THE INTERPLAY OF COGNITIVE AND SOCIO-EMOTIONAL PROCESSES IN SOCIAL INTERACTION

PROCESS-ORIENTED ANALYSES OF COLLABORATIVE LEARNING

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Process-oriented analyses of collaborative learning

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Collaborative learning in small groups is a societally relevant but challenging way of learning. It requires a rich understanding of how people think and co-elaborate knowledge together (cognitive processes) and how they feel and relate to each other (socio-emotional processes). The objective of this dissertation is to explore the interplay of cognitive and socio-emotional processes as it manifests in face-to-face social interaction during collaborative learning. The results were derived from qualitative, process-oriented analyses of video-recorded social interactions in two datasets pertaining to small groups of Finnish teacher education students (N=43) who collaborated on mathematics and environmental science tasks. The results are reported in four empirical articles.

The results show that the cognitive and socio-emotional processes fluctuated in the social interactions over the course of collaborative learning. The socio-emotional processes became especially overt and thematic in the social interactions when groups regulated their learning. During such regulation, groups’ metacognitive planning, monitoring, and evaluating could intertwine expressions of emotion, talking about emotions, or giving socio-emotional support. These moments activated group members’ joint participation and allowed them to establish agreement, respond to challenges, and recognize strengths or weaknesses, which were important functions for collaborative learning. At times, the social interaction was more directed toward cognitive processes when group members concentrated on performing task activities. However, the socio-emotional processes were still intertwined with cognitive processes. This dissertation illustrates how a case episode of argumentation proceeded through a series of counterarguments, reformulations, and elaborations, but also involved subtle ways of expressing claims tentatively, showing consideration of divergent claims, and relaxing tension.

This dissertation highlights that cognitive and socio-emotional processes of collaborative learning are continuously intertwined but fluctuate in social interaction. The intertwining gives rise to meaningful functions for collaborative learning. Attempts to support collaborative learning in education or work must acknowledge the interplay of cognitive and socio-emotional processes in social interaction.

Keywords: argumentation, collaborative learning, regulation, social interaction, teacher education, video analysis
Isohätälä, Jaana, Kognitiiviset ja sosioemotionaaliset prosessit vuorovaikutuksessa. Havaintoja yhteisöllisestä oppimisesta
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Tiivistelmä
Yhteisöllinen oppiminen pienryhmissä on yhteiskunnallisesti merkittävä mutta haastava oppimisen muoto. Se vaatii ymmärrystä siitä, miten ihmiset ajattelevat ja käsittelevät tietoa yhdessä (kognitiiviset prosessit) sekä mitä he tuntevat ja miten tulevat toimeen yhdessä (sosioemotionaaliset prosessit). Tämän väitöskirjan tavoite on tarkastella, miten nämä kognitiiviset ja sosioemotionaaliset prosessit ilmenevät pienryhmien kasvokkaisessa vuorovaikutuksessa yhteisöllisen oppimisen aikana. Tulokset perustuvat videoaineiston prosessiorientoituneeseen, laadulliseen analyysiin. Tutkimuksessa havainnoidaan kahdesta tutkimusaineisesta suomalaisen luokanopettajapiskelijoiden ($N=43$) vuorovaikutusta, kun he työskentelevät pienryhmissä matematiikan ja ympäristöopin tehtävissä. Tutkimuksen tulokset julkaistaan elävänä empiirisessä tutkimusartikkeliin.


Asiasanat: argumentaatio, oppettajankoulutus, oppimisen säätely, videoanalyysi, vuorovaikutus, yhteisöllinen oppiminen
Acknowledgments

It was a strike of good luck that I got the opportunity to complete my doctoral research and degree at the Learning and Educational Technology (LET) research unit at the University of Oulu. In 2014, I graduated as a Master of Arts in Finnish language at the Faculty of Humanities in Oulu. I had previously completed pedagogical studies as a subject teacher in Finnish language and literature, but before coming to the LET research unit, I did not have a background in the learning sciences. Luckily, I came across an interesting opportunity to work as a research assistant in the LET—the team that gave me a warm welcome and sparked my curiosity in research on collaborative learning. Before one year had passed in my role as a research assistant, the LET announced an opportunity to start my doctoral studies in the PREP21 project, funded by the Academy of Finland. As I had dreamt of pursuing a doctoral degree one day, I seized the opportunity. Later on, I got wonderful news: I had received a four-year doctoral researcher position from the human sciences Eudaimonia Institute of the University of Oulu. These opportunities have made this dissertation possible.

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In Oulu, May 4, 2020

Jaana Isohätälä
List of original publications

This dissertation is based on the following publications, which are referred to throughout the text by their Roman numerals:


Abstract

Tiivistelmä

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1 Introduction

People’s ability to collaborate and learn together in small groups is having a growing influence on their success in education and work in the modern knowledge society. It is widely agreed that the societal needs of the 21st century challenge people’s abilities to learn, communicate, collaborate, and think critically (Binkley et al., 2012). According to the Organisation for Economic Co-operation and Development (2018), future populations of students will need to be more skillful than ever to engage in learning and collaboration, among others. This echoes the Future of Jobs Report (World Economic Forum, 2018), which states that people need to be equipped with the abilities to skillfully engage in social interaction, decision-making, and reasoning in social settings. Similarly, the Rethinking Education Report (European Commission, 2012) highlights the importance of people’s transversal abilities to work collaboratively, in addition to critical thinking and problem-solving.

People’s abilities to engage in social interaction, learning, and collaboration are important because collaboration is seen as a source of innovative value creation in a society by allowing people to draw on existing knowledge from multiple people to create new knowledge (Organisation for Economic Co-operation and Development, 2018). In the Finnish context, too, the importance of collaboration and learning is emphasized. The national curriculum (Opetushallitus, 2014) highlights that learning environments and practices in schools must promote children’s participation in social interaction and the construction of knowledge with others. The curriculum emphasizes that throughout their basic education, children must learn to interact respectfully with different people, share responsibilities, and bring divergent ideas together.

The necessity to pay attention to how people learn with others is justified by the fact that collaborative learning is by no means a simple process. While learning on one’s own requires complex mental processes, such as information retrieval, management of attentional resources, and metacognitive awareness (Nathan & Sawyer, 2014), learning with others necessitates that individuals engage in social interaction in a social setting. In this social setting, one’s words, gestures, and actions influence the reactions of others (Baker, 2015; Resnick, 1991). This means that the progress of learning cannot be shaped by individuals alone. Rather, collaborative learning is an interactive, emergent process, which is more than simply the sum of individual learners’ actions and thoughts (Dillenbourg, Baker, Blaye & O’Malley, 1996; Stahl, 2006). Participating in social interaction demands
that learners jointly co-elaborate knowledge, coordinate their activities, and foster cohesion and mutual respect (Barron, 2003; P. A. Kirschner & Erkens, 2013; Sinha, Rogat, Adams-Wiggins & Hmelo-Silver, 2015). In reviewing research on thinking together and alone, Deanna Kuhn (2015) aptly summarizes as follows: “Collaboration entails demanding, resource-consuming skills of coordination … as well as affective, interpersonal ones” (p. 51). Indeed, the complexity of learning processes is multiplied by the social and interactive dimensions involved in collaborative learning.

Examining the processes involved in collaborative learning is not a new endeavor, but it is one that has received growing interest in the learning sciences especially since the 1990s (Dillenbourg, Järvelä & Fischer, 2009; Stahl, Koschmann & Suthers, 2014). Research on collaborative learning is motivated by the notion that the quality of collaborative learning can dramatically vary: at best, learning with others is exciting and rewarding, but oftentimes it can be tedious, conflictual, or fruitless (Barron, 2003; Linnenbrink-Garcia, Rogat & Koskey, 2011; Näykki, Järvelä, Kirschner & Järvenoja, 2014). A thorough understanding of the complexities of learning with others is needed so that people can be guided toward more efficient and enjoyable collaborative learning for the benefit of today’s knowledge society. Given the growing prominence of learning and collaboration as prerequisites for individual and collective success, research is still needed to address blind spots in the theoretical understanding of how people can efficiently and enjoyably learn together. Next, I will introduce three challenges that are particularly topical in research on collaborative learning and clarify how I address those challenges in this dissertation.

First, research on collaborative learning has struggled with providing a multidimensional understanding of collaborative learning—namely, an understanding that not only acknowledges cognitive processes, which relate to how people co-elaborate knowledge together, but also socio-emotional processes, which relate to how they feel and relate to each other (Kreijns, Kirschner & Jochems, 2003; Kreijns, Kirschner & Vermeulen, 2013). When you think about your everyday experiences of learning in a group, do you recall only the topic and what new perspectives you learned from others or also how you felt during the collaboration and how others behaved toward you? You will most likely have perceptions of both aspects. This is because cognitive and socio-emotional processes equally play a role in collaborative learning (P. A. Kirschner & Erkens, 2013; Kreijns et al., 2003; Ludvigsen, 2016). However, until the 2010s, research on the cognitive processes in collaborative learning was overrepresented in comparison to research on the socio-
emotional processes (Dillenbourg et al., 2009). Due to this imbalance, researchers today aim to create a more multidimensional understanding of collaborative learning by integrating evidence of both the cognitive and socio-emotional processes of collaborative learning (Baker, Andriessen & Järvelä, 2013; Phielix, Prins, Kirschner, Erkens & Jaspers, 2011; Van den Bossche, Gijselaers, Segers & Kirschner, 2006). This trend is seen in the objective of this dissertation, which is to explore the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning. This dissertation advances prior research by not only acknowledging the close relationship between cognitive and socio-emotional processes but by concretely illustrating their interplay in social interaction and their function in collaborative learning.

The second topical challenge in conducting research on collaborative learning is acknowledging the significance of time. Collaborative learning is not a static phenomenon but one that evolves according to situation-specific demands. The course of collaborative learning is shaped by each moment, be it one of confusion, of accomplishment, or of conflict. Thus, the research has been increasingly directed at understanding collaborative learning as a process that evolves temporally rather than as something that can be captured solely by questionnaires or test scores (Fischer & Järvelä, 2014; Janssen, Erkens, Kirschner & Kanselaar, 2010). This trend of process-oriented research already began when researchers began showing more interest in the dynamics of social interaction in collaborative learning and highlighting how collaborative learning evolves as a series of exchanges (Dillenbourg et al., 1996). However, process-oriented research methods are still developing and gaining importance (Azevedo, 2014; Molenaar & Järvelä, 2014). This trend is visible in the methods of this dissertation. The empirical investigation is based on video observations of social interactions, which I analyze with attention to how and when cognitive and socio-emotional processes emerge in social interactions and how they intertwine at particular moments. Thus, I view collaborative learning as a systemic phenomenon that unfolds in social interaction (Nathan & Sawyer, 2014). This approach is important because it highlights that collaborative learning is not static or predictable. Rather, collaborative learning situations are unique processes in which group members share the responsibility of creating collaborative learning through their social interaction.

This brings me to the third challenge of collaborative learning research: acknowledging the richness of social interaction. As Kreijns et al. (2003) note, social interaction is the key to collaborative learning, but understanding the complexities of social interaction is elusive. It is impossible to give a recipe of what
one needs to say to ensure effective and enjoyable collaborative learning, because isolated turns of talk are only pieces of a much larger puzzle. Social interaction is about the situated meanings that arise when people reciprocally participate in social interaction and co-elaborate each other’s contributions (Lund, 2019). The meanings that arise in social interaction are not only a sum of the meanings of individual words (Baker, 2015). Instead, meanings are created by the content of people’s speech acts, the nonverbal features that accompany speech acts, the pragmatic functions that speech acts serve, and the exchanges that occur during series of speech acts. Attempts to support people in collaborating more effectively or enjoyably must acknowledge this richness of social interaction. Thus, the current dissertation provides evidence of the intricate characteristics of social interaction in collaborative learning. Due to my background of completing a Master’s degree in Finnish language, social interaction is a particularly fascinating topic to me as a researcher. The strength of this dissertation is that I investigate the intricate characteristics of social interaction by following a microgenetic and systemic approach, which demonstrates in detail how meanings are created in reciprocal social interactions (Chinn & Sherin, 2014; Nathan & Sawyer, 2014).

In sum, this dissertation contributes to the literature by shedding light on the multidimensional, temporally unfolding, and interactive nature of collaborative learning. The empirical results stem from a specific setting and target group: the collaborative learning that takes place among Finnish teacher education students performing mathematics and environmental science tasks. Teacher education students are an important target group because they will be the ones helping children develop their abilities to learn and collaborate according to the demands of the 21st century (Hesse, Care, Buder, Sassenberg & Griffin, 2015), and they will need collaborative learning skills in their own work in school communities (Vescio, Ross & Adams, 2008; Willman, 2001). Häkkinen et al. (2017) note that teacher education can be a powerful channel for triggering long-term change in education by developing new teaching and assessment methods that will help people succeed in the knowledge society. Finnish teacher education students may perceive themselves as having good skills in collaboration (Valtonen et al., 2017), but observing them in authentic learning situations can highlight how they actually collaborate. This dissertation contributes empirical evidence of how teacher education students engage in collaborative learning. However, the aim of this dissertation is not to make general interpretations of teacher education students as such. Rather, the target group and context provide a set of authentic cases of social interaction in collaborative learning, which I will use to explore the main
phenomenon of interest: the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning.
2 Theoretical framework

This dissertation presents research on **collaborative learning**. In short, this refers to co-present individuals attempting to learn together (Dillenbourg, 1999). The objective of this dissertation is to explore the interplay of cognitive and socio-emotional processes as they manifest in face-to-face social interaction during collaborative learning, as shown in Figure 1. Collaborative learning comprises **cognitive processes**, which involve thinking and co-elaborating knowledge, and **socio-emotional processes**, concerning the formation of groups’ social and emotional relations (Kreijns et al., 2003). These processes are partly internal, operating in learners’ minds and emotions. However, they also emerge within **social interaction**, manifesting between individuals in their encounters (Goffman, 1983). The focus of this study is on the cognitive and socio-emotional processes that are observable in social interaction. The theoretical premise of this dissertation is that cognitive and socio-emotional processes are not independent of each other but emerge in relation to each other in social interaction (Kreijns et al., 2003). In other words, the processes of thinking and co-elaborating knowledge are influenced by the formation of groups’ social and emotional relations, and vice versa. I refer to this relation as the **interplay** of cognitive and socio-emotional processes.

![Fig. 1. Cognitive and socio-emotional processes in social interaction.](image)

C O L L A B O R A T I V E L E A R N I N G

**Cognitive processes**

**Regulation in social interaction**

**PARTICIPATION IN SOCIAL INTERACTION**

**Argumentation**

**Socio-em. processes**
Although the interplay of cognitive and socio-emotional processes in social interaction is acknowledged in the literature on collaborative learning, thus far, it has been insufficiently addressed in empirical research (Baker et al., 2013; P. A. Kirschner & Erkens, 2013; Ludvigsen, 2016). The interplay of cognitive and socio-emotional processes in social interaction is an important topic to investigate because prior research suggests that the way cognitive and socio-emotional processes unfold in social interaction will influence how effective and enjoyable collaborative learning is (e.g., Barron, 2003; Näykki et al., 2014; Sinha et al., 2015). Thus, if the long-term goal of research is to provide ways to support collaborative learning, it is necessary to create a comprehensive understanding of how both cognitive and socio-emotional processes manifest in social interaction and how they relate to each other. I will examine this topic from the following three perspectives.

First, I will examine how learners in small groups participate in cognitive and socio-emotional processes in social interaction. Participation is crucial to examine because it is the infrastructure that carries social interaction and enables collaboration (E. G. Cohen, 1994; Jordan & Henderson, 1995). However, it is not a given that people participate jointly in social interaction or that they remain engaged (Barron, 2000; Määttä, Järvenoja & Järvelä, 2012; Roschelle & Teasley, 1995). Rather, people’s level of participation in social interaction fluctuates, but few studies illustrate how or why this happens. I am interested in how fluctuations in participation in groups relate to the cognitive and socio-emotional processes in social interaction. Achieving this first aim will provide a broad view of the interplay between cognitive and socio-emotional processes as they manifest in social interaction.

Second, I will zoom in on the details of social interaction by investigating how cognitive and socio-emotional processes intertwine in two types of social interactions: regulation and argumentation. Regulation in social interaction refers to the verbalized planning, monitoring, and evaluation of learning, which allow learners to strategically regulate their learning processes (Hadwin, Järvelä & Miller, 2018). Argumentation refers to the critical discussion of divergent ideas, which can help group members recognize new perspectives and negotiate novel solutions to problems (Asterhan & Schwarz, 2016). I have chosen to investigate regulation and argumentation in social interaction because both are important aspects in reaching effective and enjoyable collaborative learning: argumentation promotes deeper understanding of domain knowledge (Andriessen & Baker, 2014), while regulation allows for strategically overcoming challenges in collaborative learning (Järvelä &
However, from a multidimensional perspective, the current understanding of regulation and argumentation in collaborative learning is limited. Regulation and argumentation have been shown to involve cognitive and socio-emotional processes (e.g., Polo, Lund, Plantin & Niccolai, 2016; Rogat & Linnenbrink-Garcia, 2011), but the research has predominantly investigated cognitive processes. There is less, but growing, research showing that socio-emotional processes play an important role in regulation in social interaction and argumentation. Thus, a multidimensional approach is needed to create evidence-based methods to support more effective and enjoyable collaborative learning. The novelty of this dissertation is its detailed attention to both cognitive and socio-emotional processes and their intertwining during moments of regulation and argumentation in social interaction.

Finally, I will examine what function cognitive and socio-emotional processes in social interaction serve for collaborative learning. By function, I refer to the situation-specific purpose that an exchange has in social interaction, such as the function of confirming the direction of a group’s activities (Iiskala, Volet, Lehtinen & Vauras, 2015). Functions are not embedded in the meaning of uttered words alone but are performed through meanings that arise in a social interaction. Functions are important because they will play a role in how collaborative learning unfolds and can potentially support more efficient or enjoyable collaborative learning. For example, an exchange may function as a means to sustain ongoing activity or to change that activity (Iiskala et al., 2015; Ucan & Webb, 2015). In this dissertation, I argue that if social interaction intertwines cognitive and socio-emotional processes, it is logical that both processes will have a mutual influence in constructing the functions that emerge in the social interaction. However, prior studies may have neglected the role of socio-emotional processes in creating functions in social interaction. Thus, I aim to shed light on how functions are created through the intertwining of cognitive and socio-emotional processes in social interaction.

In the following sub-chapters, I will introduce the theoretical grounding and key concepts of this dissertation in detail. I will begin with a review of the socio-cognitive theory, after which I will define the key concepts of collaborative learning, social interaction, participation, and cognitive and socio-emotional processes. Lastly, I will introduce what prior literature reveals about cognitive and socio-emotional processes during regulation and argumentation in social interaction during collaborative learning.
2.1 Socio-cognitive theory

This dissertation leans on the socio-cognitive theory of human cognition and learning. The socio-cognitive theory sees human functioning as the result of the continuous, reciprocal influence of personal, environmental, and behavioral factors (Usher & Schunk, 2018). People are seen as agentic actors that are able to direct their activities and adapt to the needs of a situation, but they are also continuously in a reciprocal relation with their environment, influencing and being influenced by external affordances and constraints. Compared to other theories, such as the socio-cultural theory (Danish & Gresalfi, 2018), distributed cognition (Salomon, 1993), or situated learning (Lave, 1991), the socio-cognitive theory is more oriented toward the individual and their cognitive, motivational, emotional, and behavioral processes. However, socio-cognitive theory is also interested in how people engage with others and their environment and how these complex social encounters impact individuals.

Guided by the socio-cognitive theory, I focus my inquiry on collaborative learning. I see collaborative learning as one type of complex social encounter, which brings together agentic individuals who participate in social interaction and engage in joint efforts to learn about a topic. Thus, the approach of this dissertation matches the collaboration-for-proximal-outcomes approach, which is one of four approaches for analyzing collaboration (Enyedy & Stevens, 2014). In line with the collaboration-for-proximal-outcomes approach, I examine how collaborative learning unfolds from moment to moment, leading to the emergence of new states within the collaboration that can distally influence individual learning, though the latter is not the focus of my inquiry.

Research on collaborative learning entails a well-established but theoretically and methodologically diverse set of research frameworks. Collaborative learning research does not represent a theory of learning in itself but consists of frameworks in which different targets of inquiry and theoretical underpinnings co-exist to explain learning processes within a social, collaborative context (Jeong & Hartley, 2018; O’Donnell & Hmelo-Silver, 2013). In this dissertation, I draw from three frameworks that have examined collaborative learning: the field of computer supported collaborative learning, research on regulated learning in collaboration, and the argumentation for learning framework.

The central framework for this dissertation is the field of computer-supported collaborative learning (hereafter CSCL), which has grown from cognitive science, social psychology, the learning sciences, and informatics (Stahl, 2013; Stahl et al.,
This framework can be roughly divided into two strands: one focusing on collaborative learning processes as such and one focusing on computer-supported tools to support collaborative learning. This dissertation leans toward the former approach, but the whole CSCL framework offers theoretical and empirical grounding. This framework provides a multidimensional view of collaborative learning, which involves cognitive and socio-emotional processes that are influenced by social interaction (Kreijns et al., 2003). This dissertation focuses especially on social interaction as the medium in which cognitive and socio-emotional processes are shaped, albeit acknowledging that social interaction does not capture cognitive and socio-emotional processes as whole.

I especially ground my research in the interactions paradigm of CSCL research (Dillenbourg et al., 1996). The interactions paradigm emerged in the 1990s and shifted the research focus from the conditions of collaboration and individuals’ behavior in groups to considering the group itself as a unit of analysis and exploring the emergent, socially constructed properties of social interaction (Dillenbourg et al., 1996). In this paradigm, social interaction is the process through which group members co-construct mutually shared cognition—that is, an agreed-on interpretation of the situation through the negotiation of propositions (Baker, 1995). This approach does not deny the existence of individual mental representations but focuses its inquiry on social interaction as a manifestation of thinking with others (Baker, 2015). The units of analysis are episodes of social interaction, which cannot be reduced to individual contributions alone but emerge and gain their meaning in social interaction through reciprocal acts of verbal and nonverbal communication. This approach does not assert the existence of a “group mind” or collective thinking that is separate from social interaction (Stahl, 2016); rather, the social interaction itself carries processes of thinking with others, reflecting theories of dialogue (Allwood, 1997).

In addition to CSCL, this dissertation is grounded in research on regulated learning in collaboration (Järvelä, Hadwin, Malmberg & Miller, 2018; Winne, Hadwin & Perry, 2013). This framework stems from the socio-cognitive theory of self-regulated learning and theories of cognition and metacognition (Schunk & Greene, 2018) and examines how learners engage in a cyclical regulation of their own, others’, and the group’s cognition, motivation, emotion, and behavior in collaborative learning (Hadwin et al., 2018). This dissertation elaborates research that has explored how regulation manifests in social interaction (e.g., De Backer, Van Keer & Valcke, 2015; Näykki, Järvenoja, Järvelä & Kirschner, 2017; Rogat & Linnenbrink-Garcia, 2011; Volet, Summers & Thurman, 2009) and what role it
plays in collaborative learning (e.g., Iiskala et al., 2015; Järvenoja & Järvelä, 2013; Lajoie et al., 2015; Ucan & Webb, 2015). This dissertation does not capture the inner processes of regulation nor provide detailed accounts of the phases, targets, or strategies of regulation. Rather, it focuses on collaborative learning and, within that, examines regulation as one central type of social interaction. Regulation in social interaction is an important component of collaborative learning because it allows group members to optimize their learning processes according to situation-specific demands (Hadwin et al., 2018). This dissertation examines how moments of regulation in social interaction intertwine cognitive and socio-emotional processes of collaborative learning and what functions such moments serve for collaborative learning.

The third notable framework in this dissertation is the argumentation for learning framework, which is inspired by the theory of argumentation and theories of learning and dialogue (Andriessen & Baker, 2014; Asterhan & Schwarz, 2016). Research using this framework examines how argumentation emerges in social interaction and how it influences learning processes and outcomes. In the context of collaborative learning, arguing to learn is viewed as a collaborative, rather than competitive, practice (Andriessen & Baker, 2014), which is both cognitive and emotional in nature (Plantin, 2004; Polo et al., 2016). Similar to my perspective of regulation in social interaction, I approach argumentation from the point of view of collaborative learning and study it as an important type of social interaction because it allows people to jointly deepen their understanding of their topic by engaging in critical debate (Baker, 1999; Osborne, 2010; Weinberger & Fischer, 2006). I will enrich prior research by illustrating how argumentation in social interaction involves not only cognitive processes but also socio-emotional processes of collaborative learning.

In sum, I ground my research in socio-cognitive theory, but I focus specifically on social interaction in collaborative learning with the help of three research frameworks. In combining these perspectives, I wish to create a richer view of social interaction in collaborative learning. This is also a trend in research on collaborative learning in general. Increasingly, researchers are attempting to bridge related fields of inquiry by drawing ideas and concepts from one another to holistically improve their understanding of how groups of people collaborate (Suthers, 2013). Though completely reconciling different analytical and interpretative approaches to understand collaborative learning may be impossible (Wise & Schwarz, 2017), interactions between different theoretical and
methodological backgrounds are considered beneficial for scientific progress (Fischer & Järvelä, 2014; Suthers, 2013).

2.2 Collaborative learning

Broadly, collaborative learning refers to situations where two or more individuals learn or attempt to learn something together (Dillenbourg, 1999). According to the classic definition of Roschelle and Teasley (1995), collaborative learning refers to the participants’ mutually engaged and coordinated effort, resulting in a continued attempt to construct and maintain a shared conception of a problem. These definitions are short but imply several criteria: (1) collaborative learning must involve several participants, (2) participants must show mutual and coordinated rather than dissociated effort toward learning, and (3) the participants must work on a shared task rather than individual tasks.

To further define collaborative learning, it is important to specify what is meant by “collaborative.” Collaboration is not achieved simply by putting individuals to work in a group (Kuhn, 2015; Miyake & Kirschner, 2014; Roschelle & Teasley, 1995). To stress that all situations of learning together are not actually collaborative, Dillenbourg (1999) distinguishes between collaborative and cooperative learning. Collaboration entails that participants share a collaborative situation, meaning that they perform the same actions, have a common goal, and work together to achieve that goal. In addition, collaboration means that participants interact collaboratively, meaning that they reciprocally influence each other and that their interaction involves negotiation (Dillenbourg & Baker, 1996). Cooperation, in turn, may involve a shared task, but participants may not actually share a collaborative situation or collaborative interaction but, instead, split the work and work individually until they collect their individual contributions (Dillenbourg, 1999). According to Baker (2015), cooperative learning may involve elements of collaboration, such as having a joint task, but genuine collaboration goes further than simply sharing tasks or actions; rather, collaborative learning involves sharing ideas, understandings, or representations. Thus, collaborative learning extends from sharing information to negotiating meanings (Baker, 1995), which makes it possible to co-construct shared representations of a problem within the social interaction that occurs (Roschelle & Teasley, 1995).

Barron’s (2000, 2003) studies illustrate differences in the degree of collaboration or cooperation in two groups of children. One group showed mutuality of exchanges, joint attention, and alignment of group members’ goals by,
for example, co-constructing solutions, referencing others’ ideas, jointly monitoring their work, and respecting the norms of turn-taking. This group showed evidence of collaborating. The other showed problems in achieving collaboration by following independent solution paths, referencing and insisting on one’s own ideas, and violating the norms of turn-taking. This evidence emphasizes that not all group work is collaboration and, thus, the term collaboration should not be used loosely to label any situation in which learners work together (Wise & Schwarz, 2017).

In addition to understanding what is collaborative, it is important to define what is meant by “learning” in collaborative learning. As was presented in the previous sub-chapter, there are different theoretical stances on learning and cognition. This dissertation leans on the socio-cognitive stance: collaboration is a social setting, which invites individual cognitive processes that can facilitate learning (Stahl, 2013; Usher & Schunk, 2018). Social interaction is a venue for constructing group-level cognitive processes, which can ultimately change individual schemas, for example, through individual conceptual change (Asterhan & Schwarz, 2009). Dillenbourg (1999) also highlights that collaborative learning does not equal or guarantee individual learning; rather, participants can learn through collaboration if they engage in activities that trigger learning mechanisms. In other words, an interaction involving, for example, explaining or disagreeing may foster individual cognitive learning mechanisms, such as internalization or induction (Dillenbourg, 1999).

Empirical evidence exists of the benefits of collaborative learning for individual cognitive development. For example, in Howe and Zachariou’s (2017) study, group dialogue involving differing opinions was beneficial for individual group members’ post-test performance among adolescents and young adults. Similarly, Webb et al. (2014) observe that the achievement of 8–10-year-old students was positively linked to the students’ engagement with each other’s ideas and providing explanations of their problem-solving strategies. Schwarz, Neuman, and Biezuner (2000) find that social interaction regarding a mathematics task among students with low levels of competence and incorrect ideas could actually help these students correct their misconceptions. F. Kirschner et al. (2009b), in turn, report that collaborative learning was more efficient than individual learning when students worked on complex tasks.

Despite the positive evidence of benefits, collaborative learning is not a “silver bullet,” as Kuhn (2015) notes. Many studies exploring collaborative learning have not proven that collaboration is superior to individual learning, and there are several
factors, such as task type, group members’ characteristics, and quality of interaction, that influence whether or not collaborative learning leads to individual learning gains (Kuhn, 2015). According to F. Kirschner et al.’s (2009b) findings, collaboration did not lead to more learning gains than individual working when the task was simple. Kapur (2008), in turn, shows that ill-structured problems caused groups to struggle and produce poor quality solutions, though some knowledge gain was evident later on. Furthermore, Sears and Reagin (2013) find that their participants’ ability influenced the degree of benefits from collaborative learning: higher-ability students were more successful at working individually, while lower-ability students, for whom the same problem was more difficult, showed more learning gains in groups than individually.

Many other studies have revealed that the characteristics of social interaction are crucial for the progress and outcomes of collaborative learning: groups can potentially achieve better results in collaborative learning if they are able to interact constructively (Barron, 2003; Damsa, Ludvigsen & Andriessen, 2013), jointly focus on the task (Barron, 2000), deepen their understanding through collaborating ideas (Andriessen, Pardijs & Baker, 2013; Sampson & Clark, 2011), and regulate their learning to optimize their collaborative learning process (Khosa & Volet, 2014; Näykki, Järvenoja, et al., 2017; Volet et al., 2009). In contrast, groups may fail to genuinely collaborate and foster individual learning gains if they disengage from the task (Sohr, Gupta & Elby, 2018), resort to achieving quick consensus (Weinberger & Fischer, 2006), or fall into socio-emotional conflict (Näykki et al., 2014). As social interaction is an important factor in determining how collaborative learning is shaped, it is also the core theme of this dissertation and elaborated further in the next sub-chapter.

2.3 Social interaction in collaborative learning

Social interaction is a key concept in this dissertation. However, it is difficult to find a clear-cut definition of social interaction, despite the importance of this concept across several disciplines, such as sociology, social psychology, linguistics, and the learning sciences. Common definitions of social interaction stem especially from sociology and social psychology (e.g., Goffman, 1983). Social interaction is seen as “that which uniquely transpires in social situations, that is, environments in which two or more individuals are physically in one another’s response presence” (Goffman, 1983, p. 2). Social interaction involves combinations of speech and nonverbal elements, such as gaze, posture, facial expressions, movements, and tone
of voice (Argyle, 1969). These elements become ordered into unique sequences, which create meanings and serve a multitude of purposes (Gagahan, 1984; Maynard & Turowetz, 2013). Social interaction is a wide concept, which can be examined from many perspectives and within many types of social encounters, ranging from small groups to organizations. Here, I focus on social interaction among small groups during collaborative learning.

In line with prior research on collaborative learning, I examine social interaction as people’s temporally unfolding verbal and nonverbal exchanges in small groups as they attempt to learn together. In collaborative learning, social interaction is the key resource for people to engage in joint processes of thinking in order to learn. According to Kreijns et al. (2003), “if there is collaboration then social interaction can be found in it, and vice versa, if there is no social interaction then there is also no real collaboration” (p. 338). Baker (2015) stresses that collaborative learning is centered on cognitive-linguistic processes of co-elaboration and negotiation of meanings, which are not merely accomplished through words but include aspects of non-verbal communication, such as posture, movement, gestures, and prosody. Furthermore, social interaction cannot be captured from isolated turns of talk. Instead, social interaction is formed by sequences of utterance–response pairs (adjacency pair; Schegloff, 2007) or moves and acts, which form exchanges that further make up series of transactions (Sinclair & Coulthard, 1992).

Baker (2015) highlights that for understanding collaborative learning, it is necessary to understand the interactive processes by which learning is potentially afforded. Social interaction in collaborative learning is an affordance for positive learning mechanisms to occur when individuals share and elaborate divergent perspectives and extend their thinking and knowledge beyond individual capabilities (Dillenbourg, 1999). Based on a review of prior empirical work, Chi and Wylie (2014) theorize that the potential for learning increases as students move from passive to active to constructive and, ultimately, to interactive activities, which involve an increasing degree of knowledge change processes afforded by social interaction. Similarly, Scardamalia and Bereiter (2014) emphasize that dialogue is the essence of collaborative knowledge creation—that is, advancing from one shared knowledge state to a more advanced knowledge state—as knowledge creation between individuals cannot occur without dialogue taking

1 Dialogue is not necessarily synonymous with social interaction, but the scope of this dissertation does not allow for a thorough conceptual discussion.
place. Thus, it is crucial that people who are attempting to learn together participate in social interaction and engage in types of social interaction that facilitate their learning. In the next sub-chapters, I will clarify what I mean by “participation” and introduce how two core processes of collaborative learning—namely, cognitive and socio-emotional processes—emerge in social interaction.

### 2.3.1 Participation

Participation provides the infrastructure through which individuals can collaborate and coordinate their joint efforts (Jordan & Henderson, 1995). Participation in social interaction refers to the basic components of communication: contributing to exchanges with communicative acts, providing evidence of attention and understanding, and responding to others’ communicative acts (H. H. Clark & Brennan, 1991; H. H. Clark & Schaefer, 1989; Sacks, Schegloff & Jefferson, 1974). These reciprocal communicative acts make up exchanges of interaction, which in their simplest form involve person A initiating a communicative act and person B responding to this act (Bara, 2011), reflecting Schegloff’s (2007) idea of utterance–response or adjacency pairs. However, participation is not only about speech: bodily alignment and eye contact, for example, also characterize how mutually engaged or disengaged people are (Jordan & Henderson, 1995). In his definitions of social interaction, Goffman (1983) notes that “the involvement of the participants—if only their attention—is critical” (p. 3), indicating that the mere presence of a person is a form of participation in social interaction.

In terms of collaborative learning, two characteristics of participation are important to consider. First, learners’ participation should be directed toward a shared task. Collaborative learning involves the idea that learners are focused on something to be learned, be it problem-solving skills or conceptual knowledge related to a domain. Thus, learners’ participation needs to be centered on the topic to be learned, though off-task interaction may also occur. Task-focused participation allows learners to co-elaborate ideas and construct knowledge from divergent perspectives (Baker, 2009), enabling them to learn about the topic. If group members completely withdraw from participating in social interaction, they cannot use each other as resources for learning (Baker & Bielaczyc, 1995) or make use of the affordances of learning as a group (H. H. Clark & Brennan, 1991). Furthermore, if learners focus too much on social and off-task activities at the expense of engaging with the task, they may be distracted from their goal of
learning (Janssen et al., 2010). Thus, participation in social interaction is an infrastructure that enables groups to think together and co-elaborate knowledge.

Second, collaborative learning entails that participation in social interaction is joint\textsuperscript{2}, thus engaging the whole group. By definition, collaborative learning requires that learners co-elaborate their understandings to construct knowledge and build shared understandings together, rather than individually (Barron, 2003; Dillenbourg & Baker, 1996; Roschelle & Teasley, 1995). Thus, collaborative learning necessarily involves joint participation in task-focused social interaction (E. G. Cohen, 1994; Dillenbourg, 1999). Joint participation can be characterized as group-level behavioral engagement in which the whole group is involved in a group activity and is focused on their task and each other’s contributions (Sinha et al., 2015). Learners’ activities and attention may occasionally diverge during the course of collaborative learning, even in coordinated collaboration, but they must regularly converge to sustain mutually engaged and coordinated effort (Barron, 2000; Roschelle & Teasley, 1995).

However, joint participation is not self-evident when people work together (Miyake & Kirschner, 2014). Common hindrances to collaboration include dominance (Dembo & McAuliffe, 1987), social loafing (Hämäläinen & Arvaja, 2009; Karau & Williams, 1993; Latané, Williams & Harkins, 1979), or free-riding (Kerr & Bruun, 1983; Salomon & Globerson, 1989). Furthermore, the degree of joint participation may also change during the course of collaborative learning due to challenges, such as socio-emotional conflicts, that cause all or some learners to disengage (Linnenbrink-Garcia et al., 2011; Näykki et al., 2014). This suggests that participation in social interaction not only relates to how group members think and co-elaborate knowledge but also to how group members feel and relate to each other. Thus, I posit that participation in social interaction can shed light on both the cognitive and socio-emotional processes of collaborative learning, which I will introduce next.

\textsuperscript{2} According to Merriam-Webster Dictionary, the adjective joint can be defined as “common to two or more,” such as involving the united activity of two or more. In the literature, researchers have also referred to equal participation (e.g., Janssen, Erkens, Kanselaar & Jaspers, 2007), which also refers to participation by all group members, but may also suggest the idea of equal roles and equal levels of participation by group members. As the empirical articles in this dissertation do not provide evidence of the equality of participation in collaborative learning, I refer to joint participation.
2.3.2 Cognitive and socio-emotional processes

According to Kreijns et al. (2003, 2013), the purpose of social interaction is to construct two core processes of collaborative learning: (1) cognitive processes and (2) socio-emotional processes (see Figure 2). These two broad categories include a variety of processes, some of which are internal and some of which manifest in social interaction. I will first introduce both types of processes, after which I will focus on how cognitive and socio-emotional processes emerge in social interaction, which is the theme of this dissertation.

In Kreijns et al.’s (2003) model (see Figure 2), cognitive processes of collaborative learning refer to processes of thinking and co-elaborating knowledge as a group, where the outcome is learning content that is educationally purposeful for the learners. Cognitive processes relate to the educational dimension of collaborative learning and involve the learners’ efforts toward deepening their understanding through thinking, reasoning, and co-elaborating knowledge. Though not explicitly mentioned by Kreijns et al. (2003), I argue that cognitive processes also involve...
metacognitive processes—namely, groups’ efforts to plan, monitor, control, and evaluate their learning—which learners use to optimize their ability to co-elaborate knowledge and learn as a group (Hadwin et al., 2018; P. A. Kirschner & Erkens, 2013). Many of these cognitive processes, including metacognitive ones, are individual and internal to people’s psychological, cognitive mechanisms (Dillenbourg, 1999; Zimmerman, 2002). However, as Kreijns et al. (2003) note, evidence suggests that cognitive processes that are necessary for individual learning also emerge in social interaction. Thus, cognitive processes can be considered to manifest within social interaction when groups share and co-elaborate knowledge (Baker, 1995; Miyake & Kirschner, 2014; Van den Bossche et al., 2006) and when they regulate their learning as a group (Hadwin et al., 2018).

Socio-emotional processes refer to processes of forming a group and ways of interacting in the group (Kreijns et al., 2003). Kreijns et al. (2003) define socio-emotional processes as processes of getting to know each other, committing to social relationships, developing trust and belonging, and building a sense of community. In other words, socio-emotional processes involve the ways in which learners interact and relate to each other and how they feel about their collaboration (Baker et al., 2013; Barron, 2003; Janssen et al., 2010; Kreijns et al., 2003). Similar to cognitive processes, socio-emotional processes involve individual, inner processes, such as beliefs about the social context (Van den Bossche et al., 2006) and people’s emotions, which can be defined as intense personal reactions that arise in response to situations or thoughts (Boekaerts & Pekrun, 2016; Frijda, 1988). However, socio-emotional processes also arguably emerge in social interaction, for example, in the way that students express their emotions during the social interaction (Cahour, 2013; Peräkylä & Ruusuvuori, 2012), regulate their emotions as a group (Järvenoja & Järvelä, 2013; Näykki et al., 2014), or express themselves toward each other (Asterhan, 2013; Damsa et al., 2013).

The Kreijns et al.’s (2003) model resembles similar distinctions between cognitive and socio-emotional processes of collaborative learning. Some distinctions are two-dimensional: Barron (2003) distinguishes between the content and relational space of collaborative learning, which are similar to cognitive and socio-emotional processes, and Van den Bossche et al. (2006) present a model of effective collaborative learning, also distinguishing between social and cognitive factors. Some researchers have distinguished three dimensions. Baker et al. (2013) and Ludvigsen (2016) refer to the cognitive, social, and affective/emotional dimensions of collaborative learning, whereas P. A. Kirschner and Erkens (2013) distinguish between cognitive, social, and motivational levels of learning. In
addition, socio-emotional processes have been conceptualized using similar terms, including social and relational aspects (Damsa et al., 2013; Janssen et al., 2010), group processes (Rogat & Linnenbrink-Garcia, 2011), socio-relational and affective dimensions (Baker et al., 2013), and social and behavioral engagement (Sinha et al., 2015). Though the conceptualizations vary, and a full review of the differences is beyond the scope of this dissertation, researchers consistently highlight that collaborative learning is multidimensional, involving cognitive, social, and emotional dimensions, with the latter two being considered as separate or joint dimensions. The multitude of concepts underlines the fact that research on this issue is still in progress.

I have chosen the model developed by Kreijns et al. (2003; see Figure 2) as the theoretical basis of this dissertation because, unlike many others, this model clearly highlights the central role of social interaction within collaborative learning. The model also underlines that cognitive and socio-emotional dimensions are not states of being but processes that continuously take shape during the course of collaborative learning. Furthermore, though theoretical distinctions between cognitive and socio-emotional processes are appealingly simple, Kreijns et al. (2003) aptly illustrate the reciprocity of the elements involved and the dynamic development that takes place in collaborative learning. Their model emphasizes that social interaction influences both cognitive and socio-emotional processes of collaborative learning, which, in turn, can reinforce the social interaction. Further, cognitive and socio-emotional processes lead to learning and social performance, which feeds back into the cognitive and socio-emotional processes.

To briefly elaborate Kreijns et al.’s (2003) model, I would like to address the fact that the model seemingly positions social interaction as separate from cognitive and socio-emotional processes. However, I argue that cognitive and socio-emotional processes can be positioned so that they partly emerge within social interaction (see Figure 1). With this positioning, I stress that cognitive and socio-emotional processes are not solely internal mental or emotional processes but are also emergent processes that are constructed during a social interaction (Dillenbourg et al., 1996). In other words, the social interaction can serve as the venue in which cognitive and socio-emotional processes emerge at the group level (Baker, 2015; Baker et al., 2013; Stahl, 2006), which can potentially influence individual, inner, cognitive, and emotional processes (Bakhtiar, Webster & Hadwin, 2018; Dillenbourg, 1999) that, in turn, feed back into the social interaction. Furthermore, I argue that cognitive and socio-emotional processes that emerge during a social interaction are closely related and intertwined. However, empirical
accounts of social interaction in collaborative learning have seldom addressed how this intertwining manifests (Ludvigsen, 2016), though such research is emerging and showing that the interplay of cognitive and socio-emotional processes plays a meaningful role for collaborative learning (Baker et al., 2013). The current dissertation addresses this research gap by specifically exploring the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning. Next, I will present prior research on the cognitive processes and socio-emotional processes in social interaction separately, acknowledging that distinguishing between the two is not straightforward. I will then discuss the interplay of these two processes in social interaction.

**Cognitive processes in social interaction**

Research on social interaction in collaborative learning has mainly concentrated on cognitive processes of collaborative learning (Järvelä, 2012). In prior research, cognitive processes in social interaction have been examined as domain-focused or metacognitive-level interactions among group members working on a collaborative task (Järvelä, Järvenoja, Malmberg, Isohätälä & Sobocinski, 2016). In this dissertation, I also examine cognitive processes from the point of view of domain-focused or metacognitive-level interactions because the former perspective is important for understanding how people engage in learning, and the latter for how they optimize their learning processes. Thus, I will briefly review prior research on both aspects.

Domain-focused interaction consists of externalizing ideas related to domain knowledge and opening them for co-elaboration, ultimately constructing knowledge from divergent perspectives (Baker, 2009). Domain knowledge refers to the body of knowledge as possessed by a recognized social group of experts and extends to conceptual representations of the domain-focused knowledge (Baker, 1999). Social interaction about domain knowledge has been thoroughly studied (Hmelo-Silver & Barrows, 2008; Roschelle, 1992; Webb, Troper & Fall, 1995). Knowledge co-construction, or knowledge building (e.g., Damso et al., 2013; Hmelo-Silver, 2003; Law & Wong, 2013; Scardamalia & Bereiter, 2014), and argumentation (e.g., Kuhn, Zillmer, Crowell & Zavala, 2013; Sampson & Clark, 2011; Stegmann, Wecker, Weinberger & Fischer, 2012) are among the common concepts that have been used to study cognitive processes related to domain knowledge. Work around these concepts has especially concentrated on how learners co-elaborate knowledge. Such interaction has been considered important
for collaborative learning because it allows students to make use of the affordances of learning as a group by pooling knowledge from multiple people and improving understandings together (H. H. Clark & Brennan, 1991).

For example, in their classic work, Roschelle and Teasley (1995) illustrate the construction of knowledge with a case dyad of 15-year-old boys in statistics. The study illustrates the process of constructing and maintaining a “Joint Problem Space” through the coordinated production of talk and action, including narrations, questions, socially distributed productions, and repairs. Beers, Boshuizen, Kirschner, and Gijselaers (2005) theorize that social interaction affords the construction of knowledge through externalizing, internalizing, negotiating, and integrating knowledge, which is achieved through various pragmatic functions, such as clarifying, rejecting, agreeing, and disagreeing. Hmelo-Silver (2003) presents a fine-grained turn-by-turn analysis, whereby she examines how sequences of sharing knowledge, questioning, responding, among others, allowed students to negotiate joint understanding of a task and create collaborative explanations. Weinberger and Fischer (2006) introduce a framework of argumentative knowledge construction, characterizing types of argumentative moves and how learners refer to their learning partners’ contributions. In their framework, argumentation is seen to deepen learners’ understanding because students subject each other’s contributions to critique rather than simply accepting them at face value (Weinberger & Fischer, 2006). These studies demonstrate how cognitive processes related to domain knowledge emerge in social interaction. However, later (see Sub-chapter 2.5), I will return to discussing how social interaction concerning domain knowledge, particularly during argumentation, not only involves cognitive processes but socio-emotional ones as well.

Another type of social interaction that constructs group-level cognitive processes, specifically metacognitive processes, relates to interaction about group members’ thinking and understanding (e.g., Khosa & Volet, 2014; Lee, O’Donnell & Rogat, 2014; Näykki, Järvenoja, et al., 2017), which is also a central element of this dissertation. Such interaction includes verbalized planning, monitoring the conditions and progress of collaborative learning, or evaluating performance, which are part of regulating learning during collaborative learning (Iiskala, Vauras, Lehtinen & Salonen, 2011; Khosa & Volet, 2014; Näykki, Järvenoja, et al., 2017). What differentiates metacognitive interaction from domain-focused interaction is the target of knowledge. According to Järvelä and Hadwin (2013), regulation does not target domain knowledge but knowledge about the collaborative learning process, such as knowledge of tasks, strategies, goals, and group, and knowledge
of the self, the collective, and each other’s beliefs, feelings, and motivations. Regulation occurs in collaborative learning when learners plan, monitor, and evaluate their own learning as well as the joint learning efforts of the group (Järvelä & Hadwin, 2013).

Social interaction plays a crucial role in helping learners metacognitively regulate their learning together (e.g., Khosa & Volet, 2014; Kwon, Hong & Laffey, 2013; Lee et al., 2014; Näykki, Järvenoja, et al., 2017). Social interaction allows learners to externalize and discuss regulatory initiations, as illustrated by an increasing number of studies. For example, Iiskala, Vauras, and Lehtinen (2004) and Iiskala, Vauras, Lehtinen, and Salonen (2011) demonstrate why metacognition should not only be understood as an individual phenomenon but also as an interindividual one. They show how regulation manifested in social interactions when students externalized their metacognitive thinking and elaborated each other’s utterances, which allowed them to facilitate ongoing learning activities or inhibit activities that were not conducive to reaching a solution to the problem at hand. Several other studies support and illustrate this (De Backer et al., 2015; Hurme, Merenluoto & Järvelä, 2009; Järvenoja & Järvelä, 2013; Ucan & Webb, 2015; Volet et al., 2009). However, it should be noted that social interaction does not account for regulation in its entirety: regulation also involves individual mental processes that originate in learners’ intentions, beliefs, and past socio-historical experiences (Hadwin et al., 2018). Furthermore, regulation in social interaction not only includes cognitive processes but socio-emotional ones as well, as I will discuss in further detail later (see Sub-chapter 2.4).

In this dissertation, I examine how cognitive processes manifest in social interaction by identifying both metacognitive and domain-focused interactions that occur during collaborative learning. In Article I, I broadly refer to both as cognitive interaction. In Articles II and III, I focus on metacognitive interaction from the perspective of regulation in social interaction, and in Article IV, I concentrate on domain-focused interaction from the perspective of argumentation. However, as prior research on collaborative learning has extensively probed into cognitive processes, I aim to extend the literature by also examining how socio-emotional processes intertwine with cognitive ones. Thus, I will next introduce how socio-

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4 Of note, I characterize argumentation as domain-focused, because the argumentative interaction analyzed in Article IV is focused on debating over the content to be learned. However, argumentation also involves metacognitive knowledge about how arguments are formed, or what is the value of argumentation, for example, but this may not be explicitly addressed in social interaction.
emotional processes manifest in social interaction and return later to discussing the interplay of cognitive and socio-emotional processes.

**Socio-emotional processes in social interaction**

In recent years, researchers have begun showing more interest in investigating how the socio-emotional processes of collaborative learning manifest and are shaped by social interaction (Baker et al., 2013; P. A. Kirschner & Erkens, 2013). This is important because social interaction is the means for learners to build trust with each other and increase or decrease their sense of belonging to the group. Studies suggest that a respectful and cohesive social interaction fosters learners’ ability to work together (Barron, 2003; Mullins, Deiglmayr & Spada, 2013; Roschelle & Teasley, 1995; Sinha et al., 2015). However, groups may struggle to achieve a respectful and cohesive social interaction, which can limit their ability to learn with each other (e.g., Barron, 2003; Näykki et al., 2014).

In recent literature on collaborative learning, especially in the regulated learning in collaboration framework, socio-emotional processes in social interaction have often been investigated with the concept of *socio-emotional interaction*, which I also use in this dissertation. Socio-emotional interaction has been defined as interaction that involves overt expressions of emotion or talking about emotions or motivation (Järvelä et al., 2016; Rogat & Adams-Wiggins, 2015; Rogat & Linnenbrink-Garcia, 2011). According to Bakhtiar et al. (2018), socio-emotional interaction includes purposeful interchanges among group members that shape perceptions of emotions and the socio-emotional climate—that is, the general perception of the quality of socio-emotional processes in a group. Socio-emotional interaction is not entirely distinct from interaction relating to cognitive processes, since the socio-emotional interaction can also target the content to be learned (e.g., when a learner expresses emotion provoked by a task) or metacognitive awareness of the learning process (e.g., when a learner positively evaluates the group’s performance). However, socio-emotional interaction additionally involves overt or explicit expressions of emotion or ways of communicating that shape the socio-emotional climate of the group (Järvelä et al., 2016). As such, socio-emotional interaction plays a part in forming socio-emotional processes in collaborative learning, though these processes also include less overt factors, such as individual learners’ emotions.

A classic categorization reflecting the concept of socio-emotional interaction stems from Bales’s (1950) interaction process analysis (IPA) scheme, which
distinguishes between turns of talk in the “task area” and “socio-emotional area,” which include positive reactions (showing solidarity, showing tension release, showing agreement) and negative reactions (showing disagreement, showing tension, showing antagonism). The IPA scheme stems from social psychology and has been used in research on small groups in many fields. In research on collaborative learning, investigations into socio-emotional interaction reflect Bales’s categorizations. Socio-emotional interaction has been operationalized in several ways, often distinguishing between positive and negative socio-emotional interactions (Linnenbrink-Garcia et al., 2011). For example, Rogat and Linnenbrink-Garcia (2011) and Sinha et al. (2015) characterize positive socio-emotional interaction as active listening and respect, inclusion, and group cohesion, while negative interaction as undermining others’ contributions, putting down or ignoring others, and conveying that the group does not work as a team. Lajoie et al. (2015) consider positive socio-emotional interaction to include expressions of emotions, showing respect, polite disagreement, complimenting, encouraging contributions, expressing appreciation, and referring to the group as “we.” They consider negative interaction to include a lack of active listening, showing distractive behavior, and negative criticism. Similarly, Bakhtiar et al. (2018) examine positive socio-emotional interaction as signs of apologizing, humor or laughter, encouraging participation and motivation, and promoting trust and cohesion among group members. They define negative interaction as discouraging participation, emphasizing the individual over the group, and pressuring others.

The literature review reveals that the concept of socio-emotional interaction has been used in many ways and a uniform understanding of the concept has yet to be established. Nevertheless, previous studies suggest that socio-emotional interaction plays a role in the progress of collaborative learning and is closely related to cognitive processes. After studying a case group of 7th graders, Sinha et al. (2015) report that positive socio-emotional interaction and on-task participation fostered high quality regulation, which further facilitated high quality interaction related to domain knowledge. Bakhtiar et al. (2018) reveal that negative socio-emotional interaction and emotions constrained a group from productively adapting to challenges, while positive socio-emotional interaction effectively created and maintained a positive climate for collaborating. Näykki et al. (2014), in turn, illustrate how negative interaction created socio-emotional conflict, which ultimately reduced students’ on-task engagement. However, positive socio-emotional interaction is not always beneficial and negative, detrimental. Focusing only on social activities, such as positive interaction, may cause a group to miss
opportunities to learn if the group fails to engage with the task (Janssen et al., 2010). In addition, negative emotions may be beneficial when they are sparked by challenging tasks (Andriessen, Baker & van der Puil, 2011; Polo et al., 2016). However, positive interaction can help manage and relieve tension created by challenges and negative socio-emotional interaction (Andriessen et al., 2013).

Despite the recent popularity of the concept of socio-emotional interaction, there are other angles from which to examine how the socio-emotional processes of collaborative learning manifest in social interaction. Overt or explicit socio-emotional interaction, such as apologizing or providing socio-emotional support, may be clearer, and thus easier, to observe, but they are not the only means by which socio-emotional processes manifest in social interaction during collaborative learning. Social interaction also offers more subtle ways to shape the socio-emotional climate. For example, the hedging of claims (Lakoff, 1972) may be a means to manage the tone of social interaction during collaborative learning (Asterhan, 2013; Damsa et al., 2013). Furthermore, nonverbal means, such as facial expressions, can be a crucial part of managing emotions in social interaction (Peräkylä & Ruusuvuori, 2012). Thus, even when there is no intense expression of emotion, socio-emotional processes are continuously shaped by how learners express themselves through verbal and nonverbal means.

In this dissertation, I examine how socio-emotional processes manifest in social interaction in two ways. In Articles I–IV, I use the concept of socio-emotional interaction to identify when emotions are overtly expressed or explicitly discussed, or when social interaction is used to shape perceptions of the socio-emotional climate. In addition, in Article IV, I examine the more subtle means by which the socio-emotional processes are shaped in social interaction. Further, in all empirical articles, I extend the approach to explore how socio-emotional processes intertwine with cognitive processes in social interaction.

**Interplay of cognitive and socio-emotional processes**

In the previous two sub-chapters, I reviewed how cognitive and socio-emotional processes manifest in social interaction according to prior literature. Both processes include distinct characteristics. For example, co-elaboration of knowledge portrays cognitive processes and explicit expressions of emotion portray socio-emotional processes. This justifies the theoretical division of cognitive and socio-emotional processes. Nevertheless, I argue that, in practice, it is not possible to provide a dichotomist distinction between social interaction that is either only portraying
cognitive processes or socio-emotional processes. For example, I argue that an episode of co-elaborating knowledge as a group will always intertwine at least some subtle (e.g., hedging) or explicit (e.g., emotional expression) means that shape the socio-emotional processes of collaborative learning. This reflects Kreijns et al.’s (2003) model, which emphasizes that collaborative learning cannot be reduced to cognitive processes or socio-emotional processes alone; instead, they function together as they emerge in social interaction.

Prior research shows that the emergence of social interaction related to cognitive processes, such as co-elaboration or attempts to regulate learning (Baker, 1999; King, 2002; Volet et al., 2009), is influenced by social interaction that fosters favorable socio-emotional processes—namely, the group’s ability to sustain a cohesive, mutually respectful social interaction (Andriessen et al., 2011; Barron, 2003; Rogat & Adams-Wiggins, 2015; Sinha et al., 2015; Ucan & Webb, 2015). In contrast, neglecting social interaction that fosters favorable socio-emotional processes may cause trouble in productively engaging with the content to be learned (Barron, 2003; Näykki et al., 2014). This evidence highlights that social interaction in collaborative learning involves an interplay of cognitive and socio-emotional processes. However, empirical studies evidencing this interplay are scarce, especially considering the robustness of research on cognitive processes of collaborative learning in social interaction (Baker et al., 2013; Järvelä, 2012; Ludvigsen, 2016). Studies tend to focus either on cognitive or socio-emotional processes in social interaction. Further, studies may summarize information about cognitive and socio-emotional processes in social interaction (Rogat & Linnenbrink-Garcia, 2011; Sinha et al., 2015), but provide little information about how these temporally emerge in the progress of collaborative learning and how they intertwine in specific moments of social interaction.

To address the gaps in our current understanding of collaborative learning, this dissertation illustrates how cognitive and socio-emotional processes manifest during the temporal progress of collaborative learning, how these processes intertwine, and what function these processes serve for collaborative learning. I will zoom in on the intertwining of cognitive and socio-emotional processes in two types of social interaction: regulation and argumentation. I have chosen to investigate regulation and argumentation because they are both important types of social interaction for groups to achieve better learning outcomes (Andriessen & Baker, 2014; Hadwin et al., 2018). However, even though both regulation and argumentation have been shown to involve cognitive and socio-emotional processes, the research has emphasized the former at the expense of the latter.
more multidimensional understanding is needed because, if cognitive and socio-emotional processes are interrelated, analyzing cognitive processes alone is not sufficient to address how collaborative learning unfolds.

2.4 Regulation in social interaction

The research on regulated learning in collaboration stems from self-regulated learning theory. Self-regulated learning refers to the strategic, cyclical planning, monitoring, control, and evaluation of the cognitive, behavioral, motivational, and emotional conditions of learning (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2000). Prior research on self-regulated learning has shown that learners benefit from regulating their learning to optimize their efforts according to situation-specific needs (Zimmerman, 2000). However, in collaborative learning, regulation is not only the responsibility of individuals; the group as a whole can regulate their joint learning by planning, monitoring, and evaluating the learning (Hadwin, Järvelä & Miller, 2011; Hadwin & Oshige, 2011).

Over the past decade, several concepts have been used to examine the characteristics of regulation emerging in social situations, including socially shared regulation of learning (hereafter SSRL), socially shared metacognitive regulation, socially shared metacognition, shared regulation, collective regulation, collaborative regulation, and co-regulation (Hadwin et al., 2018). In this dissertation, I use the term regulation in social interaction to refer to students’ verbalized planning, monitoring, and evaluation of their learning efforts during collaborative learning. I have chosen this concept to emphasize that this dissertation focuses on regulation observed in social interaction. In Article II, I also refer to a more specific type of regulation in social interaction—namely, SSRL. SSRL is a group-level phenomenon where students collectively negotiate and align common perceptions of the collaborative learning process and take control of the task through shared and negotiated, iterative fine-tuning of the cognitive, behavioral, motivational, and emotional conditions (Hadwin et al., 2018; Järvelä & Hadwin, 2013). SSRL as a phenomenon is not captured as a whole in this dissertation; rather, the manifestations of SSRL in social interaction are examined to observe how learners negotiate and align perceptions of collaborative processes through verbal and nonverbal interactions. Thus, the approach is similar to that of Järvenoja and Järvelä (2011), who describe SSRL as a transactive phenomenon manifested through multiple learners’ multiple connected utterances, which alone might not be
defined as regulation but which gain their regulatory meaning as part of a longer exchange.

Previous studies have examined the characteristics of regulation in social interaction and their influence on the progress and outcomes of collaborative learning. For example, studies have illustrated that regulation can have a positive role in supporting high-level knowledge construction (Khosa & Volet, 2014; Ucan & Webb, 2015; Volet et al., 2009), supporting group performance (Saab, van Joolingen & van Hout-Wolters, 2012; Valtonen et al., 2017), directing cognitive efforts (Iiskala et al., 2015; Molenaar & Chiu, 2014), and reducing feelings of difficulty (Hurme et al., 2009). These studies have especially focused on the cognitive processes involved in regulation in social interaction, including metacognitive planning or monitoring, because regulating learning is an intentional metacognitive process (Hadwin et al., 2018).

However, research on regulation in collaborative learning suggests that regulation in social interaction is also closely tied to the socio-emotional processes of collaborative learning (Bakhtiar et al., 2018; Järvenoja & Järvelä, 2013; Näykki et al., 2014; Rogat & Linnenbrink-Garcia, 2011). This is natural, as regulation can target motivation and emotions (Hadwin et al., 2018). For example, studies indicate that talking about feelings aroused by a task or collaboration may help learners become aware of others’ emotions and stimulate the regulation of emotions at the group level (Järvenoja & Järvelä, 2013; Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen & Häkkinen, 2017; Näykki et al., 2014). The regulation of emotion in social interaction, in turn, can help learners manage or even restore a sound socio-emotional climate for collaborative learning (Bakhtiar et al., 2018; Järvenoja & Järvelä, 2013; Ucan & Webb, 2015). Thus, studies indicate that regulation in social interaction relates to socio-emotional interaction in collaborative learning (Kwon, Liu & Johnson, 2014; Rogat & Adams-Wiggins, 2015; Rogat & Linnenbrink-Garcia, 2011; Ucan & Webb, 2015). Regulation also seems to relate to the degree of joint participation in the social interaction, which may also indicate how cohesively the group is collaborating (Grau & Whitebread, 2012; Rogat & Linnenbrink-Garcia, 2011; Volet et al., 2009).

As an example, Rogat and Linnenbrink-Garcia (2011) find that higher quality regulation among upper-elementary students was promoted by students’ positive socio-emotional interaction—namely, signs of joint listening and respect, inclusion, and group cohesion. Kwon et al. (2014) show that more successful groups of undergraduates exhibited more adaptive regulatory behaviors and in more positive socio-emotional interactions, defined as encouragement and attempts to convey of
a sense of community. Ucan and Webb (2015) suggest that attentive listening and openness to divergent ideas fostered episodes of shared regulation in social interaction among primary school students. Sinha et al. (2015) present a holistic view: productive collaborative engagement comprises active, task-focused participation and positive socio-emotional interaction as well as regulatory strategies and domain-focused learning efforts. These results highlight that regulation in social interaction involves an interplay of cognitive and socio-emotional processes, but the empirical evidence is mostly based on summarized information rather than on temporal emergence or the intertwining of the two.

Some recent studies have further elaborated the findings regarding regulation and socio-emotional interaction by addressing how these elements emerge over time in relation to each other. Lajoie et al. (2015) observe that medical students’ moments of evaluation often involved positive socio-emotional interaction, such as complimenting. Järvelä, Järvenoja, et al. (2016) recognize that socio-emotional interaction, such as discussions about motivation, were connected to moments of planning and orienting toward a task. Bakhtiar et al. (2018) suggest that negative emotions during a challenge constrained adapting to the challenge, while encouragement and motivational statements served as strategies for creating a positive socio-emotional climate.

Previous findings indicate that groups that regulate their learning during collaboration seem to interact more positively and have better opportunities to learn. Thus, regulation in social interaction seems relevant for both the cognitive and socio-emotional processes of collaborative learning (Järvelä & Hadwin, 2013). Some studies further illustrate how socio-emotional processes manifest in moments of regulation in social interaction, for example, as expressions of emotion, but detailed descriptions of this intertwining are scarce. Thus, more research is needed to shed light on how both cognitive and socio-emotional processes are shaped during regulation in social interaction. To this end, I examine how cognitive and socio-emotional processes intertwine during regulation in social interaction and what functions such moments serve for collaborative learning. However, it would be inadequate to only examine cognitive and socio-emotional processes during regulation when groups negotiate how they are learning and overlook how groups engage with the domain-specific content to be learned. Thus, I also examine the intertwining of cognitive and socio-emotional processes during moments when learners engage with domain knowledge—that is, during argumentation.
2.5 Argumentation

According to Baker (1999), argumentation in collaborative learning can be defined as “verbal communicative interaction in which the dialectical dimension is present” (p. 182). This “dialectical dimension” refers to Barth and Krabbe’s (1982) theorization of argumentation as game-like dialogue, in which participants—the proponent and the opponent—debate over a thesis. The objective of the debate is to come to an agreement on the outcome, and possibly even determine who has won or lost. This debate includes justifications, reinforcements, rebuttals, contradictions, or counterclaims, which function as “defenses” and “attacks.”

Another definition of argumentation comes from Van Eemeren, Grootendorst, and Henkemans (1996): “Argumentation is a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judge” (p. 5).

Studies show that argumentation can be an effective way of learning as a group (Asterhan & Schwarz, 2009; D. B. Clark & Sampson, 2008; Felton, Garcia-Mila & Gilabert, 2009; Yeh & She, 2010) because argumentation enables the recognition of multiple views and fosters discussion about opposing ideas (Kuhn, Shaw & Felton, 1997). This can facilitate recognizing and resolving discrepancies in one’s own and others’ understandings (Nussbaum & Sinatra, 2003). Thus, argumentation can broaden, deepen, and refine understanding by fostering justification, negotiation of meaning, and change of opinion (Baker, 2009). As such, argumentation for learning differs from simple consensual knowledge construction, where learners’ interaction may involve expanding, elaborating, and explaining ideas, but does not include challenging and critically evaluating ideas.

Argumentation is seen as a way to increase socio-cognitive conflict in which learners are confronted with divergent or incompatible views (Mugny & Doise, 1978). By weighing and integrating the divergent perspectives, learners can resolve the socio-cognitive conflict, which can potentially lead to individual learning (Andriessen, Baker & Suthers, 2003; Leitão, 2000; Nastasi & Clements, 1992).

The definition of argumentation in collaborative learning as a critical debate over divergent perspectives emphasizes the cognitive nature of argumentation, encompassing reasoning, co-elaboration, and negotiation (Asterhan & Schwarz, 2016; Baker, 2009; Osborne, 2010). However, argumentation is also emotional (Polo et al., 2016), as it can involve irritation, anxiety, joy, empathy, or other affective feelings (Gilbert, 2004; Martinovski & Mao, 2009; Plantin, 2004).
Contemporary research on argumentation suggests that dispute or victory need not be the goal of argumentation, even though divergent opinions are critically evaluated. Instead of disputative argumentation, argumentation should be deliberative (Felton et al., 2009; Felton, Garcia-Mila, Villarroel & Gilabert, 2015), co-constructive, critical argumentation (Asterhan, 2013), meaning that the interaction is characterized by a willingness to listen and critically examine different ideas, make concessions, collaborate and show mutual respect, and focus on issues rather than positions (Asterhan, 2013; Asterhan & Schwarz, 2016). Andriessen and Baker (2014) call this type of argumentation collaborative argumentation, where learners critically reason together to improve their understanding.

Research suggests that argumentation does not solely involve cognitive processes but equally involves the socio-emotional processes of collaborative learning. Polo et al. (2016) model the role of emotions in argumentation in collaborative learning situations. They suggest that interaction with a low-intensity emotional framing is connected to consensual engagement with others, while interaction with a high-intensity emotional framing is connected to more competitive engagement. Neither is necessarily optimal for learning; rather, interaction with moderate emotional framing is connected to constructively critical engagement, reflecting a deliberative or collaborative type of argumentation, which is considered beneficial for learning (Andriessen et al., 2013; Asterhan, 2013; Felton et al., 2009, 2015). Goldberg and Schwarz (2016) agree that emotions can be a fruitful part of argumentation if they can be harnessed for critical and productive interaction. However, achieving an optimal socio-emotional climate in a group is a challenging task. Argumentative debates can spark intense reactions, which can result in socio-emotional tension (Andriessen et al., 2011; Asterhan & Babichenko, 2015). Insensitivity to others during critical discussions can also threaten the face of participants in the discussion (Brown & Levinson, 1987; Muntigl & Turnbull, 1998). However, if students avoid confrontation and tension, they may also miss opportunities to recognize and debate over divergent perspectives (Andriessen et al., 2013; Baker & Bielaczyc, 1995; Weinberger & Fischer, 2006).

So far, only a few studies have illustrated how argumentation portrays the cognitive and socio-emotional processes of collaborative learning in social interaction. Andriessen et al. (2011) were among the first to integrate notions of socio-emotional processes of learners’ interaction in the analysis of argumentation in collaborative learning. Their study illustrates how two students fluctuated
between moments of more intense argumentation, which increased tension, and moments of tension relaxation, which helped the dyad sustain a favorable socio-emotional climate. Andriessen et al. (2013) also provide evidence of more optimal and less optimal tension moderation: the interaction in a triad of 13-year-old boys showed more optimal moments in which the group engaged in high-quality argumentation with a clear sense of trust, and less optimal moments, in which the group engaged in off-task discussions or uncritical consensus building at the expense of argumentation.

Asterhan (2013) further present how to examine argumentation in collaborative learning from the socio-emotional perspective. She suggests that important markers in social interaction include attempts to convey collaborative intent (e.g., first-person plural pronouns), attempts to maintain positive relationships (e.g., encouragement), actions that reduce face threats during disagreements (e.g., using hypothetical propositions), and ego-reducing moves (e.g., hedging [Lakoff, 1972], acknowledging others’ contributions, humor), though she does not illustrate these in an empirical analysis of social interaction. The set of markers that Asterhan presents draws inspiration especially from research on politeness and face work in learning settings (e.g., Brummennhenrich & Jucks, 2013; Watson, Wilson, Drew & Thompson, 2016). Some of these markers, such as encouragement and humor, fit the definition of socio-emotional interaction, while others include more subtle ways in which claims are expressed.

In sum, the literature suggests that argumentation in collaborative learning is characterized by a precarious equilibrium between engaging in critical discussion and sustaining a favorable socio-emotional climate for such critical discussion. Nevertheless, empirical evidence from examinations of how this interplay manifests in social interaction is limited because the research on argumentation has focused more on the cognitive processes involved in argumentation. However, I argue that cognitive processes are not separate from socio-emotional processes and, thus, understanding argumentation in collaborative learning necessitates analyzing both cognitive and socio-emotional processes and their interplay.
3 Aim

Collaborative learning is a societally relevant but challenging task. A rich understanding of collaborative learning is needed to support people’s ability to engage in efficient and enjoyable collaborative learning. This dissertation enriches the current understanding of collaborative learning by shedding light on the multidimensional, temporally unfolding, and interactive nature of collaborative learning. My objective is to explore the interplay of cognitive processes, related to how people co-elaborate knowledge, and socio-emotional processes, related to how people feel and relate to each other (Kreijns et al., 2003). I will examine the interplay of cognitive and socio-emotional processes as it manifests in face-to-face social interaction during the temporal progress of collaborative learning. This approach is needed because the focus of collaborative learning research has been predominantly on cognitive processes in social interaction, while a growing corpus of research suggests that socio-emotional processes are equally important in how collaborative learning unfolds (Baker et al., 2013).

I will explore the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning from three perspectives. First, I will examine participation as an infrastructure through which groups engage in cognitive and socio-emotional processes and investigate fluctuations in group participation over the course of collaborative learning. Second, I will examine in more depth how cognitive and socio-emotional processes intertwine during regulation and argumentation in social interaction, which are important moments for strategically overcoming challenges and deepening the understanding of domain knowledge. Third, I will examine how meaningful functions of collaborative learning emerge in social interaction from the mutual influence of cognitive and socio-emotional processes. In this dissertation, I posit three empirical aims, which are addressed in the original Articles I–IV with more specific research questions. The empirical aims of this study are as follows:

1. To observe how groups participate in cognitive and socio-emotional processes in social interaction during collaborative learning (see Articles I–III).
2. To investigate how cognitive and socio-emotional processes intertwine in social interaction when groups regulate their learning (see Articles I–III) and engage in argumentation (see Article IV).
3. To examine what functions cognitive and socio-emotional processes in social interaction serve for collaborative learning (see Articles I–IV).
4 Methods

This dissertation exploring the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning is based on a research design in which small groups of teacher education students were observed during collaborative learning tasks as part of their teacher education studies. The data include two datasets, which were collected in 2014 and 2015 as a part of two research projects funded by the Academy of Finland. The first dataset was collected for the project PROSPECTS (Investigating and promoting individual and SSRL in primary school and teacher education contexts), and the second was collected for PREP21 (Preparing teacher students for 21st century learning practices). Using a qualitative and process-oriented methodological approach, the analysis focused especially on groups’ video-recorded social interactions in both datasets. Additionally, students’ self-reported data of their collaborative learning experiences and teacher assessments were used as complementary data in the second dataset.

4.1 Qualitative and process-oriented research

The methodological approach of this dissertation is qualitative and process-oriented. Qualitative research differs from quantitative research in its interpretivist stance. That is, qualitative research does not assume an objective reality, which can be empirically captured as it is, but acknowledges that the targets of research need interpretation because meanings are culturally defined (Twining, Heller, Nussbaum & Tsai, 2017). The qualitative approach fits this dissertation because the main object of analysis is social interaction and the meanings that arise in social interaction. In line with the socio-cognitive theory of learning (Usher & Schunk, 2018; Zimmerman, 2000), the dissertation does not deny the existence of natural, psychological phenomena that underlie individual learning. However, social interaction cannot be captured as such or attributed to only individual processes. Rather, meanings are created through the reciprocal use of language and action, situated in a given context. This dissertation, thus, represents systemic research, which examines learning at the system level, capturing social interactions between several group members within a particular context rather than focusing on elemental components, such as an individual learner and her thoughts or contributions (Nathan & Sawyer, 2014).

According to Sawyer (2013), qualitative methods are particularly valuable for studying emergent phenomena, where meanings arise in a moment-to-moment
process of social interaction through participants’ reciprocal actions. The qualitative stance of this dissertation is also seen in the data analysis methods, which emphasize a microgenetic approach involving detailed analyses of the processes of learning as they occur in authentic learning settings (Chinn & Sherin, 2014). The empirical articles in this dissertation include careful microgenetic interpretations of social interaction as well as inductive reasoning (Twining et al., 2017), though numerical data and the quantification of data are used as a resource for qualitative inquiry (Chi, 1997; Twining et al., 2017).

This dissertation also represents a process-oriented approach, which emphasizes that group work or collaborative learning is not static but includes evolving processes, sequences, phases, and changes (Arrow, Poole, Henry, Wheelan & Moreland, 2004; Reimann, 2009). Thus, collaborative learning as a process should be captured as a series of actions and interactions unfolding over time (Fischer & Järvelä, 2014). Process-oriented studies on collaborative learning attempt to illustrate the features of social interaction that can potentially generate favorable learning results (Janssen et al., 2010). This dissertation follows the collaboration-for-proximal-outcomes approach of studying collaborative learning, which examines how collaborative processes unfold and lead to new collaborative states within the collaboration itself (Enyedy & Stevens, 2014).

A process-oriented approach is useful for the current dissertation because changes occur in social interaction during collaborative learning. For example, participation in social interaction can fluctuate from moment to moment, giving rise to moments with more and less active group-level participation (Iiskala et al., 2015; Määttä et al., 2012). Furthermore, cognitive and socio-emotional processes emerging in social interaction may fluctuate during the progress of collaborative learning, which is seen, for example, as occasional positive socio-emotional interactions (Järvelä et al., 2016; Molenaar & Chiu, 2014; Rogat & Linnenbrink-Garcia, 2011; Sinha et al., 2015). A process-oriented approach allows for examining these fluctuations as well as the relations between cognitive and socio-emotional processes as they manifest in a social interaction.

4.2 Collecting the datasets

This dissertation is based on two datasets, both of which were collected at the University of Oulu, Finland, in teacher education students’ Mathematics Education and Environmental Sciences courses. The research took place in a classroom-like research space in the LeaF research infrastructure. The facilities included three
spherical 360-degree cameras for video recording and individual microphones for each student for audio recording. Video recordings were the primary source of data for this dissertation because they enabled microgenetic, moment-to-moment analyses of groups’ social interactions during their collaborative learning. Student’s self-reports of their collaborative learning experiences were used as complementary data.

The first dataset was collected in 2014 in a Mathematics Education course and used in Articles I–II. The students enrolled were third-year teacher education students. The course included six lessons in which students worked on collaborative tasks concerning mathematical and didactical topics. Altogether, 40 hours of video data were collected, but for the purposes of a descriptive, qualitative approach, the analysis focused on the groups’ collaboration during two lessons involving more mathematical than didactical content and a similar set of tasks and level of difficulty. The topics of the lessons were estimation and mental calculation and problem solving. The tasks required students, for example, to estimate the results of calculations and solve a problem with several unit transformations. Students were asked to work collaboratively during the tasks. The groups started their collaboration by reading the task instructions and using a tablet tool called S-REG to evaluate and discuss perceptions of their cognitive capabilities, motivation, and emotions concerning the task (Järvelä et al., 2016). After the discussions prompted by S-REG, the groups began working on the tasks at their own pace.

The collaboration of 11 groups was video-recorded during the chosen lessons, but the videos of six groups were chosen for analysis. The other groups were omitted because of absences from one of the two lessons selected for analysis. The dataset consisted of video-recorded collaborations of six groups each comprising four members (N = 24; 20 women, 4 men, M_age = 24 years), but in four of the 12 videos, only three students were present. All in all, 12 videos (10 h 31 min, M_duration = 53 min) were used for detailed analysis.

The second dataset was collected in 2015 and used in Articles III–IV. The data collection took place during a six-week environmental science course. The participants were a class of 19 first-year students in a teacher education program (12 women, 7 men, M_age = 23 years). The participants were divided into five mixed-gender groups of three-to-four students. The groups were formed on the basis of a pre-questionnaire assessing the students’ disposition toward collaboration (Wang, 2009). Students were divided into three profiles according to their answers: those who were the most positive toward collaboration, those who were the least positive toward collaboration, and those who were in between. Groups were formed so that
each group included students from all three profiles. The purpose of this grouping was to ensure that groups were not completely formed of members either negative or positive toward collaboration, which could have led to differences between groups’ willingness to collaborate. It should be noted that the group members had already collaborated with all or some of the members of their small group before the data collection occurred. Familiarity has the potential to stimulate more efficient, critical, and exploratory communication and minimize the need for group members to get to know each other and foster mutual trust (Janssen, Erkens, Kirschner & Kanselaar, 2009).

The groups were assigned to work on technology-enhanced tasks relating to five environmental science topics: species, ecosystems, maps, planetary phenomena, and climate. In each 90-minute lesson, the groups were asked to discuss a specific topic and collaboratively design various tasks for teaching the topic in elementary school. The goal of the tasks was to enhance students’ conceptual and pedagogical understanding of given concepts and phenomena in environmental science. Collaborative learning was supported by a regulation macro-script that facilitated discussion about goals, progress, and challenges (Näykki, Isohätälä, et al., 2017). Short, 2–5-minute scripted discussions about planning how to proceed or reflecting on the collaboration took place at the beginning and end of each group work session and once during the group work. Guided by the wider goals of the data collection, the macro-script was used to investigate how groups could be supported in planning, monitoring, and evaluating their work, though this was not included in the aims of the current dissertation.

Before and after each session, students individually self-evaluated their expectations and experiences of collaboration. After completing the sessions, the students evaluated their overall perceptions of their collaboration. These evaluations were useful for gathering students’ own interpretations about their collaborations, which complemented researchers’ interpretations based on observations. Groups’ content knowledge and pedagogical knowledge and collaboration were also evaluated by a mathematics and environmental science teacher on the basis of the students’ interaction during each collaborative session. The teacher used an adaptation of Biggs and Collins’ (1982) 4-level SOLO Taxonomy (Structure of the Observed Learning Outcome) rubric to evaluate groups’ collaboration and pedagogical skills as well as content knowledge. The teacher evaluations were considered beneficial because they shed light on how the students achieved their educational aims—namely, activating understanding of concepts in
mathematics and environmental sciences and facilitating discussion of how to teach these concepts in primary education.

For this second dataset, 24 sessions were captured on video. However, after excluding videos in which less than three students per group were present, 20 videos (22 h 15 min) were selected for analysis. In addition, teacher evaluations and students’ self-reported perceptions of their collaboration were used as complementary data.

4.3 Data and data analysis

Table 1 presents an overview of the data sources and analysis methods used in this dissertation. For the investigation, the data sources were mainly video recordings of groups’ social interactions. The video-recorded social interactions were analyzed using the coding-and-counting approach and interaction analysis. In the second dataset, the observational analysis was complemented with self-reported data and teacher evaluations of students’ collaboration, reported with descriptive statistics.

Table 1. Data sources and analysis methods in the original articles.

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<th>Data</th>
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4.3.1 Data sources

The choice to examine video data was natural because the focus of this dissertation is on the process-oriented investigation of social interaction during collaborative learning. The strength of video data lies in the ability to document social interaction, capturing both the speech and nonverbal communication of participants, and then have multiple researchers review it several times (Derry et al., 2010; Jordan & Henderson, 1995). Video recordings allow researchers to look back at social interactions and select distinct phenomena of social interaction for close investigation, and apply different analytical practices (Derry et al., 2010). Video recordings, thus, provide a more suitable dataset for analyzing social interaction than only field notes, audio recordings, self-reports of participants’ experiences, or
observational coding conducted at the time of data collection (Jordan & Henderson, 1995). Furthermore, video recordings represent process data, allowing for the data to be analyzed with a process-oriented approach. Nevertheless, video recordings are by no means objective representations of reality. As they are limited by the choice of camera angle, duration, and quality, and video only offers audio-visual material, video recordings are, instead, transformations of reality (Jordan & Henderson, 1995). Furthermore, the presence of a camera may influence participants’ behavior and interaction (Jordan & Henderson, 1995) and raise ethical considerations (Derry et al., 2010). Though these limitations must be acknowledged, the popularity of video observation in research on collaborative learning suggests that video is a particularly powerful tool for analyzing social interaction during collaborative learning.

In this research, self-reports and teacher evaluations collected in the second dataset were used to complement video-recorded data. Self-reported data were considered useful because observational data are subject to the researcher’s interpretations, which may not reflect the participants’ experiences. Thus, self-reported data helped give validity to interpretations drawn from the video recordings. Self-reported data were collected from several perspectives, including Likert-scaled questions about cohesion (Sargent & Sue-Chan, 2001), satisfaction (Chang & Bordia, 2001), and psychological safety (Edmondson, 1999). In Articles III–IV, descriptive statistics of this data highlight students’ perceptions of their socio-emotional processes and inform of differences between groups. In addition, teacher evaluations of groups’ content knowledge and pedagogical knowledge and collaboration are reported as background data in Article III. The evaluations were made by a teacher in mathematics and environmental sciences who watched the videos of students’ collaborative learning. The data are reported with descriptive statistics.

4.3.2 Video analysis method

In each of the articles reported in this dissertation, the analysis of video-recorded social interaction was based on the combination of coding-and-counting and interaction analysis. Coding-and-counting represents a systematic observational approach in which video recordings are viewed and annotated with theoretically inspired coding categories, which may have been defined before the data collection (Chi, 1997; Derry et al., 2010; Hmelo-Silver & Bromme, 2007). The orientation is top-down, since assumptions or research questions are applied to the data (Derry et
Coding may be based on an established coding scheme that has been used in prior research (e.g., Hmelo-Silver, 2003). The coding schemes in this dissertation were based on theory and drew inspiration from coding schemes in prior studies. For example, coding schemes were used to identify moments of joint participation and regulation in social interaction, which I will describe in more detail in the following sub-chapter. The coding schemes were also elaborated by definitions and data examples, which facilitating operationalizing them and reduced ambiguity when applying the codes to actual social interactions (Chi, 1997). Further, the coding schemes were iteratively refined to integrate new insights that emerged from the data (Derry et al., 2010).

The strength of the coding-and-counting approach was that the coding results could be reported in numeric form and subjected to statistical analysis (Chi, 1997; Sawyer, 2013). Further, several researchers could code the same data, after which the coding was compared to evaluate inter-rater reliability (Chi, 1997; Derry et al., 2010). The coding-and-counting approach also allowed for examining the set of videos faster than if the analysis had only focused on inductive or descriptive analysis. However, the drawback of the coding-and-counting approach is that it is time-consuming and can be ill-suited for large scale analyses (Jeong, Hmelo-Silver & Yu, 2014) because the videos must be iteratively reviewed to make justifiable interpretations and ensure consistency in coding. The coding-and-counting approach can also be criticized for its focus on categorizations and numeric presentation of data, which may hide the nuances of social interaction (Sawyer, 2013). Thus, for this dissertation, it was considered beneficial to extend the analysis of social interaction with more detailed and data-driven analyses of selected episodes using interaction analysis.

Interaction analysis is a method whereby the researcher approaches video data of social interaction inductively by examining video recordings openly, and often collaboratively, to search for interesting phenomena in the data (Jordan & Henderson, 1995). Interaction analysis focuses on processes of learning and meanings emerging in social interactions in a particular context. Similar to coding-and-counting, it represents a systemic and microgenetic approach (Chinn & Sherin, 2014; Nathan & Sawyer, 2014), but is more data-driven than theory-driven. As such, interaction analysis is discovery-oriented owing to the objective to reveal unanticipated phenomena rather than pre-defined ones (Derry et al., 2010). In the collaborative learning literature, the coding-and-counting approach has sometimes been seen as a subcategory of interaction analysis. However, in defining interaction analysis, Jordan and Henderson (1995) clearly distinguish interaction analysis that
is inductive by nature from deductive analyses based on coding-and-counting. Thus, I consider coding-and-counting and interaction analyses as separate analytical methods, which can nevertheless complement each other.

The strength of interaction analysis for this dissertation was that it allowed for more careful descriptions of social interaction than the coding-and-counting approach alone would (Jordan & Henderson, 1995). Thus, the video data were not restricted to pre-determined coding categories, which may hide the nuances of social interaction. Episodes that were selected after the coding-and-counting analysis were viewed and analyzed openly and collaboratively to reveal important phenomena and draw evidence-based conclusions after iterative reviews.

Interaction analysis was also a means to present rich, “play-by-play” descriptions of examples of social interaction (Derry et al., 2010), which showcase how social interaction unfolds. Play-by-play analyses were used for demonstrating the flow and characteristics of social interaction, which were not evident only based on reported frequencies of coding categories.

Prior research on collaborative learning has reported a combination of coding-and counting and more inductive play-by-play descriptions of interaction (e.g., Barron, 2003; Näykki et al., 2014; Rogat & Linnenbrink-Garcia, 2011). The strength of the combination of the coding-and-counting approach and interaction analysis is that coding-and-counting provides a systematic way of identifying episodes of interest and inductive descriptions add more detailed information about the characteristics of social interaction. The choice to combine the coding-and-counting approach with interaction analysis reflects the fact that this dissertation is grounded in the socio-cognitive theory of learning (Zimmerman, 2000), but focuses especially on social interaction in collaborative learning. According to Howley, Mayfield, and Penstein Rosé (2013), more cognitivist and quantitatively oriented theorists have favored the coding-and-counting approach because they tend to be interested in the effects of certain conversational patterns on learning. However, understanding social interaction more qualitatively requires more inductive, rich descriptions of social interaction, also drawing from linguistic analysis methods, to understand how meanings emerge in social interaction. Thus, in this dissertation, the characteristics of both approaches are visible.
4.3.3 Analysis procedure

The analysis of the first dataset is reported in Articles I–II. In Article I, we focus on learners’ participation in interaction portraying cognitive and socio-emotional processes. In Article II, the analysis focuses on the emergence of SSRL during the fluctuation of students’ participation in social interaction. For both articles, the analysis began by coding the video recordings with theory-driven coding categories and examining frequencies and co-occurrences between coded phenomena. For the research reported in Article I, the analysis continued by inductively reviewing and characterizing the moments when participation changed during transitions between interactions portraying cognitive and socio-emotional processes. For the study in Article II, we complemented the coding of video data with a description of illustrative examples.

The first two steps of coding the video recordings in the first dataset were common for Articles I and II. The first step was to identify task-focused interaction—that is, joint discussion related to the task and the groups’ collaboration (Järvelä et al., 2016). The second step was to identify students’ participation in task-focused interaction. Participation was examined from the perspective of contributing and listening because initiating turns, signaling attention, and providing evidence of understanding can be considered as the core elements of communication (H. H. Clark & Brennan, 1991; Sacks et al., 1974). Participation was first analyzed at the individual level, which was aggregated to the group level to explore how actively the whole group participated in task-focused interaction. Changes in the temporal fluctuation of participation were visualized on a timeline and changes in participation were identified.

For Article I, the analysis further included identifying two types of task-focused interaction: on the one hand, domain-focused interaction as well as metacognitive discussions, which we referred to as cognitive interaction; on the other hand, interaction about emotions or motivation, encouraging peers, and laughing together, which we referred to as socio-emotional interaction. These codes were developed on the basis of Järvelä, Järvenoja, et al. (2016) and prior research on cognitive interaction (Dillenbourg & Baker, 1996; Roschelle, 1992) and socio-emotional interaction in collaborative learning (Kwon et al., 2014; Lajoie et al., 2015; Rogat & Linnenbrink-Garcia, 2011). Next, we examined the fluctuations of

5 The data were collected and analyzed as a collaborative effort of the co-authors of each empirical article. Thus, I will refer to we, rather than I, when referring to jointly accomplished analyses and results of single empirical articles in this dissertation.
participation during types of interaction by comparing how frequently the levels and changes of participation occurred in cognitive and socio-emotional interactions. Nonparametric Mann-Whitney U tests were used to explore the differences.

We further identified episodes in which changes in participation occurred when students transitioned between the types of interaction (cognitive and socio-emotional). By means of interaction analysis, we iteratively reviewed those episodes and inductively explored what characterized them. First, we examined what kinds of activities groups engaged in before and after changes in participation during transitions between types of interaction. Ultimately, three categories—domain-focused activities, metacognitive activities, and mixed activities—were found to characterize these activities. We investigated how shifts between these activities depicted the concurrent changes in participation during transitions between cognitive and socio-emotional interactions. Illustrative data examples were selected.

For Article II, the analysis of participation was accompanied by an analysis of manifestations of SSRL, based on earlier work on SSRL (Järvelä & Hadwin, 2013; Järvelä & Järvenoja, 2011; Malmberg, Järvelä & Järvenoja, 2017). We defined manifestations of SSRL as social interaction through which students negotiated and aligned perceptions of collaborative processes to co-construct shared awareness and perceptions of the task and its requirements, goals, standards and plans, learning strategies, the groups’ collective progress, strengths and weaknesses of the group, and the group’s positive or negative feelings toward the task. We combined the analyses of participation and manifestations of SSRL by comparing how levels and changes in participation occurred during SSRL and during task-focused interaction overall. Kruskal-Wallis H and Mann-Whitney U tests were used to examine the differences. Finally, we deepened the analysis by carefully describing three illustrative examples of the manifestation of SSRL and concurrent fluctuations in participation in social interaction. We selected examples from different groups, lessons, and task phases to highlight the variety of situation-specific factors shaping participation and manifestations of SSRL.

The analysis of the second dataset is reported in Articles III–IV. Article III focuses on the convergences of students’ joint and positive interaction and regulation and examines the functions of these moments during collaborative learning. Article IV investigates how students struck a balance between engaging in argumentation while sustaining socio-emotional processes that were favorable to this. In both studies, theory-driven coding of the video recordings accounted for the first part of the analysis. In Article III, the analysis continues with a more
inductive interaction analysis exploring the functions of convergences of students’ joint and positive interaction and regulation. In Article IV, the theory-driven coding is complemented by an examination of students’ self-reported data, but the main part of the study is an in-depth interaction analysis of a case example of argumentation.

For Articles III and IV, the same video recordings in the second dataset were used. The analysis of 20 videos began by dividing the videos into 30 second segments. This segmentation provided a manageable and consistent unit of analysis and created a temporally unfolding overview of the dataset. Each 30-second segment was briefly annotated with a description of what occurred within the episode. Other studies have used longer, 5-minute episodes as the unit of analysis (e.g., Sinha et al., 2015; Sullivan & Wilson, 2015), but we saw that a shorter timeframe was important for making more detailed moment-by-moment observations. We also considered 30 seconds long enough to observe several conversational turns in one episode and, thus, examine exchanges of social interaction rather than single turns of talk. Furthermore, we could observe how elements of social interaction converged in the same episodes.

The coding scheme used for Article III focused on joint and positive interaction and regulation during collaborative learning. To analyze regulation, we developed a coding scheme consisting of three categories: planning, monitoring, and evaluation. The categories were based on the theory of regulation of learning (Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2000) and empirical work examining regulation in social interaction (Khosa & Volet, 2014; Kwon et al., 2013, 2014; Näykki, Järvenoja, et al., 2017; Rogat & Linnenbrink-Garcia, 2011). In addition, we developed a coding scheme to analyze students’ joint and positive interaction, which was also based on prior research (De Backer et al., 2015; Kwon et al., 2014; Lajoie et al., 2015). Joint interaction refers to the degree of joint participation, which was investigated with three sub-categories: joint task focus, joint contributing, and joint listening. Positive socio-emotional interaction, in turn, was analyzed with two coding categories: socio-emotional support and humor.

After coding joint and positive interaction in the video recordings, we examined how joint participation and positive socio-emotional interaction converged with moments involving regulation. We compared the proportions of joint and positive interaction in episodes with and without regulation using a Mann-Whitney U test. Based on the comparisons, we saw that episodes with regulation converged with more joint contributing, joint task focus, and socio-emotional support than episodes without regulation. Thus, we continued to qualitatively
examine and describe the functions of situations in which elements converged via interaction analysis. To this end, we wrote descriptions of all episodes with converging regulation, joint contributing, joint task focus, and socio-emotional support. The descriptions were reviewed with another researcher and similar episodes were iteratively grouped until we could name categories describing the functions of episodes in the groups’ collaborative learning. We then independently reviewed the episodes and selected a category for each episode. Finally, all discrepancies between categorizations were resolved. In reporting the results, we describe the characteristics of each category and present illustrative case examples.

For Article IV, we relied on the same coding of joint participation and positive socio-emotional interaction as in Article III. This information was used to provide evidence of the quality of groups’ socio-emotional processes because the codes indicated how learners behaviorally engaged in collaboration, how they expressed their emotions, and how they related to each other. Additionally, we examined the quality of groups’ socio-emotional processes with data pertaining to students’ self-reports of their collaborative learning experiences. The questionnaire data included students’ individual interpretations of the groups’ socio-emotional processes—namely, cohesion (Sargent & Sue-Chan, 2001), satisfaction (Chang & Bordia, 2001), and psychological safety (Edmondson, 1999). The next step of the analysis was to identify argumentation in the video-recorded social interactions. The coding was based on the minimal conditions of argumentation (Baker, 1999): the interaction had to include a verbal statement indicating a difference of position or attitude against a previously stated claim or suggestion and at least one communicative act arguing for the initial claim by directly supporting the initial claim or arguing against the difference of position or attitude.

The video coding and analysis of self-reports were used to compare whether groups differed in terms of socio-emotional processes and argumentation. We utilized a Kruskal-Wallis H test for the comparisons, which indicated that one group was especially successful in sustaining favorable socio-emotional processes while also engaging in the most argumentation. This group was selected as a case group for a microgenetic and inductive interaction analysis of their argumentation. To begin the analysis presented in Article IV, we reviewed all episodes of argumentation in the group and chose one illustrative episode for analysis. We selected the given episode because it included a lengthy piece of argumentation and because the episode gave rise to the emergence of a new idea, which resolved the debated points of view. In the microgenetic analysis, we focused especially on how socio-emotional processes occurred while the group engaged in argumentation. The
analysis included viewings and discussions of the episode among the co-authors of the study, writing a descriptive narrative, and transcribing the episode using the Jefferson (2004) system of transcription notation. We not only examined students’ speech but also their nonverbal communication and the linguistic and pragmatic features of students’ social interaction. By viewing the videos and annotating the transcripts, we ultimately created a rich play-by-play description (Derry et al., 2010) of the selected episode. Multiple rounds of reviewing the descriptions and annotations allowed us to synthesize the most salient findings and create a flowchart to illustrate the group’s argumentation process and socio-emotional processes.

4.4 Evaluation of the research

According to Twining et al. (2017), the conduct of qualitative research must be rigorous and systematic. Unlike quantitative research, qualitative research is not necessarily evaluated on the basis of its replicability, generalizability, or stability (L. Cohen, Manion & Morrison, 2007). Rather, the validity and reliability of qualitative research are examined from the perspective of its truthfulness, credibility, and trustworthiness (L. Cohen et al., 2007; Holloway & Todres, 2003; Twining et al., 2017). These qualities can be enhanced by following systematic procedures in conducting qualitative research, such as aligning the methodology to the theoretical stance, providing clear aims grounded in prior research, explicating a clear and ethically acceptable design, carefully describing and justifying data collection and analysis procedures, interpreting the data beyond simple descriptions, acknowledging limitations, and discussing findings in light of prior research (Twining et al., 2017).

Several aspects affected the quality of the research presented in this dissertation. First, the ecological validity of the research was addressed. In qualitative research, it is considered important that the data stem from naturalistic, “ecologically valid” settings, which are not heavily manipulated or controlled by researchers (L. Cohen et al., 2007). The ecological validity of this research was enhanced by the fact that the data were collected in a setting resembling the participants’—teacher education students—everyday learning settings. The data were collected during normal, compulsory teacher education courses and the data collection took place in a research space that was set up as a normal classroom. However, the ecological validity was reduced by the fact that students were observed and video-recorded, which may have affected their behavior, and the groups were asked to use a script.
that guided their interaction at given times during the collaboration. Nevertheless, the setting was more naturalistic than in a controlled laboratory experiment or in observing participants performing a task that would be irrelevant to their everyday learning needs.

Second, the quality of analysis was influenced by triangulation. Triangulation is considered an important way to enhance the credibility and trustworthiness of a data analysis because triangulated interpretations are not based solely on one situation, one observer, or one method (Twining et al., 2017). Triangulation was enhanced by investigator triangulation—namely, involving several researchers in the analysis (Elliott, Fischer & Rennie, 1999). In all articles of this dissertation, the coding-and-counting approach of the data analysis included reliability coding. That is, while one researcher independently coded the whole dataset, another researcher independently coded 25–50% of the same video data using the same coding scheme. Afterwards, Cohen’s kappa value was calculated to check if the inter-raters reached similar results in their coding. When necessary, the inter-raters also discussed all non-agreements and negotiated the discrepancies. For Articles I, III, and IV, the coding-and-counting approach was followed by a more inductive analysis in which two researchers collaborated by jointly reviewing selected episodes, discussing their characteristics, and creating syntheses.

Another way to enhance triangulation is method triangulation—that is, using multiple methods to collect data (Twining et al., 2017). Method triangulation was used for Article IV, in which we complemented video analysis with students’ self-reports of their collaborative learning experiences to examine the quality of socio-emotional processes in groups. Internal consistency of the used scales was examined and reported using Cronbach’s $\alpha$. For Article III, we also employed students’ self-reports and teacher evaluations of the quality of groups’ content and pedagogical discussions as background information about the groups. However, for Articles I and II, the analysis relied solely on video data, and video analysis was the primary method of investigation in all studies reported in the dissertation. Thus, the weakness of this dissertation is that the results are based on observations and researcher interpretations. According to L. Cohen et al. (2007), observational methods may be affected by the fact that the observer is not aware of events preceding or following the observed episode or that the observer’s presence influences participants’ behavior. Moreover, observations alone do not account for participants’ own interpretations, which could have been gathered by involving the participants in interpreting the video-recorded situations (Derry et al., 2010; Jordan & Henderson, 1995). Other data collection methods, such as physiological data,
could also have yielded further information about, for example, participants’ arousal (Pijeira Díaz, Drachsler, Kirschner & Järvelä, 2018). However, as the focus of the research was on qualities of social interaction, gathering observational data of social interaction was justified.

Despite focusing mostly on video observation, we were able to strengthen the data triangulation by combining different ways of analyzing the video data. First, using the coding-and-counting approach allowed us to investigate the video data broadly as a whole. According to Erickson (2006), it is important to give a sense of the broader corpus of data rather than relying solely on rich examples. However, as coding-and-counting alone may not sufficiently portray the complexities of social interaction, we also analyzed selected episodes more inductively and presented illustrative examples to shed more light on the nuances and situative characteristics of social interaction. This enhanced the depth and richness of the analysis, which is considered an asset to qualitative inquiry (Twining et al., 2017). That said, the situative nature of the research must be acknowledged. The results must be viewed in light of the context of the study, considering, for example, that the participants were educated young adults in teacher education, whose collaborative learning may differ greatly from the collaborative learning of other groups, such as children.

In addition to investigator and method triangulation, we enhanced the data triangulation by observing several groups during several collaborative tasks. As our interpretations were drawn from a corpus of 5–6 groups in 2–5 collaborative sessions, they did not only represent a single group or task. However, other analytical choices could have had other strengths: on the one hand, examining a single group in one situation could have enhanced the richness and depth of the analysis; on the other hand, a larger corpus could have brought new insights, which did not emerge in the datasets of this dissertation. Thus, the size of the corpus was a compromise between conducting a deeper analysis with a smaller dataset and a broader analysis with a larger dataset. In any case, it is important to note that generalizations cannot be made on the basis of this dissertation alone. Rather, this research responds to the need for process-oriented research from real, inevitably “messy” learning settings (Fischer & Järvelä, 2014). Instead of providing conclusions regarding definite causal relations, qualitative studies such as the ones in this dissertation offer an empirical understanding of how collaborative learning processes intertwine and mutually influence each other in various ways (Sinha et al., 2015). As such, the empirical studies in this dissertation contribute to the wider collection of qualitative research on collaborative learning, which over time affords general syntheses of the nature of collaborative learning.
Some research limitations should be considered. The first limitation relates to the validity of constructs (L. Cohen et al., 2007)—namely, the challenges of defining conceptual phenomena that were investigated. As this research examined meanings emerging from social interaction, the empirical examination relied on abstract concepts (e.g., SSRL, socio-emotional interaction) that can be difficult to define and that may have been defined in different ways in prior literature. This brings challenges in determining whether interpretations are valid and comparable to other studies. In the empirical studies presented in this dissertation, we tackled this challenge by being explicit about our definitions of concepts and using prior literature as a source for definitions. Further, we endeavored to increase reliability by triangulation and used illustrative examples of the investigated phenomena. Nevertheless, it is important to acknowledge that the findings reported in this dissertation were influenced by the ways that we operationalized concepts and that other studies may have used somewhat divergent concepts.

Conceptual confusion has been acknowledged as a wider challenge in the field of collaborative learning (Asterhan & Schwarz, 2016; Hadwin et al., 2018; Wise & Schwarz, 2017). One issue is that we use the term collaborative learning to refer to students’ video-recorded interactions, even though all group work cannot be called “collaboration” (see Sub-chapter 2.1). Baker (2015) argues that, most likely, only parts of group work actually represent collaborative learning. Wise and Schwarz (2017) further criticize the loose use of “collaborative learning” and suggest that the key characteristics of collaboration, such as joint attention, should be empirically evidenced. Looking back, it is safe to say that not all moments of video-recorded social interaction examined in the current dissertation fit the definition of collaborative learning. However, collaborative learning certainly did occur in much of the data, which is evidenced, for example, by our results regarding groups’ joint participation. Further, our analyses focused only on task-focused social interaction and, thus, off-task social interaction was not included.

Another limitation to acknowledge is the degree of reflexivity. Criticality and reflexivity are considered important aspects of the quality of research (Twining et al., 2017), which we have enhanced by being transparent about the methods of data collection and analysis and by reporting limitations in all empirical articles. However, criticality and reflexivity also include disclosure of researchers’ values, assumptions, or biases, which may influence their point of view (Hannes, Heyvaert, Sleegers, Vandenbrande & Van Nuland, 2015). This is not explicitly discussed in the articles of this dissertation, even though no research is completely objective, without assumptions or values. In this dissertation, my work as a researcher was...
guided by orientations from socio-cognitive theory. In addition, the research was influenced by the fact that I have high regard for collaborative practices in learning. Wise and Schwarz (2017) note that collaborative learning research can be criticized for ideologically emphasizing the value of collaborative learning. However, they also note that the value of collaborative learning is not simply ideological but based on scientific evidence. It should nevertheless be noted that the benefits of collaborative learning cannot be taken for granted or automatically considered to be superior to the benefits of other learning practices (Kuhn, 2015).

This leads me to the third point of reflection about the secondary aims of this dissertation. This research was primarily guided by the pursuit of characteristics of social interaction in collaborative learning. Indirectly, however, I also wanted to contribute to the development of pedagogical practices, which support “more productive” social interaction and “better” learning outcomes. Thus, the motivations behind the dissertation are not only descriptive but also somewhat normative. This is seen, for example, in Article IV, where we present an example of how a group of students sustained a “favorable” socio-emotional climate during argumentation. Nevertheless, judgements about the learning outcomes cannot be made on the basis of this dissertation because the consequences reflecting the ultimate success of collaborative learning or individual learning were not measured.

I also want to consider the notion of time, which, on the one hand, was a limitation and, on the other hand, an asset. The empirical studies presented in this dissertation were limited by the fact that the analyses focused on a set of videos from selected lessons and, further, that there was a focus on more precise episodes. The observational analysis focused only on given timeframes and neglected events preceding or following the observed episode (L. Cohen et al., 2007). Engeström and Toivainen (2010) have criticized such a “here and now” approach, since the analysis of collaboration is narrowed down to slices of interaction with little history or future. In addition, the analysis presented in this dissertation provides no information about the groups’ development, although it is known that groups develop over time (Fransen, Weinberger & Kirschner, 2013; Raes, Kyndt, Decuyper, Van den Bossche & Dochy, 2015). However, the analytical choices made in this research support the research focus of shedding light on the characteristics of social interaction—namely, the interplay of cognitive and socio-emotional processes. The aims of the current dissertation justify the microgenetic approach of focusing on certain episodes of social interaction.

Additionally, the notion of time is arguably one of the strengths of this dissertation. The current dissertation represents process-oriented research,
examining collaborative learning as series of actions and interactions unfolding over time (Fischer & Järvelä, 2014). Thus, in the analysis, we examined the fluctuations and convergences of phenomena, and the articles present moment-to-moment descriptions of illustrative examples, contextualized with information about events before and after the selected episode. However, we also present some information about the data with frequency sums and proportions, which hide temporal characteristics of social interaction. Different analysis methods, such as sequential analyses, could shed more light on the temporal patterns of social interaction and their effects on learning (Molenaar & Chiu, 2014, 2017).

Finally, the core strength of this dissertation is its attention to detail, and particularly its focus on moment-to-moment characteristics of verbal and nonverbal social interactions. This approach made it possible to address gaps in prior research—namely, the scarcity of empirical evidence illustrating how both cognitive and socio-emotional processes emerge and intertwine in social interaction. Having said that, the drawback of this approach is that the analysis did not reveal the effects of background variables (e.g., group composition) on groups’ social interaction or how their social interaction influenced individual learning gains. An analysis of such effects, however, would have required more extensive analyses of a larger dataset, which would have limited the resources to creating descriptive accounts of social interaction.

4.5 Ethical considerations

This dissertation follows the research ethics guidelines of the Finnish Advisory Board on Research Integrity (2012). The ethical aspects of data collection and publishing were carefully considered and participants’ right to privacy was honored. One of the key elements was obtaining the participants’ informed consent (L. Cohen et al., 2007). That is, participants in the empirical studies were mature individuals who were given full information about the research prior to the data collection, and their consent to participate in the research was acquired. Although the data were collected during teacher education students’ compulsory classes, participation in the data collection was voluntary and students could withdraw their participation anytime. In the published articles, we openly report having received funding for the research from the Academy of Finland. In addition, my PhD research was funded by the Eudaimonia doctoral program of the University of Oulu Graduate School. There were no other sponsors of the research.
Furthermore, using video data poses an ethical challenge because participants are recognizable in video recordings. Since videos are inherently non-anonymous, it is necessary to protect participants’ privacy by restricting access to videos and information about the participants (Derry et al., 2010). In the research reported in this dissertation, only the researchers had access to the collected data. All data with information that could make participants recognizable were stored securely. The results of the research have been reported anonymously using pseudonyms for the students when presenting illustrative examples. However, in Article IV, the analysis of case examples includes pictures of the participants in the case group. These students were asked for consent to use pictures of the data collection in presentations and publications, and they were informed about the use of the pictures when the manuscript writing was in progress. The use of pictures was justified because they illustrate the nonverbal behaviors that are reported in the text. In addition, we considered the fact that the case example represented a positive case of skillful argumentation and maintenance of a sound socio-emotional climate. Thus, while presenting a truthful and open analysis of the actual interaction, the selected case did not pose a threat to the participants’ dignity (L. Cohen et al., 2007).
5  Overview of the original articles

This dissertation includes four empirical articles. The articles were based on the collaborative effort of several researchers, but the author of this dissertation was the first author of each article. Table 2 presents an overview of the aims of the articles and the phases of research in which the author participated.

Table 2. Aim of the articles and author’s role.

<table>
<thead>
<tr>
<th>Article</th>
<th>Aim</th>
<th>Author’s participation</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>To examine the fluctuations of learners’ participation in cognitive interaction and socio-emotional interaction</td>
<td>Data analysis, reporting</td>
</tr>
<tr>
<td>II</td>
<td>To investigate how SSRL emerges during the fluctuation of students’ participation in interaction in collaborative learning</td>
<td>Data analysis, reporting</td>
</tr>
<tr>
<td>III</td>
<td>To explore the situations in which small groups’ joint and positive interactions and regulation in social interaction converge during collaborative learning</td>
<td>Study design, theory, data collection, data analysis, reporting</td>
</tr>
<tr>
<td>IV</td>
<td>To investigate how student teachers strike a balance between engaging in argumentation while sustaining socio-emotional processes that are favorable to this</td>
<td>Study design, theory, data collection, data analysis, reporting</td>
</tr>
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5.1  Cognitive and socio-emotional interaction in collaborative learning: Exploring fluctuations in students’ participation

Collaborative learning involves fluctuations in how students participate in social interaction and how they engage in interactions that are cognitive (e.g., sharing knowledge, monitoring learning) and more socio-emotional (e.g., encouragement, positive appraisal) in nature. Few studies have investigated how participation in social interaction fluctuates in relation to these varying types of interaction. The aim of this study was to explore how actively students participate in cognitive and socio-emotional interaction and what characterizes the moments when participation changes during transitions between types of interaction. The first research question of this study addressed how actively students participate in cognitive and socio-emotional interaction. The second research question addressed the characteristics of the moments when participation in social interaction changes during transitions between cognitive and socio-emotional interaction. The qualitative analysis focused on the video-recorded collaborative learning of six groups of student teachers ($N = 24$). We found that the socio-emotional interaction involved more
active participation than the cognitive interaction. Changes in participation during transitions between types of interaction were characterized by shifts between domain-focused and metacognitive activities. Our findings suggest that groups’ metacognitive attention to their learning may coincide with socio-emotional interaction. Additionally, increased participation in these moments can allow groups to share perceptions of their learning, voice their feelings, and foster a positive socio-emotional climate. Afterwards, groups can return to more concentrated cognitive efforts.

5.2 Socially shared regulation of learning and participation in social interaction in collaborative learning

Earlier studies on SSRL point to a correlation between learners’ participation and manifestation of SSRL in their interaction. However, there is a lack of process-oriented evidence of the emergence of SSRL and temporal aspects of participation, acknowledging the temporal changes of these phenomena. The aim of this study was to investigate how socially SSRL emerged during the fluctuation of students’ participation in social interaction during collaborative learning. The first research question was “How does SSRL emerge during higher and lower levels of participation in social interaction?” The second research question was “How does SSRL emerge during changes in participation in social interaction?” Twenty-four student teachers in six small groups were video-recorded during collaborative tasks in mathematics. Manifestations of SSRL and students’ participation were micro-analytically coded. Next, the concurrence between manifestations of SSRL and the fluctuation of participation was examined and illustrative examples were described. The results show that SSRL involved more active participation than task-focused interaction overall and that SSRL often coincided with increases in participation to a higher level than general. The findings suggest that manifestations of SSRL involved activated participation during the moments when interaction was needed to reciprocally resolve situative challenges and coordinate activities. The findings support the premise that coordinated collaboration calls for joint efforts to regulate learning, but the emergence of SSRL requires students to activate it in reciprocal interaction. Thus, SSRL as a strategic activity has a role in the dynamics of participation in interaction in collaborative learning.
5.3 Convergences of joint, positive interactions and regulation in collaborative learning

Recent studies have tentatively suggested that groups’ efforts to regulate their learning in social interaction may correlate with how group members participate in the social interaction and the emotional tone of their interaction. However, these elements of social interaction fluctuate during the course of collaborative learning. It is less clear if regulation, participation, and expressions of emotion in social interaction fluctuate independently of each other or if they converge in social interaction in situations that influence the progress of collaborative learning. Thus, the aim of this study was to explore the frequency and function of the situations in which small groups’ joint and positive interactions and regulation converged during collaborative learning. We first examined how frequently joint participation and positive socio-emotional interaction converged with regulation. Next, we examined what functions the convergences of joint participation, positive socio-emotional interaction, and regulation served in collaborative learning. We analyzed the video-recorded social interactions of five groups of student teachers (N = 19) during their completion of environmental science tasks. The results show that when groups planned, monitored, or evaluated their learning, they participated more jointly in the social interaction and showed more socio-emotional support than when there was no observed regulation. The situations in which these elements converged served three functions: establishing agreement, responding to challenges or mistakes, and discussing strengths and weaknesses. The results suggest that convergences of joint and positive interaction and regulation in social interaction can serve a meaningful function for collaborative learning progress. These moments can help groups coordinate their learning as a collective while also attending to the socio-emotional processes of collaborative learning. These points of coordination, in turn, can allow students to return to more cognitive-oriented activities where mental capacity is needed for creating and negotiating ideas or performing task-related actions.

5.4 Striking a balance: Socio-emotional processes during argumentation in collaborative learning interaction

The majority of past empirical studies on arguing to learn as a group have focused on cognitive processes of reasoning, but a growing body of research suggests that optimal argumentation for learning also necessitates favorable socio-emotional
processes including cohesive and respectful social interaction. However, studies have often lacked a clear articulation of the features of interaction that lead to interpretations of socio-emotional processes. The aim of this study was to investigate how student teachers strike a balance between engaging in argumentation that deepens the topic under discussion while sustaining socio-emotional processes that are favorable to this in collaborative learning interaction.

First, we explored the quality of socio-emotional processes and the frequency of argumentation in groups’ collaborative learning interactions. Second, we examined how a case group sustained favorable socio-emotional processes during argumentation. The analysis was based on student teachers’ \( N = 19 \); 5 groups) collaborative learning interactions in an environmental science course and students’ self-reported perceptions of cohesion, satisfaction, and psychological safety in their groups. First, we broadly examined the quality of socio-emotional processes and the frequency of argumentation in the video-recorded collaboration (20 videos, 22 h). Based on the students’ self-reports and the frequency of joint participation and positive socio-emotional interaction, all groups showed signs of a favorable social climate for collaborative learning, but, apart from the case group, they mostly failed to engage in argumentation. Second, we conducted an inductive analysis of the socio-emotional processes during argumentation in the case group. The analysis illustrated how the case group members were able to reason together while sustaining a favorable socio-emotional climate. Their interaction was characterized by the tentativeness of claims, consideration of divergent claims, and moderate tension relaxation expressed through a wide set of communicative means. The findings highlight that cognitive and socio-emotional processes are intertwined and that neither the cognitive or socio-emotional qualities of interaction can be overlooked when studying or promoting argumentation in collaborative learning.
6 Main findings and discussion

The aim of this dissertation was to explore the interplay of cognitive and socio-emotional processes as it manifests in face-to-face social interaction during collaborative learning. I examined the topic from three perspectives: participation in cognitive and socio-emotional processes, the intertwining of cognitive and socio-emotional processes, and the functions of these processes for collaborative learning. Next, I will review and discuss the main findings from these three perspectives.

6.1 Participation in cognitive and socio-emotional processes in social interaction

Articles I–III examine teacher education students’ participation in cognitive and socio-emotional processes in social interaction during collaborative learning. Participation was a relevant perspective to analyze because participation is the infrastructure that carries social interaction (Jordan & Henderson, 1995). However, participation in social interaction fluctuates during the course of collaborative learning (Barron, 2000; Määttä et al., 2012), and it is unclear how that fluctuation relates to the emergence of cognitive and socio-emotional processes in social interaction. The results of this dissertation reveal fluctuations in how groups participated in social interaction and differences in participation between social interactions portraying cognitive and socio-emotional processes.

Articles I and II show that, overall, it was most common for some students to contribute to the social interaction while others listened or, in some cases, were disengaged. A minority of the groups’ social interactions represent moments in which all group members jointly contributed to the social interaction. Article I highlights differences in how jointly group members participated in types of social interaction portraying cognitive and socio-emotional processes, referred to as cognitive and socio-emotional interaction. The results of this study show that joint participation was proportionally more common in socio-emotional interaction while less active participation was more common in cognitive interaction, without overt socio-emotional interaction. Furthermore, increases in participation during transitions to socio-emotional interaction concurred with signs of regulation in social interaction, such as monitoring challenges or evaluating performance. In contrast, decreases in participation during transitions to cognitive interaction were characterized by concentrated domain-focused activity, such as reading instructions or checking calculations.
Articles II and III support the observation that groups participated more jointly in socio-emotional interaction and regulation in social interaction. Article II shows that joint participation was more common during manifestations of SSRL than during task-focused interaction in general. The illustrative examples further suggest that these manifestations of SSRL involved socio-emotional interaction, such as humor, discussing feelings, or supporting fellow group members. Similarly, Article III indicates that joint participation by all group members was more common in episodes with regulation in social interaction than without it. In addition, socio-emotional interaction in the form of socio-emotional support was more common in episodes with regulation in social interaction than without it.

Thus, the findings from Articles I–III suggest that groups’ participation in social interaction fluctuated, but these fluctuations were not identical in social interaction portraying cognitive and socio-emotional processes. Instead, we noted that (a) less active participation aligned with concentrated domain-focused activity and (b) more active participation aligned with socio-emotional interaction and regulation in social interaction. Based on the literature, participation during moments when groups are immersed in domain-focused activities, such as individual reflection, note-taking, or reading materials, may be more disperse because domain-focused activities require cognitive resources (Dillenbourg, 1999). When engaging in tasks that require mental capacity, resources cannot simultaneously be used for engaging in social interaction (F. Kirschner, Paas & Kirschner, 2009a) or social activities (Janssen et al., 2010). Joint participation may also be less common in challenging domain-focused interaction because students who are lower achieving or who have less confidence in their knowledge may be less inclined to contribute (Engin, 2017; Mulryan, 1992; Rocksén, 2017).

In comparison, it may be that the engaging nature of socio-emotional interaction activated joint participation, especially during moments of regulation in social interaction. According to prior research, positive emotions can trigger more active participation in interaction in the classroom and in group work (Do & Schallert, 2004; Linnenbrink-Garcia et al., 2011; Pekrun, Goetz, Titz & Perry, 2002; Pekrun & Linnenbrink-Garcia, 2012). Active participation in collaborative learning, in turn, may also enhance feelings of well-being or excitement (I. Clark & Dumas, 2015). Even negative emotions can induce participation if those negative emotions lead to positive group interaction (Linnenbrink-Garcia et al., 2011). Articles I–III provide several examples of how moments of joint participation involved students discussing emotional challenges and showing socio-emotional support to one another. These moments served as a social reinforcement for the groups’ socio-
emotional climate, which has been shown to trigger more joint participation in social interaction (Määttä et al., 2012). It is also possible that socio-emotional interaction invited more joint participation because it relaxed tension created by domain-focused activities and cognitive challenges (Andriessen et al., 2011, 2013). In other words, moments of socio-emotional interaction could be opportunities to momentarily direct cognitive resources from a challenging task to express emotions or lighten the atmosphere with humor or by giving socio-emotional support. These moments may also invite more active participation by students with less proficiency or confidence in the domain knowledge.

The findings reflect Barron’s (2000, 2003) and Roschelle and Teasley’s (1995) observations about participation in social interaction during collaborative learning: joint participation is not stable throughout collaborations; instead, divergences in joint participation are normal as long as engagement regularly converges. Based on the empirical results of this dissertation, it seems that students’ participation especially converges during moments of regulation in social interaction. This supports prior research on regulation: when a need for planning, monitoring, and evaluation emerges, students’ joint participation allows groups to externalize a need for regulation and collectively react to it (Iiskala et al., 2011, 2015; Järvenoja & Järvelä, 2013). The case examples of Articles II and III highlight that joint participation in planning, monitoring, or evaluation was necessary because the group needed to become aware of and resolve challenges and regulate their collaboration as a group.

The findings relating to the first empirical aim indicate that students may participate in social interaction more jointly when socio-emotional processes become overt or thematic in the social interaction and when the group faces a need to plan, monitor, or evaluate their learning. In fact, these triggers of joint participation may emerge in synchrony: socio-emotional processes may especially become overt or thematic in social interaction during the very moments of verbalized planning, monitoring, or evaluation. The findings also suggest that students may participate less jointly in social interaction whenever they need resources for performing concentration-demanding activities, such as thinking, reading, note taking, or performing a calculation. Thus, the resource-demanding nature of engaging in cognitive processes may influence the degree of participation. However, this is not to say that joint participation in domain-focused social interaction, such as co-elaboration of knowledge, would not be important. On the contrary, it is also crucial for achieving educational outcomes (Baker, 1999; E. G. Cohen, 1994; Dillenbourg, 1999), but the demanding nature of co-elaboration of
knowledge may make participation more dispere. In this dissertation, Article IV illustrates how argumentation emerged as a joint effort of the group members, requiring reciprocal contributions from several students, even though some students participated less actively than others.

6.2 Intertwining of cognitive and socio-emotional processes in social interaction

All empirical articles of this dissertation provide evidence of how cognitive and socio-emotional processes intertwine in social interaction during collaborative learning. I describe this intertwining of cognitive and socio-emotional processes in light of two types of social interaction in collaborative learning: regulation in social interaction and argumentation. This perspective is valuable because prior research on social interaction in collaborative learning has focused on cognitive processes, but it has often neglected the relationship between socio-emotional and cognitive processes. The results particularly illustrate that regulation and argumentation did not only emerge in social interaction as sequences of metacognitive monitoring or claims and counterarguments. Instead, they also intertwined expressions of emotion, acts of giving socio-emotional support, and subtle ways in which claims were expressed and responded to. The socio-emotional processes were not irrelevant elements of social interaction but crucially intertwined with cognitive processes and were involved in enabling regulation and argumentation in social interaction.

First, Articles I‒III illustrate how cognitive and socio-emotional processes intertwined when students regulated their learning in social interaction. Article I shows that cognitive and socio-emotional processes fluctuated in the social interaction during the course of collaborative learning: at times, the social interaction in collaborative learning could be more focused on cognitive processes, and at times socio-emotional processes also became more overt in the social interaction. The results of this study further suggest that regulation in social interaction characterized moments in which socio-emotional processes became more overt or thematic. The illustrative examples indicate, for example, that the monitoring of challenges could induce overt expressions of frustration or laughter, or interaction that boosted morale, such as encouragement. Similarly, groups’ evaluations of their performance could involve emotional appraisal, such as praising good performance.

This observation is described in further detail in Article II, in which the case examples illustrate how socio-emotional interaction occurred during
manifestations of SSRL. One example demonstrates how a challenge in solving a problem induced signs of confusion, joking, and laughter as the group monitored the problem and discussed strategies for continuing the mathematics task. Another example illustrates how a group’s orientation toward an upcoming task sparked discussions about positive and negative feelings and experiences of self-efficacy regarding mathematics tasks. Explicating feelings led the group to encourage each other, agree to help each other, and praise each other’s strengths. Positive socio-emotional interaction was not only communicated through speech but through nonverbal means, such as smiling and touching. Overall, the examples in Article II highlight how socio-emotional processes became overt or thematic in a group’s social interaction while cognitive processes simultaneously manifested in the way that the group monitored its capabilities and planned strategy use.

Article III focuses on the convergences of regulation in social interaction, positive socio-emotional interaction, and joint participation. The results reveal that episodes containing regulation in social interaction consistently involved a larger proportion of socio-emotional support, such as encouraging, praising, or explicating positive team spirit, than episodes without regulation. In social interaction without explicit regulation, socio-emotional support was considerably rarer. The case examples in Article III illustrate this intertwining in more detail. One example illustrates how monitoring a mistake in understanding led a student to negatively evaluate herself, but socio-emotional support from her peers ensured that the mistake did not become too socio-emotionally threatening to the group. Another example shows how socio-emotional support was integrally incorporated in monitoring the group’s strengths. Thus, the examples illustrate how cognitive processes, which manifested as monitoring understanding or capabilities, intertwined with socio-emotional processes that manifested as emotional expressions and socio-emotional support.

The results of Articles I–III illustrate how regulation in social interaction intertwines both cognitive and socio-emotional processes of collaborative learning. The results echo those of prior research indicating that groups that regulate productively also engage in more positive socio-emotional interaction (Rogat & Adams-Wiggins, 2015; Rogat & Linnenbrink-Garcia, 2011; Sinha et al., 2015). The current dissertation reveals that the relation between regulation and socio-emotional interaction is more than a correlation: socio-emotional interaction can be an integral component of the very moments of regulation in social interaction. For example, in planning their collaboration, groups can agree to help each other whenever needed, or in monitoring and evaluating their learning, they can explicitly
praise each other’s strengths or good performance. Some examples of other recent research support this observation (Bakhtiar et al., 2018; Järvelä et al., 2016; Lajoie et al., 2015; Ucan & Webb, 2015). The findings especially connect to recent research on the regulation of emotion in collaborative learning, which highlights that emotional expressions can open up opportunities for the group to become aware of and resolve challenges (Bakhtiar et al., 2018; Järvenoja & Järvelä, 2013; Näykki et al., 2014; Ucan & Webb, 2015).

It is known that regulation in social interaction activates groups’ metacognitive thinking and discussion about the collaboration itself, such as goals, progress, and success (Hadwin et al., 2018), thus relating to the cognitive processes of collaborative learning. However, I argue that these moments of self-observation and self-reflection may also induce emotional reactions and expressions, thus making the socio-emotional processes of collaborative learning more overt or thematic in social interaction. When the group members are dedicated to managing a positive socio-emotional climate, they can utilize instances of planning, monitoring, or evaluation to achieve socio-emotionally sound collaboration (Bakhtiar et al., 2018; Lajoie et al., 2015; Linnenbrink-Garcia et al., 2011). Even when the group faces challenges, its members can manage the situation by supporting each other socio-emotionally and regulating their emotions productively (Barron, 2003; Järvenoja & Järvelä, 2013) rather than ending up in a socio-emotional conflict (Näykki et al., 2014).

Article IV examines the intertwining of cognitive and socio-emotional processes from the perspective of argumentation. The results reveal that all groups generally showed signs of respectful and cohesive socio-emotional processes, which were indicated by positive socio-emotional interaction, joint participation, and the students’ self-reported perceptions of cohesion, psychological safety, and satisfaction. However, the groups rarely engaged in critical co-elaboration of ideas that could foster deeper-level, individual cognitive processes. Nevertheless, one group showed evidence of both a favorable socio-emotional climate and the most argumentation. In the second stage of the study, we examined a play-by-play case example of how this group sustained favorable socio-emotional processes while arguing. The episode included a long chain of counterarguments, reformulations, and elaborations, which highlighted how cognitive processes were constructed in the social interaction. The analysis also revealed the ways in which the group simultaneously constructed respectful and cohesive socio-emotional processes.

First, when the students presented arguments and counterarguments, they expressed their claims tentatively by hedging their opinions with linguistics
markers, showing signs of hesitation or reflection, or noting that they were stating a personal opinion. Second, the group showed consideration of divergent claims by seeking a better understanding of divergent proposals, indicating attunement to one another even when views were conflicting, praising others’ ideas before expressing disagreement, and explicitly stating a willingness to accept other ideas. Third, the group showed occasional tension relaxation, such as conceding to others’ views and using humor, which eased the tension created by the deepening of the debate. Thus, the episode of argumentation did not only emerge as a sequence of arguments but was also constructed through the way in which claims were expressed and responded to.

The results of Article IV extend prior research. The literature on argumentation has emphasized the importance of deliberative (Felton et al., 2009, 2015), co-constructive (Asterhan, 2013), or collaborative argumentation (Andriessen & Baker, 2014), but few studies have empirically addressed the characteristics of such argumentation in detail. Instead, cognitive processes have been targeted typically when studying and promoting argumentation (Asterhan, 2013), though argumentation is also an emotional process (Plantin, 2004; Polo et al., 2016). Article IV evidences how cognitive processes, manifesting as critical co-elaboration of ideas, intertwined subtle means of social interaction, which allowed the group to sustain respectful and cohesive socio-emotional processes. A few of these means of social interaction, such as praising others’ contributions and humor, exemplified overt expressions of emotion or encouragements. Most of the means of social interaction were more subtle, such as hedging and acknowledging divergent views, and delicately intertwined into presentations of claims, justifications, or counterarguments. Hence, the case example shows how socio-emotional processes were continuously being shaped alongside cognitive processes by the way that group members expressed themselves and attended to the group’s social interaction. However, the study also shows that, apart from the case group, most of the groups rarely accompanied their cohesive and respectful interaction with truly critical reasoning. This supports prior studies indicating that argumentative exchanges can be difficult to achieve (Kuhn, 2009, 2010; Rogat, Linnenbrink-Garcia & DiDonato, 2013; Saab, Van Joolingen & Van Hout-Wolters, 2005). Instead, most groups may have fostered social activities (Janssen et al., 2010) or a more consensual type of interaction (Weinberger & Fischer, 2006) at the expense of more critical debate.

This dissertation supports the theoretical notion that cognitive and socio-emotional processes are not mutually exclusive but closely intertwined (Kreijns et
As Kreijns et al. (2013) argue, social interaction during collaborative learning cannot be dichotomized strictly into on-task and educational interaction related to cognitive processes or off-task or social interaction related to socio-emotional processes. Rather, both cognitive and socio-emotional processes are continuously being shaped in a social interaction. This dissertation further highlights that cognitive and socio-emotional processes manifest in different ways during the temporal progress of collaborative learning and become more overt or thematic in social interaction during the course of collaborative learning. The findings highlight that socio-emotional processes may become especially overt or thematic during regulation in social interaction, which naturally also involves cognitive processes related to metacognitive knowledge. At other times, social interaction in collaborative learning can be more oriented toward cognitive processes, for example, when students engage in co-elaboration of knowledge in social interaction or perform task-related actions. Nevertheless, socio-emotional processes are shaped even in these moments. The case example of argumentation in Article IV illustrates how the case group was focused on debating over ideas and, thus, was especially oriented toward a cognitive processes. At the same time, however, the group shaped its socio-emotional processes through the tentativeness of claims, consideration of divergent claims, and occasional tension relaxation.

6.3 Functions of cognitive and socio-emotional processes in social interaction

The third empirical aim of this dissertation was to examine what function cognitive and socio-emotional processes in social interaction serve for collaborative learning. Understanding cognitive and socio-emotional processes as related and intertwined elements of social interaction supposes that the purposes of cognitive and socio-emotional processes for collaborative learning are not independent of each other. As I have shown in this dissertation, both cognitive and socio-emotional processes are involved in the moment-to-moment progress of social interaction. Therefore, I propose that these processes are mutually involved the situation-specific meanings that emerge in social interaction and the function they serve for collaborative learning. Thus, throughout the temporal progress of collaborative learning, both cognitive and socio-emotional processes in social interaction shape the collaborative learning outcomes (Kreijns et al., 2003). To shed light on how this happens, Articles I–IV illustrate the functions that cognitive and socio-emotional processes in social interaction mutually serve for collaborative learning.
Article III highlights the mutual roles of cognitive and socio-emotional processes for collaborative learning, focusing on moments of regulation in social interaction. In the study, we investigated the functions of moments in which groups showed concurrent regulation in social interaction, positive socio-emotional interaction, and joint participation. First, the analysis revealed that convergences of regulation and joint, positive interaction were helpful for groups to establish agreement on task-related ideas. In these moments, agreement was constructed through the combination of socio-emotional support indicating positive acceptance of an idea, monitoring of the group’s progress, and planning of the next steps. Second, convergences of regulation and joint, positive interaction allowed groups to respond to challenges. In these moments, the monitoring of a challenge induced expressions of emotion, which could trigger students to encourage each other or express sympathy. Thus, creating awareness and responding to challenges were constructed mutually through socio-emotional interaction and metacognitive monitoring. Third, convergences of regulation and joint, positive interaction helped groups recognize their strengths and weaknesses. In these moments, socio-emotional support was integrated into the monitoring or evaluation of statements when students positively appraised their understanding, progress, or performance. If weaknesses were discussed, they were balanced by supportive and positive appraisals. Thus, the study shows how the functions of establishing agreement, responding to challenges, and recognizing strengths and weaknesses were performed through sequences of social interaction that intertwined cognitive and socio-emotional processes.

Articles I and II support these observations. Article I illustrates how groups were able to recognize challenges and appraise the group’s performance. These moments involved, for example, monitoring performance, which simultaneously gave rise to positive or negative emotional appraisals and reactions that further led the groups to resolve challenges. Similarly, the case examples in Article II show that socio-emotional interaction, such as laughter or signs of confusion or anxiety, could be an integral part of becoming aware of the need for regulation. Further, when a need for regulation was identified, socio-emotional interaction could be used to enhance a positive socio-emotional climate and help control challenges in motivation and emotion. These moments allowed the groups to overcome obstacles and realign their joint activities so that they could proceed to more domain-focused efforts.

On the basis of Articles I–III, I argue that the interplay of cognitive and socio-emotional processes during moments of regulation in social interaction gave rise to
“points of coordination” during which groups aligned their collaborative efforts in agreement with each other, created shared understandings of their progress and capabilities, and resolved challenges. Coordinating collaborative learning was not solely accomplished through social interaction portraying cognitive processes, such as metacognitive monitoring, or socio-emotional processes, such as emotional expression. Rather, their mutual influence was crucial. These points of coordination then permitted groups to carry out concentration-demanding activities.

The findings support prior research indicating that coordinated collaboration (Barron, 2000, 2003; Janssen et al., 2010) relies on group members’ joint efforts to regulate learning (Hadwin & Oshige, 2011; Järvelä & Hadwin, 2013). By engaging in regulation in social interaction, group members can strategically continue or inhibit the course of the group’s actions during collaborative learning according to the needs of the situation (Iiskala et al., 2015; Ucan & Webb, 2015). However, the current dissertation extends prior research by highlighting that groups’ ability to coordinate their collaboration was not solely constructed by metacognitive planning, monitoring, and evaluation in social interaction. Instead, these moments were equally constructed by the expression of emotions and socio-emotional interaction, which could be embedded in regulation (Järvenoja & Järvelä, 2013). Thus, the cognitive and socio-emotional processes manifesting in the social interaction were mutually involved in exchanges that allowed the group to coordinate the learning.

Article IV sheds light on a similar interdependence between cognitive and socio-emotional processes from the perspective of argumentation. The article evinces how the intertwining of cognitive and socio-emotional processes in social interaction enabled the group to perform several functions in the service of collaborative learning: formulating and reformulating proposals, communicating (dis)agreement, deliberative reasoning, and seeking understanding. These situation-specific functions of social interaction equated from series of argumentative claims, elaborations, acceptances, and questions, which were simultaneously expressed via subtle ways of hedging, showing consideration of divergent claims, and relaxing tension. Arguably, the function of communicating disagreement, for example, does not emerge in social interaction as a cognitive process alone but equally intertwines socio-emotional processes (Baker, 2009). In other words, communicating disagreement is not solely an act of taking a divergent epistemic stance but is also an act of taking a social stance and potentially arousing emotions or threatening the face of a peer. The findings highlight that argumentation is emotionally charged (Plantin, 2004) and, thus, the way that
cognitive and socio-emotional processes manifest and intertwine during argumentation will influence the progress of collaborative learning (Andriessen et al., 2013). This dissertation illustrates how the subtle intertwining of cognitive and socio-emotional processes in argumentation allowed the case group to persistently argue while sustaining a favorable emotional framing for the critical debate (Polo et al., 2016).

In all, the findings suggest that cognitive and socio-emotional processes intertwine in social interaction and, consequently, have a mutual role in determining what function a specific moment serves for collaborative learning. Responding to challenges or communicating disagreement, for example, are not solely performed through acts of metacognitive monitoring or verbalized epistemic stances but also through expressions of emotions or ways of threatening or saving a peer’s face. Thus, cognitive and socio-emotional processes are mutually involved in the creation of situation-specific functions in social interaction. These functions guide the course of collaborative learning. For example, it is known that moments of communicating agreement or disagreement are necessary for a group to reach joint understanding of the topic or problem at hand (Barron, 2000), and recognizing and resolving challenges is crucial for making progress toward a desired goal (Bakhtiar et al., 2018; Järvenoja & Järvelä, 2013). Hence, functions emerging in social interaction are meaningful for the progress of collaborative learning and can potentially influence its outcomes.
7 Conclusions

This dissertation contributes to our understanding of the interplay of cognitive and socio-emotional processes in social interaction during collaborative learning. The results pave way for new empirical research and conceptual discussions. This dissertation also contributes to the discussion about educational practices and policies striving to strengthen learners’ abilities to collaborate efficiently and enjoyably. These theoretical, empirical, and practical implications of this dissertation will be discussed next.

7.1 Theoretical and empirical implications

Understanding the interplay of cognitive and socio-emotional processes in social interaction is important because the abilities to learn and collaborate are among the key competencies needed in the modern knowledge society. However, it is not an easy feat to achieve collaborative learning that is efficient and enjoyable. Prior research has acknowledged that collaborative learning involves both cognitive and socio-emotional processes, which are intertwined in social interaction (Kreijns et al., 2003, 2013). This means that collaborative learning requires joint efforts of multiple group members to co-elaborate knowledge as well as to interact respectfully and cohesively (Miyake & Kirschner, 2014; Van den Bossche et al., 2006). However, attempts to support more efficient and enjoyable collaborative learning have been weakened by the scarcity of research on socio-emotional processes and their relation the cognitive processes in collaborative learning (Ludvigsen, 2016), the limited understanding of the temporal progress of collaborative learning (Fischer & Järvelä, 2014), and the difficulty in making sense of the richness of social interaction (Baker, 2015). This dissertation was motivated by the lack of detailed evidence on how both cognitive and socio-emotional processes manifest and intertwine in social interaction during the moment-by-moment unfolding of collaborative learning. I argue that such information is crucial for a rich theoretical understanding of collaborative learning as an emergent process (Dillenbourg et al., 1996; Stahl, 2006), which, in turn, can be used to develop practices and tools that support people’s collaborative learning. To this end, this dissertation has provided detailed, microgenetic evidence of how cognitive and socio-emotional processes manifested in small groups’ social interactions during the progress of their collaborative learning.
The results illustrate that cognitive and socio-emotional processes of collaborative learning are not mutually exclusive but continuously intertwined in social interaction. However, cognitive and socio-emotional processes fluctuate as they manifest in social interaction over the course of collaborative learning. This dissertation shows that, at times, socio-emotional processes could become more overt or thematic in a social interaction when group members showed support for each other or talked about their feelings, for example. The results suggest that the socio-emotional processes became especially overt or thematic during moments of regulation, which also intertwined cognitive processes—namely, metacognitive planning, monitoring, and evaluation. These moments activated group members to participate in more actively in the social interaction than they generally did. Furthermore, these moments allowed groups to perform meaningful functions for collaborative learning—namely, establishing agreement, responding to challenges and mistakes, and recognizing strengths or weaknesses—which were helpful for coordinating their collaborative learning.

At other times, the social interaction could be more overtly cognitive when group members visibly focused on concentration-demanding activities. This was evidenced by their behavior (e.g., taking notes), or their speech (e.g., voicing out steps of a calculation), and the lack of overt expressions of emotion, or humor, for example. Consequently, group members could participate less jointly in the social interaction. However, even when groups focused on cognitive processes, socio-emotional processes were still intertwined, yet they could manifest more subtly than in explicit emotional expressions. The findings illustrate how a case example of argumentation in social interaction proceeded through a series of counterarguments, reformulations, and elaborations related to domain knowledge, but also involved subtle ways of expressing claims tentatively, showing consideration of divergent claims, and occasionally relaxing tension. Consequently, cognitive and socio-emotional processes were both involved in how groups communicated agreement or disagreement, sought understanding, and reasoned deliberatively, for example, which are all important functions for the progress and potential outcomes of collaborative learning. Groups did not perform these functions solely through social interaction portraying either cognitive processes or socio-emotional processes but, rather, through both. Thus, the influence of both processes must be acknowledged to support groups in performing functions that may support their ongoing learning efforts and lead them toward more efficient and enjoyable collaborative learning.
To extend these findings, I will conclude by theorizing how the interplay of cognitive and socio-emotional processes in social interaction may relate to cognitive load (P. A. Kirschner, Sweller, Kirschner & Zambrano, 2018). The results of this dissertation highlight that moments of regulation in social interaction were often those in which group participation converged and socio-emotional processes became overt or thematic. The intertwining of metacognitive planning, monitoring, or evaluation with socio-emotional interaction gave grounds for coordinating collaborative learning, which, in turn, allowed groups to continue to more concentrated domain-focused activity that was oriented toward cognitive processes and was less overtly socio-emotional. I hypothesize that this fluctuation between cognitive and socio-emotional processes in social interaction may relate to the management of cognitive load in collaborative learning. Collaboration involves extraneous cognitive load because group members must interact with each other and coordinate their learning efforts (a cost of collaboration), but they must also jointly engage with domain-specific knowledge, expand understandings, and pool each other’s information resources (a benefit of collaboration; Janssen et al., 2010; F. Kirschner et al., 2009; P. A. Kirschner, et al., 2018). Arguably, moments of regulation in social interaction can be used as means of focusing groups’ resource-consuming efforts of coordination in certain moments. In these moments, groups are also able to attend to their emotional experiences and relations and potentially foster a sense of cohesion and respect, even in the face of challenges. This, in turn, frees up resources for ensuing more domain-focused activity that requires concentration and cognitive capacity. Thus, concentrating efforts of regulation and explicit attention to the socio-emotional processes of collaborative learning in the same moments may indicate efficient use of resources. In other moments, when the group is more overtly focused on cognitive processes, socio-emotional processes may be more subtly expressed, though still subtly intertwined.

Ideally, these fluctuations between cognitive and socio-emotional processes in social interaction processes create grounds for efficient and enjoyable collaborative learning where the costs and benefits of collaboration are balanced. Hypothetically, a group that uses moments of regulation in social interaction as means to plan, monitor, or evaluate its learning and simultaneously foster a sense of respect and cohesion may subsequently be able to devote more cognitive resources to domain-focused efforts. However, it is known that collaborative learning is often far from ideal. In less optimal cases, groups may focus on regulating and fostering a positive socio-emotional climate at the expense of domain-focused activities (Janssen et al., 2010). Groups may also attend to their socio-emotional processes so much that they
avoid, for example, critical debate. This can result in quick consensus-building (Weinberger & Fischer, 2006), escaping challenging situations (Sohr et al., 2018), or excessive tension relaxation (Andriessen et al., 2011). It is also evident in this dissertation that many groups did not engage in critical discussion. Thus, achieving the optimal balance between cognitive and socio-emotional processes during collaborative learning is challenging. The dissertation shows that group members need to take joint responsibility for ensuring deep-level co-elaboration of knowledge as well as respectful and cohesive social interaction.

Future research must continue exploring how efficient and enjoyable collaborative learning emerges and how it can be supported. To this end, it is important to examine more closely how the interplay of cognitive and socio-emotional processes helps or hinders achieving efficient and enjoyable collaborative learning in different contexts. For example, it would be valuable to shed more light on how groups devote resources to cognitive and socio-emotional processes during the course of collaborative learning and how this influences the realization of the costs and benefits of collaborative learning (Janssen et al., 2010; F. Kirschner et al., 2009a; P. A. Kirschner et al., 2018). Potentially, this could lead to identifying patterns that result in better learning outcomes. The relations between regulation in social interaction and socio-emotional interaction could also be investigated in more detail in different contexts of collaborative learning. The current dissertation highlights that regulation in social interaction was commonly intertwined with socio-emotional interaction. However, more evidence is needed to see if this result is also visible in other contexts and how such convergence of regulation and socio-emotional interaction influences the outcomes of collaborative learning.

In future research, it is also necessary to address some conceptual difficulties. Cognitive and socio-emotional processes have been conceptualized in many ways in collaborative learning, and the variety of concepts is a challenge for collaborative learning research (Wise & Schwarz, 2017). Especially socio-emotional processes in collaborative learning have been approached in different ways and with different terms, such as group processes (Rogat & Linnenbrink-Garcia, 2011) or relational space (Barron, 2003). There are also different angles from which to examine socio-emotional processes in social interaction. For example, it would be important to discuss if the concept of socio-emotional interaction should include purposeful interchanges and overt expressions of emotion, such as showing frustration or encouraging peers (Bakhtiar et al., 2018; Kwon et al., 2014), or more subtle elements related to participation or ways of expressing claims, such as listening and
hedging (Asterhan, 2013; Rogat & Linnenbrink-Garcia, 2011) or face work (Brown & Levinson, 1987). I argue that defining socio-emotional interaction as purposeful interchanges and overt expressions of emotion makes the concept more manageable and focused for analysis. However, other concepts related to participation or face work, for example, are then needed to create a more holistic view of socio-emotional processes in social interaction. The field would benefit from efforts to make concepts more uniform or, at minimum, promote discussion about the similarities and differences between concepts.

7.2 Practical implications

This dissertation has implications for educational practice. Kreijns et al. (2003) suggest that the cognitive processes of collaborative learning directly relate to the educational dimension of collaborative learning, but cognitive processes are also influenced by socio-emotional processes. This dissertation highlights how this relation between cognitive and socio-emotional processes manifests and how their interplay serves meaningful functions for the progress of collaborative learning. However, the interplay of cognitive and socio-emotional processes may not be sufficiently addressed in pedagogical practice. As the research on collaborative learning has focused more on the characteristics of cognitive processes in social interaction (Baker et al., 2013; Ludvigsen, 2016; Miyake & Kirschner, 2014), the practices of supporting collaborative learning have also focused more on supporting thinking and co-elaboration of knowledge, but they have often neglected how these processes intertwine with the way that people feel or relate to each other. As a result, teachers may focus on cognitive processes in collaborative learning, which is reflected in collaborative learning goals and assessments (Le, Janssen & Wubbels, 2018). However, if teachers want to support collaborative argumentation (Andriessen & Baker, 2014), for example, it is not enough to focus on students’ ability to make claims and justifications but also on their ability to endure and moderate tension and to express themselves in a negotiable and respectful way. Task instructions and goal setting can guide students toward a more co-constructive type of argumentation rather than simply making agreements or competing with each other (Asterhan, 2013; Asterhan & Schwarz, 2016).

In addition, technologies can be used to support collaborative learning. It seems, however, that most support systems target cognitive processes, while socio-emotional processes are not typically the target of instructional design (Kreijns et al., 2013). For example, scripts and prompts that support argumentation (e.g.,
Noroozi, Weinberger, Biemans, Mulder & Chizari, 2013; Stegmann, Wecker, Weinberger & Fischer, 2012; Tsovaltzi, Judele, Puhl & Weinberger, 2017) have mostly focused on promoting cognitive processes, while less attention has been paid to how students can simultaneously sustain respectful and cohesive social interaction. Scripts, prompts, and awareness tools have also been used to promote regulation in social interaction (Miller & Hadwin, 2015), but again, these tools have mostly been used to facilitate cognitive processes (Bodemer, Janssen & Schnaubert, 2018). However, growing research also shows that scripts and prompts can facilitate socio-emotional processes, for example, by encouraging discussions about emotion or promoting adaptive emotion regulation (Belland, Kim & Hannafin, 2013; Näykki, Isohätälä, et al., 2017; Näykki, Laru, Vuopala, Siklander & Järvelä, 2019). Phielix et al. (2011) show that group members’ awareness of social and cognitive processes provided by a feedback tool and reflection tool enhanced social performance and satisfaction with group processes in online collaborative learning. Kreijns et al. (2013) suggest that sociability, social space, and social presence are key elements of collaborative learning, which should be emphasized in CSCL environments.

It is important to highlight that this dissertation did not investigate individual students’ learning outcomes. Thus, implications for educational practice should be drawn with caution and only with reference to other research. More robust evidence is needed to determine how individual learning outcomes are shaped during collaborative learning by the interplay of cognitive and socio-emotional processes. Furthermore, future research should develop tools that can provide more targeted support when needed. In particular, process-oriented studies are needed to develop tools that can track collaborative learning as an ongoing process and provide timely support (Azevedo, 2014; Järvelä et al., 2015; Miller & Hadwin, 2015; Näykki et al., 2014). In pursuing more automated support systems (Wise & Schwarz, 2017), it is important to explore forms of data where evidence does not rely solely on experts’ interpretations. For example, future research could explore how physiological measures, facial recognition, or speech recognition can capture the fluctuations of cognitive and socio-emotional processes during collaborative learning. Computational methods could further identify beneficial or counterproductive patterns. However, due to the situation-specific complexities of collaborative learning and emergent nature of meanings in social interaction, the pursuit of automatic and adaptive technologies is a challenging goal.

Finally, though the results of this dissertation are based on microgenetic analyses of small, situation-specific datasets, this dissertation contributes to the
broader discussion about how learners are able to learn and collaborate according to the needs of the 21st century (Binkley et al., 2012). The Organisation for Economic Co-operation and Development (2018) and World Economic Forum (2018) highlight that the future workforce will need to be equipped with stronger cognitive skills, but also social and emotional skills, among others. Though reports often focus on these skills as individual possessions, this dissertation illustrates that social interaction in collaborative learning is a group-level accomplishment. Thus, understanding people’s ability to learn and collaborate means more than individual capabilities but how people enact these skills with others during moment-to-moment constructions of meaning in social interactions. Thus, collaborative learning is not solely a performance of individual cognitive or emotional skills but an interactive accomplishment intertwining individual and group-level cognitive and socio-emotional processes. The findings of this dissertation especially highlight how collaborative learning unfolded in groups of Finnish teacher education students who participated in the studies. The findings are promising from the perspective of educational practice because the groups were able to engage in respectful and cohesive social interactions, and they frequently planned, monitored, and evaluated their learning as a collective. Thus, the teacher education students showed evidence of being able to collaborate and strategically guide their learning with others, which are crucial abilities for 21st century learning (Häkkinen et al., 2017). However, the scarcity of critical debate suggests that teacher educators may need to give attention to teacher education students’ opportunities and abilities to engage in argumentation.

Overall, it is relevant to continue the discussion of how people are able to engage in collaborative learning, which is essential in the modern-day knowledge society. For example, it is necessary to clarify what “collaborative competence” is and how it can be examined (Muukkonen et al., 2019). I argue that understanding collaborative competence demands paying attention to cognitive and socio-emotional processes of collaborative learning and both to individual skills and emergent group-level processes. Rating schemes that are used to assess the quality of collaborative learning (e.g., Meier, Spada & Rummel, 2007) include items that reflect both cognitive and socio-emotional processes, but the former are more prominent and the latter are underemphasized (Détienne, Baker & Burkhardt, 2012). Thus, it is topical to pay more attention to the role of socio-emotional processes in social interaction during collaborative learning. Such a need reflects the growing prominence of research on social and emotional learning, which is a framework aimed at increasing people’s social and emotional competencies to
foster satisfying interpersonal relationships, ethically responsible work, and personal development (Weissberg, Durlak, Domitrovich & Gullotta, 2015). Some evidence highlights that the interpersonal skills that people deploy during collaborative learning are beneficial for individual learning achievement, but more information is needed about how these skills are enacted between individual group members during collaborative learning (Slof, Nijdam & Janssen, 2016). The findings presented in this dissertation indicate that it is particularly important to recognize that cognitive and socio-emotional processes in social interaction are not independent elements of collaborative learning but intertwined ones, and their interplay can serve meaningful functions for collaborative learning.
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THE INTERPLAY OF COGNITIVE AND SOCIO-EMOTIONAL PROCESSES IN SOCIAL INTERACTION

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UNIVERSITY OF OULU GRADUATE SCHOOL, UNIVERSITY OF OULU, FACULTY OF EDUCATION