with the dynamics of group work (Burdett 2003). Hesse, Care, Buder, Sassenberg and Griffin (2015) state that the full set of social skills come into force when a task requires collaboration. In addition to social skills, regulation of learning comes into account when collaborating. Self-regulation refers to the ways that learners activate and sustain their cognitions, motivations, behaviors, and affects to reach their goals (Greene & Schunk 2017). Self-regulated learning, socially shared regulation of learning and co-regulated learning are three primary modes of regulation in collaborative learning that have been recognized to improve successful collaboration (Hadwin, Järvelä & Miller 2017).

When discussing the relations between the collaborators, Salomon and Globerson (1989) describe teams as social systems in which cognitive, motivational, and behavioral processes become increasingly interdependent. According to Van den Bossche and colleagues (2006), increasing attention has been devoted to the social bases of cognition, taking into consideration how social processes in groups and teams affect performance. Fruitful collaboration is not only a case of putting together people with relevant knowledge. Understanding is required in the interpersonal factors, such as interdependence, task cohesion and group potency, that make up successful collaboration. (Van den Bossche et al. 2006.)

The roles of individuals in collaborative learning and their relations to each other have to be considered. According to Baker (2015), collaboration refers to an interaction between persons having equal statuses and rights in the interaction, even though the individuals might not necessarily be equals in other respects. The design of effective collaboration situations requires developing tasks that make it actually necessary to work together, given that the problem cannot be solved alone. Actually, Baker (2015) notes that the bigger the extent in which students build their ideas on others' ideas rather than on their own, the more collaborative the interaction is. A collaborative type of conversation - giving and asking for reasons, questioning and seeking agreement - might be an effective opportunity for learning (Leman 2010). Actually, Roschelle and Teasley (1995) state that the most important resource for collaboration is talk-

ing. They list that it includes turn-taking, narration, questions, social-distributed productions, and repairs. Conversation and interaction with each other, are thus, the basis of collaboration.

Hesse et al. (2015) define collaboration as the activity of working together towards a common goal. Communication, cooperation and responsiveness are elements included in the definition (Hesse et al. 2015). On the other hand, collaborative learning should be set apart from cooperative learning. Baker (2015) states that cooperation works on the level of tasks and actions while collaboration works on the plane of ideas, understanding and representations. Cooperation can be seen as an agreed division of labour (Hesse et al. 2015). On the other hand, Hesse et al. (2015) mention that cooperation can be seen as nuanced, responsive contributions to planning and problem analysis or as a lower order version of collaboration. Summers et al. (2005) argue that cooperative learning is a process-oriented, methodical, and more formal form of collaborative learning. In contrast to collaborative learning techniques, cooperative learning techniques typically are seen as more structured learning tasks that are monitored much more closely by the instructor; cooperative learning is also known as a specific type of the more general collaborative learning activities (Summers et al. 2005). In real situations, cooperation and collaboration are closely linked and collaboration can be seen as a specific form of cooperation (Baker 2015).

## **2.2 Challenges in collaborative learning**

In contrast to what is often thought, studying and working in a group does not automatically lead to high-quality and deep learning (Häkkinen & Arvaja 1999; Volet, Summers & Thurman 2009). Learning with peers in cooperative or collaborative groups can be complex and difficult to achieve in deep-level (Blumenfeld, Marx, Soloway & Krajcik 1996). According to Järvenoja and Järvelä (2009), successful collaboration does not always occur. Group work is not always viewed positively due to tensions that can arise as individuals meet to complete set tasks (Näykki, Järvelä, Kirschner & Järvenoja 2014). Working collaboratively means making significant changes to conventional learning styles. The fact is that group work can be hard work both emotionally and intellectually, however this is sometimes overlooked by group work advocates and practitioners. (Burdett 2003.)

Collaborative learning situations contain different challenges. A challenge can be a problem that makes group's progress difficult or impossible, or it can also be an impulse for harder working. Challenges can be experienced by the whole group or by individual students. There

are several ways in which recent studies have categorized challenges in collaborative learning. For example, Järvelä and Järvenoja (2011) categorize challenges in collaborative learning into five categories: personal priorities, work and communication, teamwork, collaboration, and external constraints. Koivuniemi, Panadero, Malmberg and Järvelä (2017) found that first-year higher education students experienced learning challenges in collaboration in four main areas: cognitive, motivational, emotional, and well-being. Referring to the related literature, Hadwin, Järvelä and Miller (2017) present five broad types of challenges experienced by the groups: motivational, socio-emotional, cognitive, metacognitive, and environmental challenges. In the following chapters, I will present a few general phenomena that can trigger challenges in collaborative learning situations.

### 2.2.1 Challenges in social interaction and group relations

Even though it is often expected that teams and groups will be more effective in adequately solving problems than individuals, they often face challenges of integrating different perspectives (Van den Bossche et al. 2006). According to Levine, Resnick and Higgins (1993), social situations create a complex social environment where actors influence one another's knowledge, opinions, and values. Blumenfeld et al. (1996) state that students do not automatically become more involved, thoughtful, tolerant, or responsible when working with others. Without appropriate knowledge, there might be a risk of stigmatizing low achievers, raising status differences, and creating unworkable interactions among students (Blumenfeld et al. 1996). According to Näykki and colleagues (2014), the students in their study reported interaction problems as overruling, status-centric, undermining, and normative interaction. The students might discourage others, emphasize their status, undermine the atmosphere or emphasize their feelings and interpretations that something is always wrong or their working is not good enough in the group (Näykki et al. 2014). Linnenbrink-Garcia et al. (2011) describe that group members can undermine each other's participation by discouraging other students from participating or disrespecting them.

When working in groups, students may confront questioning and influencing. Expertise in communication requires different skills. Communication includes, for example, exchanging facts, ideas, views, opinions and beliefs (Antos, Ventola & Weber 2008). According to Thibault (2008), face-to-face communication is a very complex and intricate phenomenon. It involves neural connections, a range of somatic resources, social coordination between individ-

uals, and cultural forms of learning and conventions of interaction (Thibault 2008). On the other hand, Littleton and Howe (2010) remind there is often a lot of talk going on in classrooms, but with seemingly little effect. Thus, not all sort of communication during group work support collaboration.

The social nature of group work and conceivable negative phenomena are discussed in different studies. Burdett (2003) states competition, group dynamics, assessment, and poor group work organization as reasons that can influence the climate and outcomes of the participants less positively. It is also possible to confront the different negative effects such as the so-called free rider, sucker, status differential, and ganging up effects (Salomon & Globerson 1989). A free-rider is a group member using the group's common resources without contributing anything themselves. The learning will be minimal for these pupils and will impair the group's climate. (Hammar Chiriac 2011.) Hämäläinen and Arvaja (2009) mention free riding when stating the main problems for group work and unequal participation in collaboration. Unequal distribution of effort can be negative aspect of group work (Burdett 2003). On the other hand, there are other reasons why the individual's participation and focus are not always on a sufficient level. Baker (2015) reminds that during group work, there will be periods which students are not attending to each other or to a joint task focus. Collaboration presupposes a high degree of joint attention, which is not always reached (Baker 2015).

In addition, the students may not exert themselves as much in a group situation as they would if they were solitary. These kinds of group processes that hinder the group and reduce productivity are known as social loafing (Hammar Chiriac 2011; Schunk, Pintrich & Meece 2008). The larger the group, the higher is the risk for social loafing (Hammar Chiriac 2011). One important point of view that Hammar Chiriac (2011) presents about social loafing is connected to task understanding: if a student actually does not know what to do, he or she therefore does as little as possible. Thus, situations and cognitive activity differ for example on the grounds of what questions are asked or what other information is given (Levine et al. 1993).

### 2.2.2 Cognitive, emotional and motivational challenges

Cognitive processing in groups does not always work fluently and emotional and motivational challenges can hinder group members in reaching their goals. Cognitive processes are for example use of working memory and metacognition, application of prior knowledge, and acquisition of new knowledge (Pellegrino, Baxter & Glaser 1999). Cognitive processes are required

in collaborative learning and challenges related to them can be for example difficulty to create a common ground or to handle complex concepts (Järvelä & Järvenoja 2011). According to Kumpulainen and Mutanen (1999), cognitive processing can be seen as highlighting students' working strategies and situated positions towards learning, knowledge and themselves as problem solvers. According to Näykki and colleagues (2014), different cognitive challenges appeared in group interaction as different use of concepts, different task understandings, shallow knowledge construction and lack of monitoring own understandings. It can be challenging to create a shared understanding of the problem (Van den Bossche et al. 2006). According to Koivuniemi et al. (2017), students' prior knowledge and knowledge construction are the most reported cognitive challenges. Thus, learning skills and prior knowledge are especially related to the challenges that individuals experience during collaboration (Koivuniemi et al. 2017).

In addition to cognitive processes, several researchers are investigating the impact of different emotions on learning. It can be argued that the regulation of emotions is critical for successful collaboration. The emerging challenging situations create the need to control the motivations and emotions of the group. (Järvenoja & Järvelä 2009.) According to Garcia-Prieto et al. (2003), emotions occur whenever a team member is confronted with issues that are highly relevant to him or her. Emotions may have both functional and dysfunctional behavioral consequences for teams (Garcia-Prieto et al. 2003). For example, if students are tired, tense or frustrated, they may allow other students to do their work. Emotions may function differently during small group work when high levels of social interaction are required. (Linnenbrink-Garcia, Rogat & Koskey 2011.) Linnenbrink-Garcia and Pekrun (2011) list a broad variety of emotions that are in need for more research: anger, frustration, confusion, boredom, shame, hopelessness, enjoyment, hope, relief, contentment, and pride.

Motivation is an important quality that affects all classroom activities, because learning and performance are related in a reciprocal fashion to motivation (Schunk, Pintrich & Meece 2008). Motivational challenges can appear for example as different interests within the task, different targets for the group work and one/some group member(s) not being fully committed to the group work (Näykki et al. 2014). According to Järvelä and Järvenoja (2011), motivational challenges often result in declines in effort, engagement, or participation.



### 2.2.3 From disagreements to conflicts

Ways of interacting and communicating have an influence on the group's climate and may trigger learning or disagreements and even conflicts. Group members can face challenges due to different styles of working or communicating (Järvelä & Järvenoja 2011). It is possible that in some situations, emotional challenges turn into a conflict (e.g. Näykki et al., 2014). Järvenoja and Järvelä (2009) suggest that making students aware of how different group members' interpretations differ from their own may help groups to avoid emotional conflicts and to solve whatever challenges they encounter. On the other hand, emotional responses during conflicts may tell about the extent of which team members identify with the group and it may also signal the extent of which the interpretation of a conflict issue is shared by team members (Garcia-Prieto et al. 2003).

However, Baker (2015) reminds that collaboration does not mean absence of disagreement. To the contrary, certain types of disagreement dialogue can be seen as highly collaborative. When confronted with a disagreement, a person may need to validate his or her arguments for the student from the opposing side. This requires confronting own perspectives with other people's perspectives. Furthermore, it is evidenced to avoid situations, which people tend to perceive as a risk to the self and to their relationships (Muller & Perret-Clermont 2009). Therefore, it is possible to assume at some learning and group working situations students may avoid bringing up contradictory ideas (Aarnio 2015).

When working in groups, individuals deal with the need to qualify other members' comments or accept qualification of their own statements. It has been noticed that conflicts can follow from considerate moments. If an individual does not treat qualification as a contribution to the group's common thinking but as a rejection of him- or herself, a conflict can arise. (Barnes & Todd 1977.) On the other hand, Van den Bossche et al. (2006) suggest that conflicts should be seen as windows of opportunity instead of threats to progress. Problems can arouse further communication and through the negotiation, mutually shared cognitions are constructed (Van den Bossche et al. 2006).

Conflicts can be handled by separating reactions that they cause. Ayoko, Callan and Härtel (2008) have made a difference between productive and destructive reactions to conflict. Conflicts can have productive outcomes such as learning from disagreements and settling disagreements. On the other hand, conflicts can have poor outcomes such as failing to learn from the conflict, finding it difficult to settle conflicts, and difficulties moving on after a conflict

episode. (Ayoko et al. 2008.) Several researchers have investigated different ways to support collaboration. In the next chapter, I will introduce scripting as one opportunity.

### **2.3 Scripts as a way to support collaboration**

As mentioned earlier, successful collaborative learning does not always occur and not all group work leads to a high-level of learning and understanding (e.g. Järvenoja & Järvelä 2009; Volet et al. 2009, Burdett 2003; Häkkinen & Arvaja 1999). According to King (2007), learners do not interact in cognitively effective ways without some structured guidance. In addition, Rummel and Spada (2005) remark that the majority of collaborations only succeed with adequate support. They argue that collaboration needs to be supported to ensure well-coordinated and efficient work.

King (2007) considers several explanations for why learners do not interact in effective ways as a group without guidance. Learners may not know what it actually means to explain and argue and analyze ideas: they may not have been taught how to do so or they may not be well practiced in the skills of explanation, argumentation, analysis and other aspects of high-level discourse in a collaborative setting (King 2007).

Thus, scripts are one way to support collaboration. Fischer and colleagues (2013) describe collaboration scripts as scaffolds that aim to improve collaboration through structuring the interactive processes between learning partners. Collaboration scripts for face-to-face learning often focus on supporting collaborators in engaging in activities that are specifically related to individual knowledge acquisition and metacognition. Scaffolds that structure the interactive processes provide support between the collaborators. Instructional support might guarantee a higher quality of collaborative learning processes and individual learning outcomes. (Kollar, Fischer & Hesse 2006.) In addition, it is assumed that scripts can lead to higher-level cognitive processing. (Hämäläinen & Arvaja 2009).

With the help of scripts, learners in small groups can engage, plan, monitor, and evaluate their problem solving process and problem solution in a strategic manner (King 2007). The general strategic questions can be designed, for example, to prompt learners to clarify the problem, think about the problem in new ways, access their existing knowledge and strategies, formulate plans and strategies for solving the problem, and evaluate alternatives (King 2007). In that way scripts make thinking explicit by “thinking aloud” during interaction and set the

stage for more strategic learning to occur. It is useful during collaboration, because it makes thinking explicit and available to the individual doing the thinking and exposes that same thinking to the rest of the group. (King 2007.) In their study, Hämäläinen and Arvaja (2009) describe collaboration scripts as a pedagogical method to facilitate collaborative learning. For different learning goals, there are different principles through which scripts are designed to trigger specific interactions (Hämäläinen & Häkkinen 2010).

Miller and Hadwin (2015) add that scripts can provide opportunities to identify in time when learners or groups get stuck and attempt to overcome difficulties by prompting learners to make challenge episodes visible in and across collaborative tasks. One meaning of scripts is to support regulation of collaboration (Miller & Hadwin 2015). In addition, differences between individuals' opinions and understandings about a topic are exposed during group interaction. Individuals discover that their own understanding of an aspect of the content, their opinions about an issue, or their basic background information about the material may not be shared by others in the group and may even differ notably from others. (King 2007.) Even active critical argumentation is expected in the ideal script (Hämäläinen & Häkkinen 2010).

In fact, Rummel and Spada (2005) see scripts as instructional approaches that are a promising way to improve collaboration and its outcomes. They argue that the instructional approach promotes the individual's capabilities to collaborate in a fruitful way and furthering their understanding about good collaboration. Thus, even though the main idea of scripts is to improve a fruitful interaction, there are also some limits. For example, the long-term effects of scripts, negative responses to the scripts, and possibilities to learn to collaborate through scripts are discussed. (Rummel & Spada 2005.) In addition, different groups might need different kinds of support, because groups can act differently despite using a similar script (Hämäläinen & Häkkinen 2010; Näykki et al. 2017).

In summary, collaboration scripts can be described as instructional means that provides collaborators with instructions for task-related interactions, that can be represented in different ways, and that can be directed at specific learning objectives. (Kollar et al. 2006.) Scripted collaboration is one future possibility to engage the whole group in the collaboration process (Hämäläinen & Arvaja 2009), even though macro-scripts do not necessarily guarantee high-level collaboration (Hämäläinen & Häkkinen 2010). According to Näykki and colleagues (2017), the emergent topic in collaborative learning scripting research is how to increase students' flexible and transferable collaborative learning knowledge and skills.

It is worthwhile asking questions about challenges and supporting students to describe and identify them. Without identifying, there are no chances for solving challenges and learning about them. In addition, giving and receiving support is not possible until being aware of the needs for it. According to Aarnio (2015), during difficult situations students need more support than otherwise. To receive support from the other group members, individuals should be aware of their challenges. In addition, Lieberman (1992) states that teacher participation is the most critical component of the entire process of change in the building of a collaborative culture in schools that are learner-centered. Häkkinen et al. (submitted) remind that skills related to collaboration are important for both teachers and students.

## **2.4 Characteristics of mathematical context**

In typical mathematical learning situations, the students are expected to cope with complex social and emotional challenges (Kaasila, Hannula, Laine & Pehkonen 2005). Kaasila with colleagues (2008) studied 269 Finnish elementary teacher students' views of the mathematics and they note that at the beginning of teacher education, 22 % of the students had a negative view of the subject (43 % had a positive and 35 % had a neutral view). According to Pietilä (2002), pre-service teachers who hold a negative view of mathematics can transmit their negative emotions to their pupils. In addition, if teachers have a weak view of themselves as learners and teachers of mathematics, they might convey their fear to their future students (Laine et al. 2004). Self-confidence has a central role in the formation of a student's view of mathematics (Kaasila et al. 2008).

Pehkonen and Pietilä (2003) describe an individual's view of mathematics as a filter that regulates his or her thinking and actions in situations that are mathematics-related. An individual's view of mathematics comprises of knowledge, beliefs, conceptions, attitudes, goals, motivation and emotions (Pehkonen & Pietilä 2003; Kaasila et al. 2008). Vinson (2001) notes that many students have a moderate level of procedural knowledge of mathematics, and even lower level of conceptual knowledge. Becoming aware of sectors that need revision in mathematics will help pre-service teachers to develop as teachers.

Argumentation takes the substantial place in mathematics learning nowadays. It fosters sense-making and conjecturing, leads to substantial learning gains, and integrates a rich semiotic system. It opens opportunities for cognitive unity and by doing so naturally leads from enquiry to proving activity. Designing activities for productive argumentation necessitates tak-

ing into consideration the students' knowledge, the different ways to arrange them in groups, the tools to provide them with for raising or checking hypotheses, and the strategies the teacher should enact to structure discussions. (Schwartz, Prusak & Hershkowitz 2010.) However, argumentation and cognitive challenges can also arouse negative emotions and cause problems for interaction. Thus, they are not automatically functional parts of mathematics learning, if they are not appropriately addressed and resolved.

### **3 Aims and research questions**

The aim of this master's thesis is to observe challenges that pre-service teachers experience in collaborative learning in mathematics and find out how exhaustively do the students describe those challenges. The research questions are:

1. What kinds of challenges do students experience during collaborative learning in mathematics?
2. How do students describe challenges during script discussions?

The data analysis has two main perspectives: observing challenges that students experience during group work and investigating described challenges that students mention during script discussions. In this work, describing means that a student explicitly mentions a challenge or challenges that someone in the group had experienced or felt during the collaborative learning situation. I decided to focus on challenges that were described specifically during the scripts because I was interested in exploring how efficient scripts are in getting students aware of their learning process. I wanted to find out what kinds of issues the script discussions reveal about how pre-service teachers identify and describe challenges that appeared during their collaborative learning tasks.

In addition to the main research questions, I am interested in finding out if there are notable differences between groups and sessions. Overall, this work aims to consider the results from the perspective of teacher education.

## 4 Methodology

In this chapter, I describe the data collection and data analysis. In addition, I evaluate the reliability of the work and consider ethical issues.

### 4.1 Data collection

The data utilized in this master's thesis is part of the PREP21 -data collection. In the following sub-chapters, I will introduce the participants and context and explain how the group work was divided into three phases through script discussions.

#### 4.1.1 Participants and context

The sample for this work was teacher education students ( $N = 20$ ) whose studying in groups during three face-to-face collaborative mathematical tasks was video recorded. Participants were first-year primary teacher education students attending their first course in mathematics education at a Finnish university. The gender distribution in the target group was  $N_{\text{female}} = 15$  (75 %);  $N_{\text{male}} = 5$  (25 %) and mean age was 22 years (between 19 to 29 years). After studying almost the whole year together, the students know each other well. Students were informed about the PREP21 -research study at the beginning of the course. Participation was voluntary, and all students gave written consent to be involved in data collection.

The research place was a classroom-like area with 360 cameras. In total, the face-to-face collaboration of 15 groups was video-recorded, but the sample of this master's thesis consists of five groups' working. In total, the groups worked together six times, but I analyzed the first three sessions. Overall, 15 videos (altogether 14 h 42 min,  $M_{\text{duration}} = 58$  min) were selected for further analysis. The groups and sessions were selected in such a way that the most of the group members were present every time.

The groups consisted of four students. Due to absences, in some sessions there were only three students present. The mixed-gender groups were composed on the grounds of the questionnaires, which had been conducted before the video recordings. Likert-scaled items measured, for example, how much the students enjoy exchanging thoughts and are they open to all sorts of opinions. Based on their answers, students were divided into three profiles. Thus,

each group included members who were the most positive towards collaboration, students who were the least positive towards collaboration, and students who were in-between.

It is important to determine under which conditions the described interactions occur (Van den Bossche et al. 2006). Lessons to which the students attended are called sessions. Each session was one lesson included to the students' mathematics education course. The groups had approximately one hour to complete the task. The first session was a workshop on arithmetic algorithms and base ten blocks. The purpose of the task was to get to know the use of base ten blocks and number cards. The idea was to make calculation with the blocks and at the same time document what happens in normal algorithm way on paper. There were four kinds of exercises: addition, subtraction, multiplication, and division. The second session dealt with teaching fractions using fraction cakes. The aim of the task was to repeat the basic fraction calculation rules, get to know fraction cakes and plan the use of fraction models in teaching. There were two kinds of exercises: first, to form different difficulty level exercises of the topics, and second, to write exercises in symbolic form to the paper and solve them using the fraction cakes. The third session dealt with spatial thinking. There were different kind of mathematics tasks to solve using wooden cubes and a paper grid. In addition, some discussion tasks were included to these exercises.

I will include a short description of each group to give the reader an idea of what kinds of groups I observed from video recordings. First three groups discussed in Finnish and last two groups in English. Ilona, Maria, Elias and Sami belong to Group 1. They solved all of the tasks every time and their working progressed efficiently. In sessions one and two Sami worked as a secretary. Elias was the most talkative and expressed various feelings. Sometimes the group's work was divided so that Ilona and Maria concentrated on discussing and precise understanding while Elias and Sami lost their focus. Ilona, Maria and Sami thought aloud a lot. This group will be presented as a case example in chapter 5.3.

Aino, Emma, Jenna and Riku compose Group 2. The group's working was inefficient in session one when they solved only a few tasks during the lesson. Jenna was talking and asking questions very actively and pointed out that mathematics is not her strength. The others helped and advised her thoroughly. The group members' participation varied during the lessons. However, the group was mostly satisfied in their working and they seemed to agree that being in a different level was actually a good thing.



Johanna, Julia, Iina and Olli belong to Group 3. In every session, there were different students present. However, their working was calm and thorough. They did not hurry but tried to discuss and illustrate their decisions so clearly that everyone understood. Julia and Johanna expressed their insecure feelings towards mathematics. Olli had the most confident feelings and knowledge, but he focused on considering the problems as intensively as the others did.

Daniel, Beth, Viola and Sara belong to Group 4. Sara was talkative and, in many occasions, she dominated group work by explaining her own thoughts and using manipulatives on her own. Discussions were often divided so that Sara and Daniel shared thoughts and Beth and Viola shared their thoughts together. Viola and especially Beth often stayed aside and acted as passive observers.

Anna, Amy, Ella and Noora compose the Group 5. Their interaction was easy-going and they laughed many times while solving the problems. Their working was mainly balanced even though in some occasions it was difficult for Amy to follow and concentrate. On the other hand, the others took care of everyone's learning and they did not hesitate to ask the teacher if they were unsure about their understanding.

#### 4.1.2 Script discussions

The group work was divided into three phases through orientation, check-up and reflection. A designed macro script supported the students' collaborative learning. Students found questions on tablets that they had been given. According to Näykki et al. (2017), the pedagogical PREP21 model is a macro script that combines elements of both collaborative problem solving and socially shared regulation of learning. The model starts with orienting and planning, follows by strategic learning activities that are constantly monitored and controlled, and completes with reflection and evaluation. Prompts will focus students' attention on their group members' thoughts and understanding and stimulate cognitive and metacognitive processing. (Näykki et al. 2017.)

At the beginning, the students discussed about orientation questions, which focused on planning the group work and setting the goals. In the middle of the session, they had a check-up in which the group had to consider how the work had proceeded and what kinds of challenges they had experienced. At the end of the lesson, they reflected on their work and discussed how they had reached their goals. These discussions give information about students'

thoughts about the task and group work in a way that might not appear without external guidance and exact questions. Näykki et al. (2017) describe these questions as prompts for groups to stop and discuss about their thoughts and feelings and reflect on the efficiency of their group interaction. My analysis focused especially on the questions that raised discussions about challenging feelings and situations.

Questions in orientation:

*What is the purpose of the task?*

*What kinds of feelings does your work arouse?*

*What kinds of strengths does your group have?*

*What is the goal of your group work?*

Questions in check up:

*How has your work progressed?*

*What kinds of feelings does the task arouse?*

*What kinds of challenges are you currently facing?*

*How will you proceed from here on?*

Questions in reflection:

*How did you reach your results?*

*How would you evaluate your work as a group?*

*What helped or hindered reaching your goals?*

*How did you overcome possible challenges?*

## **4.2 Data analysis**

Interaction analysis is the main method in this work and the basics of video analysis supports it. The analysis concentrates on challenging situations and students' discussions about them. Reporting the results combines qualitative and quantitative perspectives. According to Chi (1997), the qualitative data is examined, methods of coding are develop, and the coding can

then be analyzed quantitatively. With quantitative-based qualitative approach it is possible to compare the frequencies of the codes quantitatively (Chi 1997).

Quantifying the qualitative data offer possibilities to vary the angle from which to examine the data. However, it should be noticed, that it is by no means universal that video data is coded in a way that can yield quantitative data. Some researchers prefer to focus on the development of rich examples and therefore do not count types of events within or across cases. Quantification does not allow the researcher to communicate how an interaction unfolds across time in all of its complexity. Narrative description is a method of representation that better describes the dynamics of interaction. (Derry et al. 2010.) I decided to utilize both ways in order to do an extensive look into the data and the subject. I started with a qualitative phase by analyzing video recordings and continued to a quantitative phase by counting and comparing the frequencies of challenges. In addition, I considered one group's discussion with the help of qualitative case-example.

#### 4.2.1 Interaction analysis

Interaction analysis is a method for the empirical investigation of the interaction of human beings with each other and with objects in their environment. It investigates human activities, such as talk, non-verbal interaction, and the use of artifacts and technologies, identifying routine practices and problems and the resources for their solution. (Jordan & Henderson 1995.) As a method for investigating human activities, interaction analysis is a useful choice for my thesis. Because of the complexity and multidimensionality of learning situations and human interaction, describing only the meaning of qualitative material or studying only verbal actions is not enough to offer an extensive view of them.

There are some underlying assumptions that Jordan and Henderson (1995) want to make explicit. First, in interaction analysis, knowledge and action are fundamentally social in origin, organization, and use and are situated in particular social and material ecologies. Second, verifiable observation provides the best foundation for analytic knowledge of the world. Third, the domain of questions of interest to interaction analysis revolves around the achievement of social order in everyday settings. (Jordan & Henderson 1995.)

According to Jordan and Henderson (1995), intentions, motivations, understandings, and other internal states cannot be talked about in interaction analysis. Rather, they can be talked

about only by reference to evidence on the tape (Jordan & Henderson 1995). The researcher can't deny the existence of mental representations or of unshared private thoughts. Baker (2015) reminds that the thoughts of individuals surely exist but they are only relevant to its analysis to the extent that they are publicly manifested in some way. In this thesis study, motivations and understandings are counted when a participant expresses them verbally or very clearly in some other way. It has to be noticed that the world is sensible not only to participants but also to analysts when they observe such interaction on videotape. Analytic work draws on our experience as competent members of ongoing social systems and functioning communities of practice. (Jordan and Henderson 1995.)

Overall, video-based interaction analysis is a powerful tool in the investigation of human activity and it is effective in complex, multiactor, technology-mediated work settings and learning environments (Jordan & Henderson 1995).

#### 4.2.2 Video analysis

According to Barron (2007), video analysis can be extraordinary productive as a way to deeper our understanding of learning and human interaction. Derry et al. (2010) present two ways in which researchers use video records. I use the first mentioned way: to locate and analyze data for finding patterns within and across events. The other way is to use video clips more holistically and narratively (Derry et al. 2010).

Derry et al. (2010) distinguish between inductive and deductive approaches to selection for data analysis. I used the inductive approach when I started to process the data. According to Derry et al. (2010), inductive approaches apply when a minimally edited video corpus is investigated with broad questions in mind but without a strong orienting theory. One generally begins by considering the data corpus in its entirety, then considering it in progressively with greater depth. The researcher can strategically select events for deeper analyses that adequately cover major themes. A deductive approach, instead, would be required when the researcher has a strong theory and clear research questions. (Derry et al. 2010.)

I did not start to investigate and select the suitable theories until getting to know the data and starting to focus on the major theme. I also specified the research questions at that point. When starting to analyze the data, I decided to focus on challenging situations in collaborative

learning. That offered me a frame but did not define the exact theme of the research. Actually, as Derry et al. (2010) remind, it is important to remain open to discovering new phenomena.

The challenge for research on learning in social contexts is to develop methods to code between-person engagement explicitly (Angelillo, Rogoff & Chavajay 2006). Derry et al. (2010) remark that the researcher should expect to have to engage in multiple cycles of analysis. The researcher marks, transcribes, and categorizes; analyses and reflects; searches and finds; and so on in the recursive loops that define such knowledge-building activities (Derry et al. 2010).

According to Jordan and Henderson (1995), a question about a degree to which people are influenced by the presence of a camera cannot be decided in principle but must be investigated on each occasion of camera work. The tape can provide evidence that the camera mattered to participants, like visible monitoring of the camera or avoiding showing face to the camera. However, people habituate to the camera surprisingly quickly, especially if there is no operator behind it. The presence of a camera is likely to fade out of awareness quite rapidly when people are intensely involved in what they are doing. Furthermore, different behaviors are on different levels of awareness and some are difficult to manipulate and control. In talk, people make greater attempts to modify what and how they say things, but microbehaviors like gaze and head turns are usually out-of-awareness. (Jordan & Henderson 1995.) In the data, only a couple of students expressed they were aware of the camera. For example, one student commented playfully the filming and recording system aloud, looking amused:

*“I have some appliance on my head and someone is filming me... What should I do? Go away!”* (Riku, Group 2, session 1)

#### 4.2.3 Segmentation, content log and coding

I analyzed the video recordings with the help of QSR International’s NVivo 10 Software. According to Schreier (2011), one has to first divide the material up into smaller units, which will then be coded using a coding frame. I did segmentation by dividing all the videos into segments of 30 seconds. Segmentation is helpful and important in many reasons: it helps to make sure that all the material is considered, it helps with implementing a clear research focus, and it helps with assessing consistency (Schreier 2011). In most videos, there were from 118 to 131 segments that covered active working time. Group 2 session two included only 83 segments because the recording stopped too early because of a technical error. In addition,

Group 5 worked quickly in session three, and there were only 81 segments in that video. Later, I used segments of 30 seconds as the unit of analysis to code the challenging situations with time-logged codes. Time-based coding reduces the challenges related to pinpointing the exact second of the beginning or end of the observation (Näykki et al. 2017).

According to Jordan and Henderson (1995), having a content log is an important step towards the analysis. The content log consists of a heading that gives identifying information, followed by a very rough summary listing of events as they occur on the video. Content logs are useful for providing a quick overview of the data corpus. Content logs must be expanded into transcriptions. They may contain a representation of participants' talk, annotations for non-verbal behaviors, document processing, and employment of certain technologies. (Jordan & Henderson 1995.) There are many conventions for how one might transcribe different aspects of the social interactions captured on video. Typically, the researcher adapts existing conventions that are substantial for their study. (Derry et al. 2010.) My interest focused mainly on challenging situations and discussions about challenges, and the level of details in the content log is deeper when issues with regard to them appeared.

After dividing the data into smaller units and writing content logs, I decided to find, define and categorize what kinds of challenges the students experience during collaborative learning. It was important to define what kinds of issues were possible to code as challenges in this context. Challenges were for example comments, dialogues, actions or facial expressions or gestures that revealed negative aspects. It was enough that one student experienced a challenge during a segment of 30 seconds.

According to Angelillo et al. (2006), a coding scheme cannot be used unmodified from one study to the next. Each new study requires some adaptation of the coding scheme because of learning from each study and the need to take into account the next study's research question and the differing participants, cultural communities, and activities of each study (Angelillo et al. 2006). I suppose that it is possible to explore and compare the previous coding schemes but, after all, it is reasonable to revise and complete one's own coding scheme. The key to the process of developing a coding scheme is using the study's working question to guide decisions about what categories should be coded, and how. There is a risk of trying to capture everything that happens or of examining variables that do not address the purpose of the research. (Angelillo, Rogoff & Chavajay 2006.) Good research questions help maintain perspective and prevent the researcher from getting lost in detail (Derry et al. 2010). I started

answering to the research questions and creating a coding category by considering the findings from the video data and using related literature as a help. In the beginning, I planned rough categories and revised them later.

Finally, I ended up categorizing challenges in five different categories and one sub-category. The categories are: 1) cognitive challenges related to content understanding, 2) cognitive challenges related to task understanding, 3) communication challenges, 4) emotional and motivational challenges, and 5) working challenges. Illustration of each category is presented in Table 1. Categories were not mutually exclusive; rather it was possible to use more than one code at a time. I coded all the segments that included verbal or non-verbal expressions of a challenge. During the categorization process, I made some combining and removing. The small data sample forced me into constructing a compact categorization.

**Table 1**

The thematic categorization of challenges and the definition of each category.

<b>Challenge categories</b>	<b>Definition</b>
1 Cognitive	Challenges in content understanding Challenges in conceptualization or understanding Task difficulty Differing skill levels Questioning own skills Poor concentration
2 Task understanding	Difficulties in task understanding
3 Communication	Misunderstandings between group members Disputes between group members Students are talking at the same time Difficulty to express oneself
4 Emotional & motivational	Expressing signs of frustration, agitation, relief, becoming annoyed Difficulties in controlling feelings Expressing lack of self-efficacy Expressing lack of energy Expressing lack of interest Physical discomfort
5 Working	Difficulty to make a collective decision on how to work Someone doesn't understand the others' way of working Lack of time Lack of space



When investigating the described challenges during the script discussions, I ended up changing the method during the analyses. First, I coded challenges that were described during scripts with the same method than the challenges during group work. However, I noticed that the segments of 30 seconds contained easily more than one mentioned challenge. For example, the students could mention more than one emotional issue, or they brought up several points of views about a challenge in working. Thus, I changed the method and studied script discussions more carefully by defining the meaningful statement as the unit of the analysis. Still, I used the same coding scheme presented in Table 1. According to Chi (1997), segmentation can be based on different semantic features such as ideas, argument chains, or discussion topic while solving problems. In this study the meaningful statement represents those features when they are linked to challenges.

*Cognitive challenges* (1) include challenges in content understanding or challenges that hinder the group in solving the problem, like challenges in conceptualizing or understanding. A student might express that the task is difficult, question the sufficiency of his or her knowledge or point out differing skill levels. In addition, poor concentration is included in cognitive challenges. It was added to this category because when poor concentration appeared a couple of times, it was connected to earlier cognitive challenges. The category of cognitive challenge is the widest category in this categorization.

I decided to insert *task understanding* (2) as a subcategory for cognitive challenges. It is worth remembering that cognition is always situated (Levine et al. 1993). Situations in which cognition takes place differ for example on the grounds of what questions are asked or what other information is given (Levine et al. 1993). I decided to separate task understanding as its own category because it is linked to specific task instructions and differs from the other cognitive aspects that are more related to an individual competence and knowledge. In addition, I wanted to compare if there are any differences between sessions. Task understanding contains difficulties to understand task instructions or the idea of the task. Task understanding is an essential part of collaborative learning.

Challenges in *communication* (3) can be misunderstandings, disputes or difficulties in expressing oneself. Students may be not listening each other's point of views but talking at the same time and someone does not get the time to express his or her thoughts. According to Jordan and Henderson (1995), problems in interaction are usually invisible to the observer because participants are good at fixing them on the fly. Troubles in talk, such as lack of un-

derstanding or mishearing are commonly repaired without being aware of it. Often neither participants nor observers consciously experiences the problem. (Jordan & Henderson 1995.) Thus, analyzing communicational challenges differed from the other categories.

*Emotional and motivational challenges* (4) form one category. Emotions play central roles in learning (Linnenbrik-Garcia & Pekrun 2011) and interpersonal communication (Kaasila et al. 2005). Motivation is an important aspect concerning the progress of the group work (Hammar Chiriac 2011). In this categorization, the students' emotional challenges can be signs of frustration, agitation and relief or becoming annoyed. Notable difficulties in controlling these kinds of feelings belong to this category. In addition, lack of self-efficacy is included in this category. Because of the interplay between cognition and emotion, there are descriptions of questioning one's own skills in both categories. Concerning the emotional aspect, I named it as lack of self-efficacy. Thus, if a student experiences insecure or irritated emotions with regard to low knowledge, I used both codes. Problems with regard to physical discomfort might turn up when being, for example, disturbed by a bad smell or a headache. Thus, the cause of physical discomfort can be external or internal.

The group can encounter challenges in *working* (5) when an individual does not understand the others' way of working, or a group has difficulties to make a collective decision on how to work. Lack of time and lack of space belong to this category. Furthermore, difficulties in using mathematical tools, such as, the manipulatives are included in this category.

During group work, some actions and interactions were not unambiguously regarded as challenges. Therefore, I had to be sure that I argued only by evidence on the tape. Furthermore, for ensuring consistent interpretations in a few repeated unclear situations, I decided to obey the following principles: I counted all situations when a group or one student decided to call a teacher and ask help. In many situations asking help revealed difficulties with content or indicated insecurity. I did not code little miscalculations, speculations of challenges which children can come across, situations in which a student taught other group members if it did not turn up as a problem, remote difficulties with content if those did not have an influence on group's working or if the other knew the right answer easily.

It should be underlined that non-verbal acts demand careful interpretations during analysis. Lahti et al. (2004) mention that in their study emotional aspects were not only expressed by words but also communicated through non-verbal acts such as tears, blushing, sweating,

movement of eyebrows, gestures, and other bodily movements. Additionally, Baker (2015) reminds that even though dialogical thinking is naturally cognitive, communicative and discursive, it is also significant to take into account non-verbal communication such as bodily posture and movement, gesture and prosody. It enables understanding the evolution of negotiated meanings (Baker 2015).

Reliability coding confirms the functionality of the coding scheme and the analysis. The coding system needs to be simple enough for other observers to achieve interrater reliability (Baron 2007). Quantifying the communication for comparative statistical analysis requires that two independent coders code the same segments (Strijbos, Martens, Prins & Jochems 2006). The reliability of the coding was tested by selecting 25 % of the video data (three videos) to be classified by the independent coder. I selected Cohen's kappa coefficient as a statistical measure for evaluating an inter-rater agreement for qualitative items.

The first intercoder reliability was 0.70. According to Landis and Koch (1997), Kappa value between 0.61-0.80 means substantial agreement. It was a promising sign of the functioning coding scheme and reasonable analysis. To finalize the reliability of the coding included two meaning negotiations about different interpretations. Remote divergent interpretations are acceptable and do not affect the final reliability of the study. In total, Cohen's kappa was 0.77. (sample 1,  $k = 0.77$ , sample 2,  $k = 0.75$  and sample 3,  $k = 0.81$ ). It means that the reliability of the coding shows substantial agreement. The independent coder viewed that the 30 seconds segmentation, ready written content logs, and coding scheme with many examples facilitated her work.

According to Strijbos et al. (2006), Cohen's kappa is mostly used to confirm the reliability of coding categories. However, the number of categories included is ignored – even though the higher the number of categories, the smaller the likelihood of chance agreement as opposed to possible deviations (Strijbos et al. 2006). In my case, the low number of the categories might have influenced the good value of Cohen's kappa.

#### **4.3 Evaluation of the reliability**

In this chapter, I evaluate the reliability of this master's thesis. First, I evaluate the reliability from the perspective of the data and participants. Second, I consider issues that might have

influenced on the reliability of methods and analysis. Finally, I describe my own background as a teacher education student.

The variation between group work and scripted discussions in the data offered me a possibility to take advantage of distinct sources of information, which improves reliability. Overall, I had three points of view in this study: my own as a researcher, as well as groups' and individuals' perspectives. The researcher's perspective arises from the observed actions and interactions in video recordings; and the groups' and individuals' perspectives come up from the script discussions during orientation, check-up and reflection phases. That means that the reliability of this work leans not only on my interpretations but is based on more than one source of information.

The small data sample was a limitation in this study. I analyzed only 15 videos of over 80 videos that have been captured. In a master's thesis, however, it is a decent amount to work with. On the other hand, the results of this work are based on the collaboration of five groups on three mathematics lessons which means that the evidence is highly situated in the selected tasks and groups. If I have had different groups and sessions to analyze, I could have got different results. Unfortunately, all the students did not participate every time. For example, in Group 2, there were different persons present every time. On the opposite, the students in Group 1 participated in all three sessions. This might have influenced the group dynamics for example by changing the leader role in the group. The small data sample set the generalizability of the results open to question. On the other hand, the generalizability is not the main purpose of this kind of qualitative study. Rather, the aim is to better understand the phenomenon and rouse questions that can drive forward the research in this area.

The participants were pre-service teachers. It is noteworthy to remind that it is not easy to get into teacher studies in Finland – below 10 % of applicants are accepted. That means that there is a large amount of applicants from which to select. Thus, the participants' background can have an influence on their thinking and group working skills. Häkkinen et al. (submitted) state that teacher education attracts students who have strong strategic learning skills and collaboration dispositions. Lutovac and Kaasila (2014) sum that pre-service teachers are highly motivated about their future profession. Valtonen et al. (2016) adds that the most of the first-year pre-service teachers assess themselves as skillful learners, especially in the area of collaboration. On the other hand, Häkkinen et al. (submitted) remind that pre-service teachers do not

form a homogenous group but represent differences in strategic learning skills and collaboration dispositions.

On the other hand, the principles that had guided the group forming may have had an influence on the ways of working. Three collaboration dispositions had an influence on the group forming: the aim was to put together students who were pleased to work in groups, students who did not enjoy group work, and students whose attitudes were in the middle of these extremities. If the groups had formed randomly, there could have been divergent challenges. The students also knew each other and they had studied together almost for a year. This has obviously aroused team spirit and after working several times together during the previous year, the students had already started to become better collaborators.

What comes to evaluating methods and analysis, using more than one method and studying data from different perspectives improve the reliability of this work. Integrating qualitative and quantitative perspectives offers diverse point of views when reporting the results. According to Chi (1997), qualitative research can provide a richer and deeper understanding of a situation. Quantitative perspectives have the advantage of objectivity (Chi 1997). Twining, Heller, Nussbaum and Tsai (2017) state that there is much confusion of the extent to which you can mix and match between quantitative and qualitative research. In the beginning, my plan was to utilize numerical perspective more notably, but I ended up showing frequencies and handling non-numerical data mainly qualitatively. Despite that, this study cannot be criticized due to its lack of repeatability of the analysis. Categorization and precise description of analysis enable replicating the study, though it should be noted that contextual and situation specific factors influencing collaborative learning will always vary.

What comes to the analysis, the opportunity to watch video recordings as many times as needed strengthens the reliability. In addition to advantages, video recordings can also have some limits. Even though Jordan and Henderson (1995) state that people habituate to the camera surprisingly quickly, it is possible that the students were aware of the camera and the research project in spite of the missing clear signals. They might have avoided drifting into challenging situations or causing problems because of the research situation. On the other hand, the explanation can also be related to the students' positive stance towards collaborative learning situations. In addition, Koivuniemi et al. (2017) argue that to access students' challenges, participants needed to be asked directly and self-reporting is the best option. I admit

that adding self-reporting to the examination would have given another interesting point of view.

The tools that researchers choose significantly shape their work (Derry et al. 2010). I assume that using 30 seconds segments as coding units influenced my work. Time-logged codes are a handy way to analyze data and the investigation of the frequencies is effective. On the other hand, using segments makes it impossible to compare the duration of challenge types. In addition, I had to change the method when analyzing script discussions. However, I assume that choosing to investigate script discussions through transcriptions improved reliability. It confirmed that every aspect that the students brought into discussion was taken into account. On the other hand, there are some limitations of investigating described challenges only during script discussions, because the participants described their challenges also during group work. Thus, for clarity and in order to avoid overlapping, I decided to distinguish observed and described challenges and study them with different methods.

Interpretation of what constituted as a challenge was problematic while working amongst this study. Because it is possible that all members in a group interpret a certain situation in their own ways, it is presumable that my interpretations as an observer differ from the participants' thoughts. According to Garcia-Prieto et al. (2003), each team member has a repertoire of multiple identities that have an influence on how they define themselves in different situations, and how they define the situation. My challenge was to work as an objective observer and interpreter. I must admit that distinguishing all the shadings of the data was not possible in every perspective, but I am sure that I succeeded in creating a truthful picture of this subject. The data consisted of many situations with multiple meanings.

The reader should know some information about my own background in order to understand my starting point and to be able to evaluate the reliability of my work. Observation can never be wholly free from the values, assumptions and theoretical perspectives of researchers, though a great deal can be done to show readers what these assumptions are (Seale 1999). Raatikainen (2009) states that especially researchers in the field of applied studies might have difficulties to keep their own values apart from matters that are strongly related to sensitive issues. However, it is not impossible, and objectivity is possible and worthwhile in human sciences (Raatikainen 2009).

Like the participants in the PREP21 -research project, I am a pre-service teacher and know some of the other participants. I have also taken part in another data collection of that study as a student. Therefore, it felt a bit confusing to start go through the data at first. In time, however, it felt more and more natural and I suppose that I succeeded in forgetting the links between me and the participants when focusing intently on the subject and the research questions. When starting to do this master's thesis, my main intentions were to learn about making reliable research, to deepen understanding about collaborative learning and to bring new perspectives from the PREP21-data. Reliability coding and frequent discussions with the researchers improve the reliability of this work.

#### **4.4 Evaluation of ethical issues**

Ethical issues should be considered during all phases of the research process. According to Creswell (2013), during the planning and designing a qualitative study, researchers need to consider what ethical issues might surface during the study and plan how they need to be addressed. In addition, Cohen, Manion and Morrison (2002) remind that each stage in the research sequence may be a potential source of ethical problems. In this chapter, I evaluate critically different research phases and consider participants' anonymity and position.

I was not involved in the PREP21 research project until the analysis phase so I act as an outside monitor when exploring the decisions that have been made before the study and data collection. According to Creswell (2013), prior to conducting a study it is necessary to gather university approval from the institutional review board for the data collection involved in the study. In addition, it is important to disclose the purpose of the study to the participants (Creswell 2013). What comes to the PREP21 -research project, the purpose of the study was made clear for the participants. The researchers told about it face-to-face and allowed the participants to pose questions if they found something unclear. Participation was voluntary and all students gave written consent to be involved in data collection.

Ethical issues occur in the process of research continuously: in analyzing the data, reporting the data and publishing the study. When analyzing data, a researcher should report multiple perspectives and contrary findings. Reporting should be done as honestly as possible and composite stories should be used the way that individuals cannot be identified. Publishing the study requires for example sharing practical results. (Creswell 2013.) I explored the results from several perspectives, which helped me to consider the whole process as widely as possi-

ble. In addition, I will highlight many citations in order to get a more authentic view when reporting the results.

Participants' anonymity is important to secure. Even though video recordings can in no way preserve anonymity in a longitudinal research project, another way of protecting a participant's right to privacy is through the promise of confidentiality. This means that although researchers know who has provided the information, they will in no way make the connection known publicly. (Cohen et al. 2002.)

Anonymity requires that the information provided by participants should in no way reveal their identity (Cohen et al. 2002). Derry et al. (2010) point out that the participants' expectations and rights to privacy and confidentiality should be honored. To secure the anonymity of the participants, I used pseudonyms. At the beginning, I considered if there is a need to fade out the gender differences of the names because of the small amount of male participants. On the other hand, the gender differences played quite an important role in some groups. I ended up changing the names but leaving references to gender.

The anonymous nature of this study ensures that the data cannot be used in a way that might embarrass participants. If these principles are not taken seriously, it is possible to talk about betrayal. According to Cohen et al. (2002), the term is usually applied to occasions when data disclosed in confidence are revealed publicly in such a way as to cause embarrassment or anxiety. In my thesis, the challenges can be regarded in a way as a critical issue. That is why I tried to be as truthful as possible and did not exaggerate comments or situations. In short, my target was to secure the anonymity of the participants and give only realistic descriptions of the data in a way that does not harm anyone.



## 5 Results

This master's thesis provides an overview of different challenges that first-year pre-service teachers experienced and described during collaborative learning in mathematics. The aim was to observe what kinds of challenges the students experience during solving mathematical tasks and how do they describe their challenges during script discussions. I will use three different representations to convey the complexity of actions and interactions that the data showed. First, two tables show the quantitative results. Table 2 shows a general overview of the findings and Table 3 presents frequencies of challenges by each group and session.

Second, I introduce the most significant observations from the groups' working and enrich the investigation with illustrative data examples. It is important to give the readers a sufficient sample of the video data to allow assessing the quality of the arguments (Derry et al. 2010). I proceed challenge by challenge and describe shortly what kinds of issues the groups handled in regard to them. I investigate both individual-level and group level processes of collaboration. I mostly observed the individual's actions, but when taking into consideration also interactions, reactions, responses, and a collaborative way to work, group level processes are essential for the observations. In collaborative learning, it is a complicated to separate these perspectives, but I decided to notice both with the help of qualitative descriptions and illustrative case examples presented below.

Third, I investigate the challenges that the groups described during script discussions and give data examples in the same way than explicated above. Usually describing happened when the students answered to a prompted question about challenges or a question about what hindered them to reach their goals.

Table 2 shows that in total, there were 217 challenge events that were observed in students' working and 87 challenge events that the students described during script discussions. According to Table 2, the students seemed to experience cognitive challenges most often (93 events observed). Following those, there were challenges related to working (54 events observed), emotions and motivation (32 events observed), task understanding (20 events observed) and communication (18 events observed).

**Table 2**

The general overview of the frequencies and proportions of observed and described challenges.

	<b>Observed</b>	<b>%</b>	<b>Described</b>	<b>%</b>
Cognitive	93	43 %	34	39 %
Working	54	25 %	33	38 %
Emotional & motivational	32	15 %	20	23 %
Task understanding	20	9 %	0	0 %
Communication	18	8 %	0	0 %
Total	217	100 %	87	100 %

Table 2 shows that during script discussions, the students discussed about cognitive and working challenges the most often (34 and 33 mentions). Emotional and motivational challenges were mentioned 20 times. The students did not describe challenges related to task understanding or communication during script discussions.

It is worth reminding that the number of challenges presented above does not directly tell the precise number of challenging situations or expressed challenges. Challenges were coded with time-logged codes so that every segment (30 seconds) that contained a challenging situation or expression of a challenge was counted. Some situations took place for more than half a minute and thus contained more than one code. Therefore, the biggest interest falls upon the differences between different challenge types.

## **5.1 What kinds of challenges do students experience during collaborative learning in mathematics?**

It was possible to observe challenges that were 1) cognitive challenges, 2) cognitive challenges related to task understanding, 3) emotional and motivational challenges, 4) challenges in working, and 5) challenges in communication. Table 3 shows that the frequencies of observed challenges varied among the groups and sessions. The difference between the groups that experienced the least and the most challenges was quite notable: from one to 29 observed challenges. Thus, the mean of all the video recordings was 14 challenges per session.

On average, the groups experienced more challenges in session one, which handled base ten blocks. The mean was 16 challenges. Groups 3 and 5 experienced the most challenges in session one. However, Groups 1 and 2 experienced the most challenges in session three, which dealt with spatial thinking. Group 4 was the only group that experienced the most challenges in session two that handled fractions.

Generally, Group 1 seemed to experience the most challenges. In every session, they experienced the biggest number of challenges: 25 in session one, 23 in session two, and 29 in session three. In sessions two and three, they also described challenges the most actively. Later, I will introduce Group 1 as a case example. On the opposite, Group 4 and Group 5 experienced the least challenges: the minimum was one challenging situation during session three. In the following sub-chapters, I will present each challenge type by presenting frequencies, explaining the observations, and by giving illustrative data examples.

**Table 3**

Frequencies of experienced and described challenges of each group and session.

	<b>Session 1</b>		<b>Session 2</b>		<b>Session 3</b>		<b>Total</b>	
	Exper.	Descr.	Exper.	Descr.	Exper.	Descr.	Exper.	Descr.
<b>Group 1</b>								
Cognitive	8	0	9	4	5	5	<b>22</b>	<b>9</b>
Task understanding	3	-	2	-	0	-	<b>5</b>	<b>0</b>
Communication	0	-	2	-	7	-	<b>9</b>	<b>0</b>
Emot. & motiv.	4	4	4	3	8	2	<b>16</b>	<b>9</b>
Working	10	2	6	5	9	5	<b>25</b>	<b>12</b>
<b>Total</b>	<b>25</b>	<b>6</b>	<b>23</b>	<b>12</b>	<b>29</b>	<b>12</b>	<b>77</b>	<b>30</b>
<b>Group 2</b>								
Cognitive	7	2	8	2	8	3	<b>23</b>	<b>7</b>
Task understanding	2	-	2	-	2	-	<b>6</b>	<b>0</b>
Communication	4	-	1	-	2	-	<b>7</b>	<b>0</b>
Emot. & motiv.	2	1	1	1	7	0	<b>10</b>	<b>2</b>
Working	7	4	0	1	4	1	<b>11</b>	<b>6</b>
<b>Total</b>	<b>22</b>	<b>7</b>	<b>12</b>	<b>4</b>	<b>23</b>	<b>4</b>	<b>57</b>	<b>15</b>
<b>Group 3</b>								
Cognitive	12	4	6	5	5	6	<b>23</b>	<b>15</b>
Task understanding	0	-	0	-	1	-	<b>1</b>	<b>0</b>
Communication	0	-	0	-	0	-	<b>0</b>	<b>0</b>
Emot. & motiv.	0	1	0	0	2	0	<b>2</b>	<b>1</b>
Working	1	1	3	3	1	1	<b>5</b>	<b>5</b>
<b>Total</b>	<b>13</b>	<b>6</b>	<b>9</b>	<b>8</b>	<b>9</b>	<b>7</b>	<b>31</b>	<b>21</b>
<b>Group 4</b>								
Cognitive	1	1	9	1	0	0	<b>10</b>	<b>2</b>
Task understanding	1	-	3	-	0	-	<b>4</b>	<b>0</b>
Communication	0	-	2	-	0	-	<b>2</b>	<b>0</b>
Emot. & motiv.	0	4	1	0	1	1	<b>2</b>	<b>5</b>
Working	3	0	2	2	0	0	<b>5</b>	<b>2</b>
<b>Total</b>	<b>5</b>	<b>5</b>	<b>17</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>23</b>	<b>9</b>
<b>Group 5</b>								
Cognitive	6	0	2	0	7	1	<b>15</b>	<b>1</b>
Task understanding	4	-	0	-	0	-	<b>4</b>	<b>0</b>
Communication	0	-	0	-	0	-	<b>0</b>	<b>0</b>
Emot. & motiv.	1	3	0	0	1	0	<b>2</b>	<b>3</b>
Working	6	2	0	4	2	2	<b>8</b>	<b>8</b>
<b>Total</b>	<b>17</b>	<b>5</b>	<b>2</b>	<b>4</b>	<b>10</b>	<b>3</b>	<b>29</b>	<b>12</b>

### 5.1.1 Cognitive

The definition of cognitive challenges is the widest among other categories in this work, which means that the biggest amount of challenges were regarded as cognitive. It can be seen in Table 3, which shows that cognitive challenges were the most common challenges in all groups excluding Group 1. Group 3 had the biggest number of cognitive challenges in session one when cognitive challenge turned up altogether 12 times. On average, groups experienced cognitive challenges six times per session.

Cognitive challenges were usually linked to the mathematical context. It was common that students expressed task difficulty concerning either the whole lesson or a specific task. Students could mention task difficulty before starting a task, while doing calculations or after getting the task solved. Students also expressed their cognitive challenges by revealing insecure feelings about their knowledge or questioning their own skills in using the learning tools.

In the beginning of the lesson, Elias says that he *“had never understood the base ten blocks”*. (Group 1, session 1)

Ilona and Sami consider that division with the base ten blocks was challenging. (Group 1, session 1)

While working on the tasks of spatial thinking, Johanna sighs: *“I am not able to do these at all.”* (Group 3, session 3)

All the groups had problems in content understanding at some level. The students were confused with the concepts like mixed fraction, algorithm or reduction. Struggling with cognitive challenges often led to discussions about the concepts or teaching other group members. However, it was a common decision for the groups to ask the teacher for help.

"Jenna turns to others and whispers, *“what are algorithms?”* (Group 2, session 1)

The others try to remember to which side converting and reducing fractions to have common should be written. Jenna says that she doesn't understand what they are talking about. (Group 2, session 2)

The group does not remember if zero belongs to integers. (Group 5, session 2)

In many sessions, it was visible that the group had challenges to get the task solved. Some students had problems with conceptualization or someone did not know or remember the basic knowledge that was needed in a specific task.

The group has problems in remembering the concepts they need when documenting multiplication. They do not remember how to note down the numbers that they should remember. (Group 3, session 1)

Julia says that it is difficult to picture the actual structures with the help of the diagram pictures. (Group 3, session 3)

Poor concentration came up visibly in Group 5 for a couple of time. The student's concentration started to be poor after experiencing cognitive challenges during the session. For example, Amy looked confused and said:

*"I don't understand why, but I'm not following at all."* After proceeding in working for a while, Noora turns to Amy and asks if she is following. Amy admits again that she is not. (Group 5, session 1)

### 5.1.2 Task understanding

Challenge in task understanding is a subcategory for cognitive challenges. Table 3 shows that challenges in task understanding varied between zero to four times per session. The groups expressed challenges in task understanding in the beginning of the session or when moving on to the next task. The students did not dare to start or continue without asking teacher if they had understood the instructions right, or without checking the meaning of the concept like mixed fraction or algorithm. Furthermore, the request to document calculations on paper raised questions. Every group had challenges in task understanding at least once during the three sessions.

The group does not understand what they should do on the grounds of task instructions. Elias reads the instructions aloud and states: *"Now I don't... this is as unclear as it can be in this state of tiredness."* (Group 1, session 1)

Jenna holds the task instructions about fractions in her hands and mentions that the task is quite difficult because they do not have any examples. (Group 2, session 2)

When trying to solve the problems with regard to task understanding, the students read the instructions aloud and tried to figure it out together. Members in Group 5 turned quickly to their teacher.

### 5.1.3 Communication

Challenges in communication remained quite low. One group was an exception: Group 1 had seven communication challenges in session three, while usually the frequency was from zero to four challenges. Group 3 and Group 5 did not show challenges in communication at any session. Communication challenges were usually misunderstandings between the students or talking at the same time without listening others. In some cases, a student asked something but did not get any reaction. In addition, it was possible that communication challenges were linked to other challenges, for example cognitive challenges.

Jenna states that she did not understand anything what Riku said about the base ten system. Jenna looks annoyed and states sharply: *"Well this was really too complicated for a child at my age."* (Group 2, session 1)

Ilona tries to write a calculation down and asks that Elias would not talk at the same time. Elias continues talking. (Group 1, session 2)

Beth tries to tell her ideas about dividing fractions but she does not get the floor. (Group 4, session 2)

Riku explains his idea about how to continue building a structure and points at it with a pen: *"it should look like this – so that on the top is like dykdykdyk, dykdykdyk."* The moment of silent. Jenna states in wonder: *"I did not understand."* Riku starts explaining again, building with the bricks at the same time. (Group 2, session 3)

Communication changed to short disputes now and then. Disputes were visible when a student looked severe or participants raised their voice. In some situations, non-verbal signs like gestures or facial expressions showed disagreements between the group members. In the following examples, challenges in communication are linked to cognitive challenges:

After disagreeing the information given in the diagram pictures, Elias presses: *"Are we looking at the same picture?"* He turns around and tries to call a teach-

er. Ilona stops him and starts to assure that the others' way to do is the right way. Elias starts to explain how he would solve the task, but turns to call a teacher again. (Group 1, session 2)

There is a misunderstanding between Riku and Emma, when Emma explains her idea about starting to document calculations and Riku starts to correct her. However, after noticing that Riku had understood Emma's aim wrong and explained about a different issue, he apologizes to her. (Group 2, session 1)

Difficulties to express one's own thoughts (black outs) came up a couple of times.

Riku agonizes about the difficulty to express himself. (Group 2, session 2)

Even though the students knew each other quite well, hardly any off-topic discussions appeared during these sessions. Off-topic discussions can turn into challenges if only pair group members stop working and start to chat while the others would like to proceed.

#### 5.1.4 Emotional and motivational

In total, emotional and motivational challenges varied from zero to eight per session. Emotional and motivational challenges were quite uncommon during group work. On average, a group experienced only two emotional and motivational challenges during one session. Mostly emotional and motivational challenges were expressing the lack of energy or negative feelings like frustration, agitation or annoyance. In some cases, emotional challenges were difficulties to control feelings. Strong emotions occurred typically together with cognitive or communication challenges.

Jenna says that number cards are annoying because it took such a long time to find the right ones. (Group 2, session 1)

Group 1 had the biggest amount of emotional and motivational challenges in session three:

After a disagreement between him and the rest of the group members Elias says: *"I am starting to understand the problems of the mathematical genius a couple of centuries ago ---. I almost got angry."* (Group 1, session 3)

Confusion was mentioned several times. For example, students felt the teacher's advice, others' explanations or task instructions to be confusing. Confusion caused also dissatisfaction for some students. For example, Jenna shared an unhappy memory that seemed to follow her



from primary school to the present: she noted that when she does not understand something in mathematics and asks questions, she always gets "*it just happens to be like that*" for an answer. Jenna expressed that she was frustrated because of that comment.

Surprisingly, physical discomfort affected group members' emotions and participation. Students found the bricks used in the task that tests spatial thinking were very bad smelling. At the worst, Johanna had to go out from the classroom for a few minutes because of the headache that was caused by the smell. In addition, Riku felt that his eyes began to hurt because of the complex pictures on the paper:

Riku holds the task instructions in his hands and looks at the isometric perspective pictures. He sighs: "*This is quite terrible. That picture hurts my eyes.*" (Group 2, session 3)

In some situations, proceeding slowly caused negative emotions. For example, Emma described her feeling as shocked when she noticed that they were only in the task 1 a by the middle of the lesson. Later, she hoped that they could proceed to the other exercises.

#### 5.1.5 Working

Challenges in working varied more than the previous three types: from 0 times to 10 times per session. The most remarkable difference was between Group 1 and Groups 3 and 4. When Group 1 had between 6 to 10 working challenges in every session, Group 3 and 4 had only from 0 to 2 of them. On average, groups experienced four challenges in working per session.

At their lightest, challenges with regard to working were separate comments without responses, like mentioning that the group has quite little space on the table. Sometimes students had problems to find a right way to use manipulatives. Thus, there were challenges to work fluently in the concrete learning environment.

Ilona and Elias mention that they have quite little space on the table. (Group 1, session 1)

Emma makes a suggestion on how the number cards could be used instead of the base ten blocks. The others argue that it can't work like Emma suggested. (Group 2, session 1)

In some situations, the students argued over different ways to work or they did not agree with others' suggestions. These situations included pointing out others' mistakes or insufficient suggestions.

The group has different opinions on in which order they should proceed in the calculation. Ilona says that they started the subtraction from the wrong direction. Elias does not agree and argues that they can see the solution already. (Group 1, session 1)

Julia and Aino finish borrowing in subtraction with the base ten blocks. Riku thinks that it was impractical to do and Emma says that it was difficult to follow. (Group 2, session 1)

Challenges in understanding others' way of working or difficulties to make a collective decision on how to proceed was sometimes linked to emotional expressions:

Maria: *"I am really confused."* Elias continues impatiently: *"How do you think that Ilona? I say, you can scribble drawings but now I'm getting confused of this."* (Group 1, session 2)

Group 5 was especially worried about the lack of time. However, there was not much to do with the fact that they had approximately one hour to complete the task. This was seen especially during script discussions.

The others have continued to the next task when Amy is still working with the previous one. (Group 5, session 1)

Amy looks upset when the teacher asks them to stop calculating. She says that she would have liked to finish the task. (Group 5, session 1)

## **5.2 How do students describe challenges during script discussions?**

During the script discussions in orientation, check-up and reflection phases only the cognitive, emotional and motivational, and working challenges were described. Interestingly, all types of challenges that appeared during group work were not discussed during script discussions. Students did not evaluate challenges with regard to task understanding or communication during script discussions.

Table 3 shows that on average, groups described five challenges per script session. The range was remarkable: from one to 12 identified challenges. Group 1 was the most active to describe and discuss about their challenges. While Group 1 described challenges 30 times during all three sessions, Group 4 described only nine challenges. Surprisingly, there was not a single challenge type that would have clearly been the most often described. In total, Group 1, 2 and 3 described most cognitive challenges; Group 4 identified emotional and motivational challenges, and Group 5 described challenges in working the most often. Unfortunately, two groups' video recording end before they get to reflection. That means that parts of data are missing and it makes the comparison of reflection parts incomplete.

In the following chapters, I will explain what kinds of challenges the students highlighted during script discussions. I will separate issues that were handled in orientation, check-up, and reflection.

### 5.2.1 Cognitive

Cognitive challenges that the students described were different in the orientation, check-up, and reflection phases. In the beginning of the session, the students read the task instructions and during orientation, they shared their feelings about the task and evaluated their own abilities and knowledge. For example, the students mentioned that the tasks seem difficult or that they are not good at mathematics. Sometimes expressions were emotionally emphasized.

Referring to fractions, Jenna says that she really needs revision. (Group 2, session 3)

When starting the session related to spatial thinking, Riku says that he “*sucks in that type of assignments*”. (Group 2, session 3)

Especially Group 3 revealed insecure feelings towards the upcoming tasks or doubts about their mathematical abilities. The second session concerning fractions made everyone in Group 3 state that the task seemed to be difficult. On the other hand, Julia said that the task looks difficult in every orientation. She also compared herself to the other students in their group.

“*Iina and Olli are good at calculation – unlike me.*” (Julia, Group 3, session 1)

Thus, it was common for Group 3 to state that the lesson or the tasks are demanding. Later, Julia found the division of fractions especially challenging. During orientation in third ses-

sion, Johanna said that she has challenges in spatial thinking. It was the reason why the task seemed demanding for her. Thus, that session especially required patience and persistence even though the others helped her always when needed. In Group 2, Jenna monitored her understanding very actively starting from orientation. Especially concerning fractions, she admitted that she really needed revision.

After working for a while with the task, the students monitored their group work and skills during check-up. Students mostly evaluated their own cognitive skills or revealed feelings about the difficulty of the task.

Jenna explains that she did not understand the idea of fraction cakes at first and that not everything is clear yet. (Group 2, session 1)

Julia says that the tasks feel challenging and that the lesson is more difficult than the previous lessons. (Group 3, session 3)

In some cases, one student could evaluate other's cognitive skills during check-up. That happened mostly in Group 1, when the group members concentrated on evaluating their differing skill levels and too complicated thinking. In addition, Group 1 was the only group which regarded different skills as a problem. This perspective caused contradictions in their working, and sometimes aroused feelings of frustration. For example, Elias put it in words:

Elias says that they have so many different thinkers in their group that he noticed how complex it is possible to express the things. - - *"just had to wait that the others understand, too."* (Group 1, session 2)

On the opposite, Group 2 described the differing skill levels more positively:

Jenna thinks that they were in a different level, but that it was maybe a good thing and everyone benefitted somehow. (Group 2, session 2)

During reflection, the students did not activate discussion about cognitive challenges very often. They mainly focused on listing the ways that helped them to reach their goals or reflecting on how they overcame their challenges. A few cognitive issues that the groups handled during reflection were too complicated thinking, inability to focus all the time, and insufficiency of one's own skills. On the other hand, the students linked humor to cognitive challenges and thus pointed out good atmosphere. Sami joked about unworkable democracy in Group 1, and two students in Group 2 joked about their defective intelligence:

Jenna, laughing: *“Low intelligence hindered us to reach our goals.”* Riku: *“Yeah, narrow brainpower!”* (Group 2, session 2)

Reflection in session two instigated two groups to ponder their differing skill levels. After that session, Jenna stated that they were on different levels but it might have been a good thing and that everyone benefitted somehow. This opinion differs clearly from the perspective that Group 1 presented about their differing skill levels. Referring to the significance of the group members, Aino expressed that the others offered essential help:

*“I would not have been able to solve these tasks on my own.”* (Aino, Group 2, session 3)

### 5.2.2 Emotional and motivational

Emotional and motivational challenges were actively discussed especially during orientation. In the orientation phase, participants expressed lack of energy and other feelings. In addition to tiredness, the students mentioned a wide variety of emotions: frustration, irritation, confusion, trauma, suspicion, fear, and anxiety. Some descriptions were short answers to the straight questions, while some emotions were strongly expressed. The following examples show what kind of emotional and motivational issues the students brought out:

*“Physically here, mentally somewhere else.”* (Elias, Group 1, session 3)

Sami feels conflicting feelings, because the task *“should be easy”*. Elias mentions that *“In this state of tiredness the task won’t be very easy.”* He adds that mathematics always arouses frustration. (Group 1, session 1)

Daniel says that he is suspicious. Sara says that she feels fear when she thinks that she has to use learning tools in teaching. (Group 4, session 1)

Sara says that she feels anxiety because she hates spatial stuff. Beth agrees. Beth nods at Viola that her challenge is to motivate the others. (Group 4, session 3)

Expressing and describing emotions was more common than discussions clearly about motivation. On the other hand, emotions can be seen as clues about motivation. Surprisingly, however, lack of motivation came up directly only once:

In orientation, Sara says that she feels anxiety because she hates spatial stuff. Beth agrees. Beth notes to Viola that her challenge is to motivate others. (Group 4, session 3)

Discussion about emotions decreases when comparing orientation and check-up. During check-up phases, only two groups discussed emotional and motivational issues. In both groups, there was one student who expressed emotions explicitly and loudly. Only those students' emotions were evaluated in check-up.

Ilona states: "*Elias got bored and became frustrated.*" Elias admits that he became frustrated. (Group 1, session 1)

Jenna: "*I'm annoyed, because now it is the same situation what I had in ~~the~~ primary school and I really don't get this. And then it is only said that 'well we just have to proceed on to the next exercises' and then the problem is skipped again.*" (Group 2, session 2)

### 5.2.3 Working

During script discussions, talking about challenges that were linked to working was common. During orientation, groups brought out problems related to the learning environment, like lack of space or insufficient manipulatives. In addition, the students were worried about not having enough time. During check-ups, the students often talked about challenges in proceeding or progressing at a different pace.

Sami says that working started to get slow. (Group 1, session 1)

Ilona says that the boys are somehow ahead of them [the girls]. She adds that she and Maria play only with the fraction cakes, while boys calculate also in other ways. Elias answers that his eyes see directly things that the other's eyes do not notice. "*There are group members of different levels who notice things at different times. It might cause a little confusion.*" (Group 1, session 2)

Even though Ilona and Maria stated that the boys were somehow ahead and there was some kind of dichotomy between the boys and the girls, it was mostly Ilona and Elias who involved themselves in actions and interactions by thinking aloud and discussing. Maria acted more

like a solver and Sami hardly participated in the discussions. On the contrary, Group 4 did not have problems in the differences in the pace, because they decided together to proceed as slowly as it takes. Aino summed this up in session one in saying that their group had proceeded slowly, but thoroughly. Thus, in session two, Jenna compared their group to a class where one student does not understand - and this being the reason why the whole class is proceeding slowly.

During the reflection phase, Group 1 discussed very actively about working challenges. When the other groups mentioned challenges once, Group 1 discussed about them six times. They compared group members' ways to choose the way to solve tasks and evaluated different ways of working.

Ilona and Maria say that they started to complete the task with learning tools at first, while Elias does mental calculation. Elias says that this is why the girls had difficulties with borrowing. (Group 1, session 1)

Describing challenges in working stirred also humoristic comments:

Elias: *"Here was this classical one against tree."* Ilona: *"We prevented Elias to reach his goals!"* Riku: *"Democracy doesn't work when the people are too stupid."* (Group 1, session 3)

Group 5 stuck out from the other groups by worrying continuously about the hurry and the lack of time.

*The time is our enemy.* (Noora, Group 5, session 2)

### **5.3 Group 1 as a case example**

In this chapter, I present Group 1 as a case example. I present situations that the group experienced challenging while working and which they described also during script discussions. I focus on check-up and reflection parts because they included discussions about the group's recent working periods. Some descriptions about challenges that the group brought up during orientations have been presented earlier in Results. Group 1 was a choice for an example, because Group 1 experienced and described the biggest amount of challenges when comparing

it with the other groups. Furthermore, all group members were present in the three analyzed group sessions.

#### Session one

*Experienced challenges:* The first session was a workshop on arithmetic algorithms and base ten blocks. The group experienced the base ten blocks challenging. That was shown in cognitive, working, and emotional and motivational challenges. The students had difficulties in borrowing and in checking division by writing a calculation down, the manipulatives confused them, and they found that the number cards were problematic. When the whole group found number cards problematic, they decided to avoid them and use only base ten blocks.

As mentioned above, challenges in working were mostly related to the base ten blocks. The group found that they did not have enough space to use the manipulatives, they had challenges to create common understanding in what order and how they should have been using them, and Elias considered the manipulatives “*really slow and problematic*”. When Ilona wanted to slow down and consider borrowing more thoroughly, Elias expressed frustration by bringing his hands in front of his face.

#### *Described challenges:*

Check-up 1: According to their experiences, group members described the difficulties with the manipulatives during check-up. They agreed that the manipulatives are challenging. Furthermore, Sami noticed that their working pace was getting slower. Ilona stated that Elias got frustrated and by doing so pointed out the short emotional challenge that happened between them. Elias admitted it and added that the manipulatives were frustrating. Thus, their descriptions focused on one issue.

Reflection 1: During reflection, the group continued talking about frustrating manipulatives and stated that playing with blocks hindered them in reaching their goal. Maria and Ilona described carefully the differences that they noticed between the boys and the girls: when starting to solve a task, the girls started to solve it with the manipulatives, while Elias counted mentally first. Elias argued that it was the reason why the girls had troubles in borrowing. Ilona defended that the whole idea was to learn how to use manipulatives and face problems that the children might have. Sami summed up that the manipulatives hindered them to reach their goals and the others laugh. They admitted that they were not used to calculating with the manipulatives. Thus, during reflection, group members focused on analyzing one challenge



that they seemed to regard as their major challenge. Despite the experienced hindrance and the negative evaluations, they did not seem desperate but proceeded continuously.

#### Session two

*Experienced challenges:* The second session dealt with teaching fractions using the fraction cakes. Group 1 experienced cognitive challenges in the single parts of the task. For example, multiplying fractions by fractions using the gridded paper and dividing fractions caused problems. Trying to explain her ideas about dividing, Ilona grabbed a pen and a piece of paper. This moment of writing and thinking aloud engaged the whole group and included emotional and communicational challenges. Ilona tried to focus on writing and reaching understanding, and asked Elias not to talk at the same time. Waving ahead this appeal, Elias continued talking. Being not able to understand Ilona's thoughts, Elias faced a moment of frustration and waved his hands and seemed to be upset. He wondered to Sami: "*Have I missed something in primary school mathematics?*" Later, Elias blamed that in the beginning, the girls only played with the fraction cakes – but when the boys tried to only play with them, it seemed to cause problems.

#### *Described challenges:*

Check-up 2: During check-up, Ilona considered carefully the group members' different working styles and differing skill levels. Ilona felt that the boys were somehow ahead of the girls and that she and Maria only played with the fraction cakes, while boys calculated mentally. Elias says that his eyes see directly things that their eyes do not notice. Elias: "*There are group members with differing skill levels - who notice things at a different time. It might cause a bit of confusion.*" Cognitive and emotional aspects get mixed in these considerations about differing skill levels and gender differences. Ilona seemed to experience that instead of collaborating, they worked more as pairs.

Reflection 2: The group continued the same pondering during reflection. When Ilona mentioned neutrally that it was clearly possible to see different ways of thinking in their group, Elias considered that they had so many different thinkers that he noticed how complicated it is possible to express the things. He described that they had to wait that the others understand. Maria assumed that her thinking was too complicated now and then. Thus, the group identified and described well their different ways of thinking and working that they had experi-

enced challenging. The biggest challenge seemed to be linked to the experience that it was difficult to proceed at the same time.

### Session three

*Experienced challenges:* The third session dealt with spatial thinking. An important point about the interaction during this session was that the group had a remarkable disagreement between Elias and the other three group members. Emotional and communicational challenges were visible during this situation. The situation started when Ilona, Maria and Sami pictured one structure seen on the paper in the same way and started to build it together. Elias was left alone to wonder the others' way of working. He tried to call a teacher, but Ilona stopped him and tried to explain how the picture should be seen. Elias' restless gestures indicated frustration, and his continuous teacher calling pointed out that he was not happy with the others' point of view.

When a teacher finally came to them, Elias said that he felt himself to be the losing side in the group of four and that he was "*a misunderstood genius*". He added that he started to understand the problems of the mathematical genius a couple of centuries ago and admitted that he almost got angry. The teacher told that Elias' point of view was right. The teacher prompted him to advise the others and justify his opinion. As a result, however, the group was amused by the episode. The students laughed at the reaction together and after all commented on the task as "*funny*" and "*fascinating*".

### *Described challenges:*

Check-up 3: Ilona was the only student who described challenges during check-up. Those were other cognitive challenges that they have met during surprisingly challenging tasks. The actual disagreement happened between check-up and reflection phases.

Reflection 3: During reflection, the group focused on describing their disagreement. Ilona laughed that the others hindered Elias in reaching his goal. Elias described that they had a situation that was "*classical one against three*". Sami commented jokingly that "*democracy doesn't work when the people are too stupid*". Elias described his emotions by admitting that he was upset when others saw the building in a different way. Despite that Elias seemed really frustrated during the disagreement, the descriptions during script discussion were humorous. Joking and smiling showed that they were able to describe that disagreement positively without blaming anyone.

*Summary:* Challenges described during scripts varied between sessions. The certain topic was selected in every session based on the students' experiences. In session one, frustration towards the subject and towards using manipulatives was repeated in every script discussion. In session two, script discussions provided a break to consider and describe different ways of thinking and working. In session three, attention was paid only to one challenge that caused remarkable disagreement between Elias and the other group members. These examples show that in spite of describing various challenges, the group ended up discussing one challenge that they obviously had regarded as the most remarkable. On the other hand, only two of four group members lead the discussions and made relevant perceptions. It would have been important to know all group members' opinions, not only those who participated the most actively. As many descriptions as possible would have given more exact information about different learners' challenges in collaboration and possible needs for support. On the other hand, despite challenges and discussions about them, the atmosphere of the group work stayed positive. That may refer to an open dialogic connection that would have made it possible to reveal all kinds of opinions.

However, Group 1 experienced moments of both frustration and success. For a couple of times, the group drifted into a situation that almost turned into a conflict. Group members' argumentation and the need to qualify others' comments, however, lead to further communication and mutually shared cognition. In these situations, it was possible to notice conflicts more as windows of opportunity instead of threats to progress.

## **6 Discussion**

The aim of the current master's thesis was to study challenges in collaborative learning in mathematics by observing video data and by investigating script discussions. The main purpose was to consider what kinds of challenges the groups experience and how do they describe their challenges. This is an important issue to consider from the perspective of teacher education: according to Häkkinen et al. (submitted), research should recognize and elaborate students' challenges in 21<sup>st</sup> century learning skills. Learning to collaborate is highly important among pre-service teachers in order to develop and utilize collaboration skills in the future schools (Häkkinen et al. 2016). Identifying experienced challenges is an important strategic learning skill and ability to handle challenges in collaboration is needed when pursuing good learning outcomes. Thus, challenging situations can be seen as an opportunity to learn (Leman 2010; Van den Bossche et al. 2006).

Students experienced and described different types of challenges during collaborative learning in mathematics. It was possible to observe challenges that were 1) cognitive challenges; 2) challenges in task understanding as a sub-category for cognitive challenges; 3) communication challenges; 4) emotional and motivational challenges; and 5) working challenges. In the following chapters, I will present aspects of both observed and described challenges, consider various factors affecting the results, and suggest a few practical implications and questions for future studies.

### **6.1 Aspects of experienced challenges**

In total, there were 217 challenges that were observed happening during groups' working. Students seemed to experience cognitive challenges the most often (93 observations). Following those, there were challenges related to working (54 observations), emotions and motivation (32 observations), task understanding (20 observations), and communication (18 observations).

The frequencies of observed challenges varied among the groups and sessions. As presented above, Group 1 experienced and described the largest amount of challenges. The high number of cognitive challenges may be explained by the mathematical context that caused challenges and unawareness. Working challenges were mostly related to the difficulties in understanding the others' way of working or hurry to get the tasks finished. Emotional and motivational

challenges usually were expressions of lack of energy or negative feelings towards tasks or learning tools. Challenges in task understanding often demanded asking the teacher for advice. Communication challenges were usually little misunderstandings or inability to listen others' point of views when talking at the same time.

The empirical part of this study showed that severe challenges during collaborative learning situations were relatively rare in most of the groups. Given that working collaboratively means making significant changes to conventional learning styles and that collaboration is difficult to achieve, even more challenges might have been expected to take place. One explanation for quite low frequencies of challenges may be related to the common attempt to avoid challenges and conflicts. Hämäläinen and Häkkinen (2010) noticed that the students seemed to prefer to avoid conflicts and to solve tasks in mutual understanding. In addition, avoiding conflicts was seen in Aarnio's (2015) study about collaborative knowledge construction that showed that conflicts on knowledge were rare among students. He suggests that the low number of conflict episodes may indicate that students avoid bringing up contradictory ideas. Avoidance may result from the negative emotions evoked by conflicts on knowledge (Aarnio 2015). It is common to avoid these kinds of situations that people tend to perceive as a risk to the self and to the relationship (Muller & Perret-Clermont 2009). On the other hand, the participants in the PREP21 -research project knew each other quite well and underlined their good social and conversational skills and openness. As seen earlier, the students expressed also their negative feelings and critical thoughts without hiding their perceptions.

Even though the groups worked at the same tasks, the groups' and individuals' ways of acting and interacting differed. It is noteworthy, that the amount of challenges did not reveal the quality or outcome of the group work. For example, Group 1 experienced the most challenges during group work but progressed continuously and was the only group that finished the tasks every time. Sometimes the external outcome is the same but the degree of understanding differs. Thus, group work and challenges in collaboration can be seen as linked to the situation and context. According to Järvenoja, Järvelä and Malmberg (2015), challenges are specific to time and social context and contextual features can influence learners' cognitive processing, motivation, and well-being. In addition, groups can have their own strategies to overcome a challenge or to avoid it (Järvenoja, Järvelä & Malmberg 2015). On the other hand, a high activity level does not always indicate good collaboration and guarantee satisfaction with the group work (Hämäläinen & Arvaja 2009).

It is interesting to compare the results of this master's thesis to other studies that are similar in some perspectives. For example, Näykki et al. (2014) found that in their study of socio-emotional conflict in collaborative learning in a higher education context, all of the groups experienced challenges in their collaborative tasks. Like in this master's thesis, one group differed from other groups. Näykki et al. (2014) present that students reported cognitive, motivational, socio-emotional, and other challenges. However, the order was different from my work. Näykki et al. (2014) presented the biggest proportion of socio-emotional challenges (41 %) while my observations showed that cognitive challenges were most common.

In line with Koivuniemi et al. (2017), challenges seemed to trigger another type of challenges and appeared together in different areas. For example, cognitive challenges raised often also emotional challenges. According to Koivuniemi et al. (2017), students' self-reports revealed that in collaborative learning, students experienced motivational (34 %), emotional (30 %) and cognitive challenges (23 %) the most often. Challenges in well-being were more rare (7 %). The order is different but with the same kind of categories the study reflects the same kinds of issues than my thesis points out. Interestingly, when comparing individual learning and collaboration, most of the challenges reported by the students were experienced during individual learning (Koivuniemi et al. 2017). The significance of the group was seen also in my data in the situations in which the students mentioned that they would not even have been able to solve the tasks on their own.

Järvenoja and Järvelä (2009) studied socio-emotional challenges during collaborative learning and found teamwork (34.3 %), collaboration (24.3%), work and communication (22.7 %), personal priorities (16 %) and external constraints (2.8 %) as the challenge types reported by the students. Incompatible styles of working or different standards of working seemed to be significant challenges (Järvenoja & Järvelä 2009) and got quite high frequencies also in my analysis.

Bakhtiar, Webster and Hadwin (2017) suggest that their observations of the groups' socio-emotional interactions highlight the importance of communicating in a positive tone and minimizing negative interactions. However, despite attempts to interact positively, the presence of negative interactions may have detrimental effects and cause negative emotions and lower satisfaction. A positive socio-emotional climate requires preparing, engaging, and maintaining shared responsibility to conquer challenging circumstances. (Bakhtiar et al. 2017.) In the data of my master's thesis, having a positive tone and helping each other seemed to be dominant.

The students were mostly willing to support those with lower knowledge and showed shared responsibility.

One noteworthy finding in this master's thesis is that challenges in this context seemed to be more often constructive than negative. Challenging situations lead often to explaining, helping others and discussing together. My general overview and different signs indicated that the students challenged others to validate or to think or work differently. This kind of action might not occur during individual work. More than challenges, challenging situations and interactions that the group work offers may be seen more as opportunities to develop and learn (Van den Bossche et al. 2006; Leman 2010). From group work the students may develop their argumentation technique, critical way of thinking, organizing ability and promote pupils' ability to think for themselves (Hammar Chiriac (2011). According to Van den Bossche et al. (2006), the active use of different views in working on and solving problems may entail a consideration of more alternatives and a richer argumentation, and thereby the nature of communication itself and problem solutions may become more creative. The group will only benefit if disagreement or divergence in meaning leads to further negotiation (Van den Bossche et al. 2006). On the other hand, according to Isohätälä, Näykki, Järvelä, and Baker (2018), spontaneous argumentation can be scarce even when the learning situation is carefully planned and students are familiar with collaborative learning as a pedagogical practice. Isohätälä et al. (2018) suggest that if teachers wish to promote learning through collaborative argumentation, they should pay attention to the goals of collaborative learning. In addition, pedagogical methods for the explicit teaching and practice of arguing respectfully should be developed (Isohätälä et al. 2018).

However, I concluded that the students are required different skills and a certain group composition is needed. These skills are similar to those that are needed in successful collaboration in general. As defined earlier, in collaborative learning individuals need to be able to negotiate, compromise, reconsider, explain, and listen (Baker, 2015; Dillenbourg, 1999; Järvenoja & Järvelä 2009). Näykki et al. (2014) clarify that collaborative learning is not about outperforming others, but about monitoring and directing one's own and one's learning partners' understanding, interests and feelings towards the group, task and content that makes collaborative learning either successful or unsuccessful (Näykki et al. 2014). On the grounds of these kinds of lists and the empirical findings of this study, I can draw a conclusion that it is very demanding to continuously succeed in collaborative learning situations. Collaborative learning is a wide and multidimensional concept and putting it into practice can be challenging.

Thus, it is not very surprising that the groups experience different challenges with regard to working collaboratively. The complexity lies behind the question when challenges give rise to the positive impulses and when they start to cause negative responses and hinder successful collaboration.

## **6.2 Aspects of challenges described during script discussions**

In addition to observing challenges that were experienced during group work, I investigated challenges that the students described during script discussions. Scripts are one way to provide opportunity to identify when learners get stuck and to prompt learners to make challenge episodes visible (Miller & Hadwin 2015). During the orientation, check-up and reflection script phases, the students described cognitive, emotional and motivational, and working challenges. In the whole data, the students mentioned cognitive challenges 34 times, working challenges 33 times and emotional and motivational challenges 20 times during script discussions. In total, the students brought up different challenges 87 times during scripts. The order of the amounts of described challenges is the same that the order of the most often experienced challenges, which means that the discussions reflected the experienced situations.

Described cognitive challenges were expressions of low mathematical skills or concerns that the given tasks are difficult. Working challenges were expressed when the students evaluated their working pace or the different ways to use the manipulatives. Emotional and motivational challenges were mentioned when the students described their feelings toward forthcoming tasks or released them after working together.

All types of challenges that appeared during group work were not discussed during scripts at all. Students did not evaluate challenges with regard to task understanding or communication during script discussions. Challenges with regard to task understanding were not evaluated in scripts possibly because the students got the answer easily by asking a teacher or a researcher for help. A more notable question lies behind the finding that challenges in communication were not discussed during scripts. Reasons for it can be that the challenge type was not very common and communicational challenges did not shape group work or interaction remarkably. Furthermore, it is possible that the students did not regard those situations as challenges. It was notable that the students knew each other, because participation and interaction seemed natural and communication worked well in most of the groups. It can be that the students did not find it essential to describe light communicational challenges. On the other hand, commu-



nication problems can be more difficult to handle when compared to other type of challenges. It is said that face-to-face communication is a very complex and intricate phenomenon (Thibault 2008).

In general, the data showed that students were not very willing to talk about challenges. Analyzing script discussions revealed that the students did not describe their group work and challenges deeply. That can be followed by many reasons. Possible reasons are that the students did not consider script discussions meaningful, they did not judge the challenges as being serious, they did not dare to bring up challenging issues, or they simply did not remember them or there was not enough time. Prepared questions and scripting did not secure fluent and deep discussions even though they would have been a hoped-for result. It would be important that scripts make thinking explicit and available to the rest of the group (King 2007). However, the participation in discussions varied a lot – mostly only a couple of students even took part in them. As stated earlier, most of the challenges that were observed during group work remained without mention during scripts. The students rather focused on describing one or two challenging situations from several perspectives. For example, Group 1 described one challenge in third session from cognitive, emotional and working perspectives. All group members wanted to give their own description of the situation that they regarded as remarkable.

In line with the study of Hämäläinen and Häkkinen (2010), active conflict situations based on critical elaboration were rare in groups - even though that critical elaboration is expected in the ideal script use. Critical discussion would be important when engaging the whole group in the collaboration process and furthering students' understanding about good collaboration (Hämäläinen & Arvaja 2009; Rummel & Spara 2005). On the other hand, maybe the groups did not regard critical thinking during script discussions as the most important task. Instead of focusing on analyzing their learning and collaboration during script discussions, the groups might have felt that their main goal was to complete mathematical tasks. This notification came from the observation that the groups often wanted to return quickly back to the problem solving.

On the other hand, scripted discussions revealed challenges that remained invisible during collaborative learning but were thought aloud during script discussions. I found that this was a useful possibility that scripting can provide. For example, the speculation of the differing skill levels or feelings about falling behind were not expressed until script discussions. I noticed

that scripted discussions gave opportunities to bring up issues that were not spontaneously mentioned during working. Prepared questions forced students to return to the challenging moments and reconsider them. Actually, Howe (2010) reminds that resolutions for differing opinions do not always happen at the time differences are expressed, but that the resolution can take place later. In addition, investigating scripts gave more information about students' thoughts about learning collaboratively. Especially the orientation gave information about the students' emotions, attitudes and previous knowledge.

Script discussions showed that even though there were opposite opinions about working together with the students that have differing skill levels, the general atmosphere stayed positive. For example, Beth mentioned that she was ready to learn from the others' perspective, Sara was happy to mention that working as a team helped them to reach their goal, and Ella stated that they did not have too many challenges while working. Ella's comment refers to a positive perception of the challenges: the students seem to be ready to face a suitable amount of challenges. Thus, script discussions prompted the students to think also positive influences of challenges and it might have helped them to maintain positive interaction despite challenges.

In summary, I found that students may need encouragement to discuss about challenges and information about the importance of identifying and describing them. As mentioned earlier, without identifying challenges there are no chances for solving them and learning about them. In addition, giving and receiving support requires skills to identify and describe challenges. On the other hand, sometimes speaking second language can influence on the ability to take part to discussions. In two groups, there were students who were speaking English as a second language. It might have influenced the participation. Students may need to have time to prepare what they want to say, or they preferred to listen rather than verbally participate (Engin 2017).

Describing challenges can be seen as a part of pre-service teachers' involvement in their own learning. The ability to describe different challenges in collaborative learning can have wide-ranging effects from teacher competence to building collaborative culture in schools. Thus, the skills to describe one's own and the group's challenges in collaboration can prove to be necessary. Lieberman (1992) states that the teacher's involvement in their own learning has powerful effects on students, on the culture of the school and on teachers' own sense of efficacy. When making changes in teaching or the whole school system, it is necessary to be

aware of one's own knowledge and understanding of the critical issues in learning. When pre-service teachers come aware of possible challenges in collaborative learning through their own experience, they have better possibilities to create functional collaborative culture in schools.

### **6.3 Invisible issues behind**

I considered it interesting to suggest what kinds of invisible issues had an effect on individuals' behavior and groups' working. These notifications give new perspectives when considering challenges in collaborative learning in this context. I paid attention to the influences of group dynamics, perspectives of gender and signals of group identity. In the end, I consider the effects of mathematical context.

Students considered and compared their skills. Group 1 mentioned that they were on different levels and that their working was divided. The students explained them on the grounds of the gender differences. In line with Hannula et al. (2005) it seemed that female students perceive themselves to be more hard-working and diligent than male students. On the other hand, there can be differences in self-efficacy. In Group 3, Julia claimed that the others are good at calculations but she is not. Hannula et al. (2005) found gender differences in self-confidence, but not in liking mathematics or perceiving mathematics difficult. In addition, Summers et al. (2005) found that women's tendency to feel more connected in courses using collaborative learning might be a natural reflection of their social connectedness development in general. In addition, according to Leman (2010), beliefs about gender differences in intelligence, education or cognitive ability permeate society. It is difficult to imagine that these commonly held perceptions of gender do not tie in to processes of communication and collaboration in some way or other. (Leman 2010.)

However, individuals and their knowledge and skills are the resources of the group. It is useful to make either good knowledge or insecure feelings obvious before collaborative problem solving. Hesse et al. (2015) mention that collaborative planning needs to include the management of resources. In the case of groups composed of members with different problem-relevant knowledge, the management of resources ideally takes into account that group members share all available information (Hesse et al. 2015). From this viewpoint, it is also fruitful to express if you are insecure of your skills – then the others will know that they should share their information and give support.

According to Cremer and Dijk (2002), how an individual sees his- or herself as a part of a group and the levels of group identity can have a significant influence on group work. In fact, previous research has shown that strengthening group identity promotes collaboration. When people have a strong sense of group identification, their self is defined at the level of the group, rather than at the level of their personal identity. Because of this redefinition of the self, pursuing the group's interest becomes a direct and natural expression of self-interest. That means that collective and personal interests become interchangeable. (Cremer & Dijk 2002.) I suggest that the data showed a sense of group identification. Several groups mentioned that they knew each other well and that they regarded themselves as good collaborators and socially gifted. They mentioned that they could have not been able to complete the task alone and that they were more pleased to solve them together.

Cremer and Dijk (2002) noticed that when confronted with failure, people in the group identity condition started contributing even more, whereas people in the personal identity condition started contributing less. In the data, the students did not withdraw from the task but tried to solve it. For example, in the first session Emma said that she was shocked when the group had completed only task 1a when it was time to start the check-up. Later, she started to contribute more when trying to get their group to move on more efficiently. She possibly felt group identity because she started to contribute more. In addition, Emma might have felt that group failure indicates personal failure. According to Cremer and Dijk (2002), strengthening group identity seemed to increase the value attached to the collective outcome. However, there may also be a personal issue at stake in the sense that group failure indicates personal failure. On the other hand, the primary effect of group identity is to make the collective outcome seem more valuable, which then leads to more contributions. (Cremer & Dijk 2002.)

Group members do not always participate as efficiently as desired. Salomon and Globerson (1989) present the concept of free riders and reasons why some students avoid participating in group work. There is an important difference between two kinds of tasks. In a disjunctive task, the less able member feels useless, becomes unmotivated and uses only little effort. In the conjunctive task, the more able member feels the same way and avoids putting effort to the task. (Salomon & Globerson 1989.) Both perspectives were shown in the data: Elias and Sami in Group 1 did not participate all the time in session one and explained that with saying that they already did the calculations. On the other hand, in Group 5 Beth stayed in the back-

ground because she was “*always confused with math*” and regardless of that statement, the pace of their group working did not slow down.

In the end, the mathematical context obviously had an effect for the results. Cognitive challenges were mostly linked to the mathematical context and they also aroused emotional responses. Low confidence, comparing skills and complex tasks caused problems that were related to mathematics. Collaborative learning in some other subject could have highlighted different meanings to reflect. A few comments revealed a few general challenges concerning mathematical context:

“*Mathematics always arouses frustration.*” (Elias, Group 1, session 1)

“*I am always confused with math.*” (Beth, Group 4, session 1)

“*Mathematics is hard as hell to explain verbally.*” (Riku, Group 2, session 3)

The individuals’ view of mathematics can be seen as a filter that regulates his or her thinking and actions in mathematics-related situations (Pehkonen & Pietilä 2008). The more interested and capable the students are in the subject, the more actively they can be assumed to act. In Group 4, Beth was constantly left aside with her confused feelings about mathematics. That may be the reason why she was not focusing all the time and did not participate in problem solving very actively. In addition, Beth did not have as good language skills as the others in the group, which meant that it was difficult for her to discuss about mathematical issues and influence the pace. According to Engin (2017), learners’ confidence in their language ability is fundamental to their willingness to participate in the interaction.

Hannula, Kaasila, Laine and Pehkonen (2005) found that those who had done well in mathematics held more positive views about themselves and mathematics. In the present data, some of the students were quite insecure about their skills. However, it was interesting to notice that it was possible that mathematically talented students also expressed that they were not sure about succeeding in solving the task. In Group 4, Sara was visibly talented in mathematical thinking, but still she felt suspicious about their group’s possibility to solve tasks in spatial thinking. Thus, insecure feelings were not strictly linked to the real skills. Finally, they succeeded in very well and were satisfied with their performance. According to Pehkonen and Pietilä (2008), when an individual has solved a difficult task, they feel joy and satisfaction because their knowledge and emotions intersect each other.

## 6.4 Practical implications and future studies

It is noteworthy that Finland's new core curriculum places heavy emphasis on a collaborative school culture (Vahtivuori-Hänninen et al. 2014). Familiarization with this subject deepens understanding and gives new perspectives about collaborative learning, mathematical problem solving and possible challenges and contradictions in group action. Learning more about individual learners and groups can instigate people to monitor their own behavior and communication in collaborative learning situations and encourage bringing up also demanding issues to discussions. Collaboration that contains challenges is not bad collaboration at all, but demands awareness about challenges. It is useless to only point out different challenges but they should be considered constructively.

I would like to suggest a few practical implications from the perspective of teacher education. In addition to describing challenges while and after working, groups could benefit by better preparing for learning situations. According to Näykki et al. (2014), it is concluded that if emotions triggered by different kinds of challenges are not well regulated and a collaborative learning situation is not balanced, the situation may turn into a conflict. Thus, the importance of recognizing and responding to socio-emotional challenges in group work is emphasized (Näykki et al. 2014). These findings instigate pondering about whether group members should prepare for collaborative learning situations in a different way than for individual learning settings. Mental and perhaps scholarly preparations that offer awareness of complex collaborative learning situations could help students to prevent hidden challenges in turning into wider challenges or a conflict. Actually, Finnish teacher education is research-based, in which the idea is to connect theory and practice and promote pre-service teachers' reflective thinking. Considering collaboration and regulation skills and learning to analyze one's own and the group's work are essential skills in one's future life as a teacher.

Näykki et al. (2014) suppose that insufficient collaboration and regulation skills can be the reason why groups sometimes create challenges that obstruct their working together. On the grounds of that finding, collaboration and regulation skills would be important issues to handle more carefully already during teacher studies. Because the number of the described challenges remained quite low in this master's thesis, I presume that it is not always easy to neither identify challenges nor to bring up demanding subjects.

In addition, the mathematical context should be taken into account. Collaborative learning in mathematics inevitably reveals students' attitudes to mathematics. According to Pietilä

(2002), it is important to observe pre-service teachers' attitudes to mathematics, because the aim of the teacher education is to educate teachers who are able to identify the limitations of their beliefs and knowledge, and the demands of different situations. This perspective should be taken into account in teacher education. As mentioned earlier, being aware of one's own attitudes and possible challenges can be seen as a part of pre-service teachers' involvement in their own learning and can affect teachers' competence to build collaborative culture in schools.

Finnish school culture is in the middle of changes. Vahtivuori-Hänninen et al. (2014) state that a new viewpoint in the curriculum draft is the importance of discovering joy of learning, which has a dramatically positive effect on student motivation. At the same time, challenges can be regarded as opportunities to develop and learn (Van den Bossche et al. 2006; Leman 2010). It would be worthwhile to assess these two perspectives in teacher education in terms of contemplating and testing them as an effective combination for collaborative learning patterns.

Future studies are needed to deepen and widen this subject concerning collaborative learning. What comes to the data I have been utilizing in this thesis, numerous questions remained without answers. For example, it would have been fascinating to investigate more carefully the situations and moments that stirred challenges; the solutions that were made after challenges; differences in individuals' actions and ways to interact; regulation; or individuals' personal interpretations about events. Challenges cause different influences and responses, and they require reactions and actions from group members. It would have been interesting to study how the challenges influenced on individual learning or group outcomes in practice.

The research design can be expanded with new measures. It would be interesting to choose different context and participants, because pre-service teachers compose a specific and exclusive group. If the participants had been different-aged or they had come from various branches of science, the results might have been different. Future studies in different contexts or different sizes and compositions of the groups could strengthen the validity of the findings. In addition, according to Hadwin, Järvelä and Miller (2017), more empirical research is needed with respect to researching regulation within challenge episodes.

Therefore, more information is needed to understand pre-service teachers' twenty-first century skills and the development of these skills (Valtonen et al. 2016). Collaborative learning will be one of these skills and it is important that pre-service teachers have experience and

knowledge about possible challenges. According to Valtonen et al. (2016), pre-service teachers play an important role in transferring twenty-first century skills into school practice. It means that the skills they develop during teacher education are essential.



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