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Low-achieving students’ participation to collaborative learning and group-level regulation

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Low-achieving students' participation to collaborative learning and group-level regulation
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The aim of this thesis was to first explore low-achieving students' participation to collaborative group learning interaction. Second, the thesis explored low-achieving students' participation to group-level regulation of learning.

Students who regulate their own learning process, individually and in groups, have been found to achieve higher learning outcomes. In collaborative groups, students engage in interactions to negotiate strategy and construct shared knowledge. To regulate their learning, student groups actively direct their efforts, and exercise agency by controlling their learning, strategic choices, learning goals, and task engagement, rather than relying on instructors to do it for them. As such, students take an active role in their own learning, and in doing so, demonstrate a high level of self-efficacy and motivation towards learning.

In this study, 31 students, nine of which low-achieving in a physics individual examination, were selected to explore and compare low-achieving students' collaborative activity through coding and analysis of video data. Through two research questions, this thesis aimed to explore: 1) how low-achieving students participate in small group collaborative interaction, and 2) how low-achieving students participate in group-level regulation of learning.

Results suggest that some students regardless of achievement level appear considerably inactive in group-level regulation. This thesis also found that initiating regulation does not seem to be distributed evenly between group members, but rather that an individual member often has the lead in initiating group-level regulation. It also appears that low-achieving students may be less active in metacognitive interaction and less likely to take a lead role in group interaction and regulatory activities. However, larger samples of low-achieving students are necessary for generalizable results on achievement groups.

Future research should look to explore the factors influencing individual low-achieving student activity in collaborative learning and regulation of learning. The main implications to teaching should be to aim to develop effective solutions for identifying and supporting low-achieving students who are consistently inactive in collaborative learning and regulation of learning.

Keywords: achievement, collaborative learning, co-regulation of learning, interaction, participation, socially shared regulation of learning

Contents

1 Introduction

With education shifting towards increasingly student-centered, constructivist learning theories and teaching practices, an emphasis has been placed on student collaboration. However, successful collaborative learning is not an automatic process. As Dillenbourg (1999) notes, *collaboration* can be interpreted in several ways, and it is likely that some students' conceptions of collaborative work do not meet those of collaborative learning research (Patrick & Middleton, 2002). To facilitate collaboration as it is understood in research, it is important for teachers to understand what effective collaborative learning is, and how to provide such opportunities in the classroom (Patrick & Middleton, 2002).

In educational research, the concept of regulation is generally acknowledged as an essential 21st century skill (Hadwin et al., 2017). In the last 20 years, theories of self-regulation of learning have moved from conceptions of an aptitude to a more contextual process which can be taught and learned (Dillenbourg et al., 2009; Zimmerman, 2002). Self-regulation strategies have been studied in terms of developing learners who lack such skills, but in the context of computer-supported collaborative learning and regulation in groups, special needs perspectives are sparce.

Existing research suggests that interventions for learning disabilities ought to target a broader range of cognitive self-regulatory processes (Baird et al., 2009). Through self-regulation, students including those with difficulties in learning can become more active, in control, and aware of their own learning processes. Ideally, with this increased awareness, students may be able to strategically adapt their own actions, gain positive learning experiences, and gradually increase their academic self-efficacy and intrinsic motivation, ultimately leading to better academic achievement (Schunk & Mullen, 2012).

Although there is considerable evidence on the benefits of effective collaborative learning, the overall effect of the shift towards increased collaboration remains questionable among students with deficient collaboration skills. The prospective value of developing collaborative and regulatory skills among students with deficient learning skills merits further research.

2 Theoretical framework

2.1 Collaborative learning

As established by constructivist learning theory, learning is a highly interactive process. Through interaction, learners form and reshape their own conceptions (Vygotsky, 1978). In this constructivist vein, Roschelle and Teasley (1995, p. 70) define collaboration as *a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem*.

Previous research has suggested that collaborative groups can reach deeper knowledge construction and better learning outcomes through constructive and cohesive interaction (Isohätälä et al., 2021; Roschelle & Teasley, 1995). Although the potential positive effect of collaborative learning is generally acknowledged, the specific conditions in which these effects can be achieved remain open to interpretation (Slavin, 2014). As noted by Barron (2003), the benefits of collaborative learning are not achieved by simply dividing students into groups.

One important factor to consider is the type of learning task. Cohen and Arechavala-Vargas (1987) define an inherent group task as follows:

> *A group task is a task that requires resources (information, knowledge, heuristic problem-solving strategies, materials, and skills) that no single individual possesses, so that no single individual can solve the problem or accomplish the task objectives without at least some input from others.*

As put by Cohen (1994), given a problem with no one right answer and a learning task that will require all students to exchange resources, achievement gains will depend on the frequency of task-related interaction. On the other hand, if the interaction is largely off-task, a high frequency of interaction can hinder achievement (Cohen & Arechavala-Vargas, 1987). Given this type of task, collaborative group members are largely dependent on one another to reach group goals (positive goal interdependence) and need to successfully utilize each group member's resources to attain those goals (resource interdependence; Cohen 1994; Johnson & Johnson, 1990). As such, collaboration is also prone to social loafing, which refers to a decrease in individual effort due to the social presence of other group members (Latané et al., 1979).

2.1.1 Types of collaborative interaction

In a collaborative setting, interactions are the base through which students shape their learning process and regulate their cognitive and emotional processes on a group level. Going back to the definition by Roschelle and Teasley (1995), in collaboration the group constructs a shared conception of a problem through interaction. Students build shared cognition through collective cognitive activities, where group members influence each other's constructive cognitive processes by providing information, pointing things out, asking questions, and elaborating on each other's ideas (Razzouk & Johnson, 2012; Resnick, 1991). If there is no interaction, there is no collaboration. Therefore, understanding the quality of interaction helps us understand the quality of collaboration (Kreijns et al., 2003).

According to Dillenbourg et al. (1996), the following outlines have generally been used in forming analysis categories for the categorization of interaction: *social–cognitive*, *cognitive–metacognitive*, and *task–communicative*. First, at the base of this categorization process is the social–cognitive split. Central to the collaborative learning process, cognitive interaction concerns the learning task, its conceptualization, as well as strategies and processes aimed toward completing the learning task. However, cognitive processes are never independent of the social, or socio-emotional context of the group. This social context includes interactions concerning the social dynamics and relationships between group members (Dillenbourg et al., 1996).

Furthermore, socio-emotional interactions among group members shape perceptions of emotions and the socio-emotional climate, affecting group cohesion, support, efficacy, and motivation (Kreijns et al., 2003; Näykki et al., 2014; Rogat & Linnenbrink-Garcia, 2011). Positive socio-emotional interactions between group members can enhance group functioning and positive emotions during group work. Conversely, persistent negative socio-emotional interactions can hinder group functioning (Molenaar et al., 2014; Rogat & Linnenbrink-Garcia, 2011). Socio-emotional interaction plays a role in the regulation of emotions in that positive socio-emotional interactions have been linked to a higher quality of social regulation (Rogat & Adams-Wiggins, 2015; Rogat & Linnenbrink-Garcia, 2011), conflict resolution and improvement in emotions and motivation (Linnenbrink-Garcia et al. 2011; Näykki et al. 2014). Meanwhile, negative socio-emotional interactions have been connected to less effective forms of social regulation and lowered task engagement (Näykki et al. 2014, Rogat & Adams-Wiggins, 2015; Rogat & Linnenbrink-Garcia, 2011).

Second, the cognitive–metacognitive categorization separates purely task-centered learning activities from the more strategic learning activities (Dillenbourg et al., 1996). Traditionally, metacognition is defined as "knowledge about knowing", which a learner needs to control and monitor their learning (Flavell, 1979). To distinguish between cognitive and metacognitive activities, according to Nelson (1996), cognitive activities specifically deal with task content, while metacognitive activities deal with controlling and monitoring cognitive activities, such as orientation, planning, monitoring, evaluation, and reflection (Meijer et al. 2006).

As such, metacognitive activities form the basis of self-regulated learning as well as group-level regulation of learning. Group-level metacognitive activities occur when one or more group members control or monitor the group's collaborative cognitive activities (Volet et al. 2009), for example, when evaluating the quality of answers or products of the group (Molenaar et al., 2014). Shared metacognition is an essential part of interactions between group members and given that metacognitive interaction has strong ties to the level of regulation of learning activities that groups perform, there is a distinct interest to investigate the frequency of metacognitive interaction in collaborative learning (Iiskala et al., 2011; Molenaar et al., 2014).

Finally, the task–communicative dichotomy distinguishes between interactions aimed specifically at the task product construction, and the interactions aimed at forming a shared understanding between group members (Dillenbourg et al., 1996). In other words, shared cognition between team members can be seen as consisting of task knowledge on the specific procedures and strategies for successfully performing a task, and team knowledge on team processes and team members' abilities and characteristics (Cannon-Bowers et al., 1993; Johnson et al., 2007). Still, interactions focusing on task execution are not separate from the more evidently social aspects of collaboration and regulation, as interactions focusing on task execution have been found to promote socially shared planning and socially shared regulation (Malmberg et al., 2017).

In each of the three categorizations, it is understood that given their highly intertwined nature, interactions can contain elements of both categories (i.e., social *and* cognitive, cognitive *and* metacognitive, or task-centered *and* communicative; Dillenbourg et al., 1996). This means that in any such categorization, overlap should be expected, and categorizations considered mutually inclusive. This is given the assumption that group interaction reflects collaborative engagement (Järvelä et al., 2016), which consists of both emotional and cognitive engagement (Fredricks et al., 2004; Järvelä & Renninger, 2014). School engagement has been considered an important factor in possibly amending low levels of academic achievement, negative attitudes towards education, and high dropout rates (Fredricks et al., 2004).

2.1.2 Low-achieving students in collaborative settings

Previous research on collaborative learning between achievement groups has largely proposed a benefit to low-achieving students without actively impeding high-achieving students' learning outcomes. According to Cohen (1994), low achievers are helped during interaction within cooperative groups in many ways beyond specific requests for help. Thus, the use of heterogeneous groups is often recommended in collaborative learning contexts given the benefits to low-achieving students (Cohen, 1994). According to Cohen (1994), there is considerable support in the research for the beneficial effects of heterogeneous groups on low-achieving students, even when tasks demand higher order thinking. Hypothetically, low-achieving students can absorb information from interactions and receive instruction from high-achieving students. Additionally, this type of grouping can increase trust and friendliness between members of different social groups (Cohen, 1994).

Shachar (2003) concluded in a review of five studies, that while collaborative learning was somewhat beneficial to students of all achievement levels, the increase in achievement was highest among low achievers (9.3 %), and significantly lower among high achievers (1 %). Likewise, Webb et al. (1996) found that collaborative learning in a mixed-ability group can benefit low-achieving students without negative effects to high-achieving students' learning outcomes. However, in a later study Webb (2009) noted that for high-achieving students, the results of mixed-ability group work seem to be mixed based on the quality of group functioning.

Furthermore, Xin (1999) also found a collaborative learning setting beneficial to the academic achievement of students with learning disabilities, in comparison to a traditional general education classroom setting. Jenkins et al. (2003) mapped class teachers' perceptions of collaborative learning for special education students and found that teachers were generally positive, while acknowledging that the effectiveness of collaborative learning varied from student to student. The benefits they reported included improved self-esteem, a safe learning environment, and better classroom success rates and products.

Research has also suggested that collaborative learning has a positive effect on peer-acceptance and social interaction of students with learning disabilities (Johnson & Johnson, 1986; Putnam et al., 1996). Ashman (2003) notes, however, that a sufficient level of social interaction skill is needed for successful collaboration, and the attainment of this positive effect. Cohen (1994) argues that when low-status and low-achieving students show engagement and competence in their collaborative learning groups, interaction is more equal-status and reinforces peer acceptance.

Balanced participation between group members is essential to successful collaboration (Bachour et al., 2008). In a classroom setting, unbalanced participation typically means that one or more members in a collaborative learning group take very few turns in verbal communication. According to Adams-Wiggins and Rogat (2014), high-achieving students or students with high social status may dominate interaction in a collaborative setting. In a previous study by King (1993), high-achieving students assumed dominant roles in group tasks, group decision making, and in the frequency and quality of contributions to group efforts, while low-achievers were generally passive during collaboration.

Verbally inactive students contribute little to the construction of shared conceptions and may miss out on reassessing and developing their own understanding of concepts. Typically, this lends itself to lower learning outcomes in groups with unbalanced participation (Bachour et al., 2008). As found by Rogat and Linnenbrink-Garcia (2011), some groups may also decide to forgo a collaborative effort in favor of dividing tasks into smaller individual tasks, which bypasses a collaborative constructive process altogether.

To closely examine individual students' differences in volume and quality of participation to interaction, individual roles in group interaction have been discussed for decades, including the 26 role categories of Benne and Sheats (1948) some seventy years ago. Salazar noted already in 1996, that much of the original small group interaction research such as that of Benne and Sheats (1948) and Goffman (1959) is too static to capture the complexity of human behavior. While this classical research still offers a basis for contemporary research, it is now generally acknowledged that during dynamic and spontaneous group interaction individuals can perform several roles within short interaction segments (Chiu, 2000). Yet, as noted by Heinimäki et al. (2020), given that much of previous research has utilized pre-assigned, scripted, or rigid student roles, an understanding of the roles that emerge spontaneously during student-led collaborative activities is still lacking.

In recent years, interaction roles have been approached with a selection of more fluid categorizations. Chiu (2000) proposed a categorization of five interaction roles (facilitator, proposer, supporter, critic, recorder). Similarly, Gu et al. (2015) utilized a pre-assigned role structure including six roles (starter, supporter, arguer, questioner, challenger, timer). Meanwhile, Volet et al. (2017) adapted Benne and Sheats' 26-role coding to that of ten categories (information seeker, information giver, knowledge seeker, knowledge provider, opinion seeker, opinion giver, follower, supporter, challenger, harmonizer). Lastly, Törmänen et al. (2021) utilized a four-category coding scheme (initiator, participator, observer, target) to specifically examine emotion regulation.

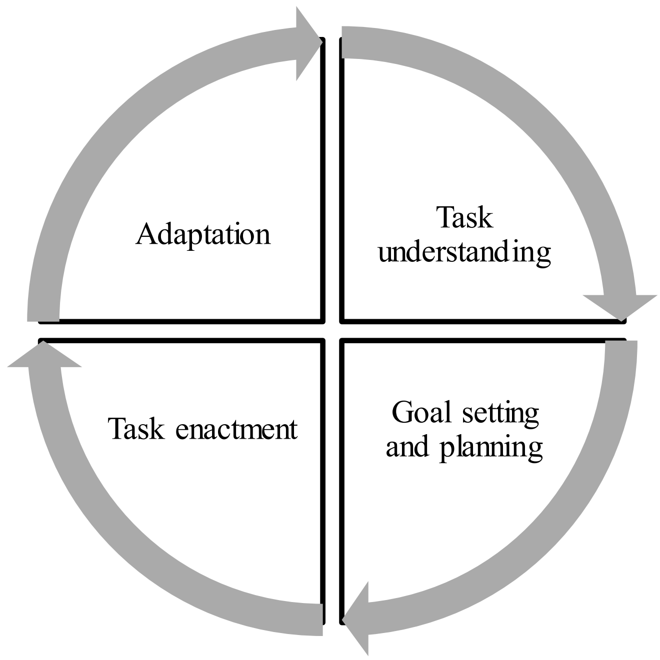
2.2 Regulation of learning

Successful collaborative learning begins on an individual level, as students need to possess skills for successful learning both in individual and collaborative settings. Today, considered a central part of an individual's learning process is the concept of *self-regulated learning* (SRL) (Hadwin et al., 2017; Zimmerman, 1989). Self-regulating students initiate and direct their own efforts to acquire knowledge and skill rather than relying on teachers or other instructors. As such, self-regulating students are metacognitively, motivationally, and behaviorally active participants in their own learning process (Zimmerman, 1989). Students exercise agency by consciously controlling and intervening in their learning, making choices, setting goals, and controlling their own engagement in a task (Winne & Hadwin, 2012).

Regulation of learning is conceptualized by Winne and Hadwin (1998, 2012) as four loosely sequential and recurring phases: 1) task understanding, during which learners form a mental representation of the task; 2) goal setting and planning, during which learners set goals and strategize to meet task demands; 3) task enactment, during which learners enact tactics to achieve goals; and 4) adaptation, during which learners strategically adapt the previous three phases for future tasks (Figure 1).

Figure 1

Cyclical Model of SRL (Adapted From Winne & Hadwin, 1998, 2012)



In Winne and Hadwin's work (1998, 2012) this cyclical model is accompanied by a framework called COPES (conditions, operations, products, evaluations, and standards) in each SRL phase (see Table 1).

Table 1

COPES Model (Adapted From Winne & Hadwin, 2012)

Conditions	Internal (e.g., motivation, self-efficacy) and external (e.g., time constraints, resources) conditions form a context for working on a task.
Operations	Operations are the cognitive processing of information, the work towards solving a learning task.
Products	Learners' operations result in products in each SRL cycle phase.
Evaluations	Evaluations are made of each product to determine how well they meet standards.
Standards	Standards represent optimal products in each phase.

The COPES model underlies each phase of regulation and guides transition across phases. Within internal and external conditions, students cognitively process information through operations, resulting in products in each of the four phases of SRL. The products of the *Goal setting and planning* phase, for example, would be the set goals and plans. Finally, students evaluate the products by comparing them to set or perceived standards (Winne & Hadwin, 2012).

SRL bases on three central elements: students' self-regulated learning strategies, self-efficacy perceptions of performance skill, and commitment to academic goals. Self-regulated learning strategies are processes directed towards achieving academic goals such as learning a skill, or acquiring relevant information (Winne & Hadwin, 2012). As outlined by Zimmerman and Martinez-Pons (1986), these strategies include seeking, organizing, and transforming information, and rehearsing or using memory aids.

However, collaborative learning cannot come to pass through individual processes alone. As outlined by Järvelä and Hadwin (2013), successful collaboration requires regulatory action on three distinct levels. In successful collaboration, each group member regulates their individual learning processes (*self-regulated learning*), but also supports fellow group members in their respective regulation of learning (*co-regulated learning*). Additionally, the group must regulate their learning processes collectively and synchronously as a group (*socially shared regulation of learning*). Whereas *self-regulated learning* (SRL) is an individual process, often internal and undetectable or challenging to identify from observational data, co- and socially shared regulation of learning are group-level processes (Hadwin et al., 2017). These group-level processes are interactional by nature, and as such, explicitly detectable in student interaction.

Co-regulation of learning (CoRL) is a temporary and shifting support enabling productive self-regulation by the student being co-regulated, or shared regulation by the group. Effective co-regulation shifts individuals' or groups' attention towards correcting their learning process. This occurs by temporarily redirecting the regulation process of cognition, motivation, emotion, or behavior as necessary (Hadwin et al., 2017). Transactional by nature, it presumes that at least one participant in an interaction, the co-regulator, has knowledge or skill that is needed and shared by those being regulated. However, the co-regulator role can shift from student to student depending on who needs and who is able to provide regulatory support at a given time, hence not implying repetitive initiation by a single more capable other (Hadwin et al., 2017; Perry & Winne, 2013).

Socially shared regulation of learning (SSRL) refers to a group's deliberate, strategic, and transactive planning, task enactment, reflection, and adaptation (Hadwin et al., 2017). Socially shared regulation occurs when collaborators co-construct understandings about tasks and shape engagement by pooling metacognitive, motivational, and strategic resources, then negotiating and selecting what the group perceives to be an optimal path to reach common goals. Shared regulation of learning implies shared awareness of goals, and joint monitoring of progress toward a shared outcome (Perry & Winne, 2013).

A lack of regulation can hamper individual learning and group functioning (Barron, 2000). If group members cannot regulate their learning, they may repeat their own opinions, ignore others' suggestions, or refuse others' proposals (Webb, 2013). Previous research has suggested that on the group level, students engage mostly in co-regulation of learning (Malmberg et al., 2015). According to Malmberg et al. (2015), low-performing groups focus on managing external aspects of the collaboration through SSRL, whereas high-performing groups focus on cognitive challenges and temporally progressed from external towards internal challenges like group members' motivation. Research has also strongly suggested that the quality of students' metacognitive and regulatory processes improves with age (e.g., Grau et al., 2018; van der Stel & Veenman, 2010).

Prior research has suggested that academic performance is linked to both the cognitive strategies and metacognitive processes of self-regulated learning (Dent & Koenka, 2016). Consequently, there is a need to develop self-regulated learning skills among students with repeated poor academic performance. The lack of such skills may present itself in several ways. Lack of regulation is thought to lead to lowered optimism and task avoidance strategies, as well as decreased interest and increased stress and exhaustion (Heikkilä et al., 2011, 2012). Task-avoidant strategies have been found to predict poor academic achievement, and furthermore, poor achievement can lead to further task avoidance, thus forming a cumulative cycle of poor academic achievement (Nurmi et al., 2003).

According to Baird et al. (2009) youth with a learning disability were also more likely to possess low academic self-efficacy, to believe that intelligence was fixed and nonmalleable as opposed to incremental and changeable, and to interpret the exertion of effort as meaning they possessed limited levels of ability. To remedy these obstacles to learning, Järvelä et al. (2015) suggest three principles for supporting group-level regulation of learning: 1) increasing learners' awareness of their own and others' learning processes, 2) supporting externalization of learning processes, and 3) prompting regulatory processes.

2.3 Regulation as a mediator of academic performance

Positive interaction and successful collaboration can have profound effects on how students view learning situations and themselves in relation to education (Li et al., 2021; Prince & Nurius, 2014; Wentzel & Caldwell, 1997). To maintain positive interaction, and to succeed in collaborative tasks, successful collaborative groups rely on regulation of learning on the individual and group level, by actively monitoring and adapting their metacognitive and socio-emotional processes and strategies (Hadwin et al., 2017). Conversely, groups that interact negatively and are not able to actively engage in regulation of learning may end up achieving poorly in collaborative tasks (Lodewyk et al., 2009).

Where task achievement and group interactions affect collaborative engagement, on a larger scale, academic achievement along with positive experiences and school interactions are vital to the school engagement of students (Fredricks et al., 2004; Sinha et al., 2015). Like regulation of learning, engagement is a multi-faceted construct consisting of both emotional and cognitive engagement (Fredricks et al., 2004; Järvelä & Renninger, 2014; Sinha et al., 2015). As highly interrelated concepts, different facets of engagement are thought to play a central role in academic achievement, and in resolving issues with underachievement, truancy, and dropout (Fredricks et al., 2004; Wang et al., 2015). More specifically, student engagement enables an active, self-regulated and strategic way of approaching learning tasks (Sinha et al., 2015). Other research has also linked self-efficacy to positive schoolwork engagement, and positive engagement to life satisfaction, while negative schoolwork engagement has been linked to burnout (Salmela-Aro & Upadyaya, 2014).

Regulation of learning is a socio-historically and contextually situated process. According to Dent and Koenka (2016), prior achievement can affect subsequent SRL processes, which in turn can affect subsequent achievement. Therefore, Hirt et al. (2021) suggest that studies on differences between low and high achievers' self-regulated learning should consider prior achievement as possible different starting points for upcoming tasks. As stated by Hadwin et al. (2017, p. 86), *individual and collective beliefs and experiences create a set of shared conditions continually shaping and being shaped by joint task engagement*. This remark ties into the concept of self-efficacy.

Self-efficacy refers to the beliefs in one's own abilities to carry out a desired course of action (Bandura, 1997). In Winne and Hadwin's (1998, 2012) COPES model, self-efficacy is part of the internal conditions that underlie regulation throughout the SRL cycle. As such, students' self-efficacy perceptions are the basis for SRL strategy use (Winne & Hadwin, 2012). Students with high self-efficacy perceptions make better use of cognitive strategies, monitor, and regulate their learning closer, and manage their time and work environment more efficiently (Bandura, 1997). As noted by Schunk and DiBenedetto (2016), students with high self-efficacy generally participate more readily, work harder, persist longer, and exhibit better learning achievement.

Experiences of self-efficacy can be dependent on several factors, and in a classroom context, self-efficacy can be linked to behavior like differing verbal engagement (Jurik et al., 2013). Existing research offers extensive evidence for male students exhibiting higher self-efficacy measures in physics education (e.g., Marshman et al., 2018; Nissen, 2019; Stoeckel & Roehrig, 2021) than their female peers. On the other hand, research has indicated that males are more likely to show overconfidence in their task ability (e.g., Herbst, 2020; Hewitt, 2015; Pulford & Colman, 1997) and performance relative to peers (e.g., Ring et al., 2016).

Along with self-efficacy, motivation is a key requirement for the performance of regulatory actions (Zimmerman & Schunk, 2008). Students with high self-efficacy exhibit higher interest towards learning, and by engaging in regulatory tasks, students display a level of intrinsic motivation towards learning or achieving academic goals (Schunk & DiBenedetto, 2016; Zimmerman & Schunk, 2008). As outlined by Bandura (1997), efficacy beliefs can also be influenced by peer modeling, which is a particularly valuable consideration in the context of collaborative learning. To students mirroring a level of efficacy, effort, or strategy use, perceived similarity to a peer can suggest an attainable level of achievement (Bandura, 1997). This means that such an effect would be weakened when students are to model a teacher, or a student perceived substantially more capable than oneself. This potentially negative effect of dissimilar peers could likewise be worth considering in the assignment of collaborative learning groups.

In the field of special education, low achievement level and its effects on self-efficacy have previously been researched in the context of learning disabilities. Research on the self-efficacy of students with learning disabilities has produced varying results (Klassen & Lynch, 2007). It is generally acknowledged that poor academic performance can lead to decreased motivation in academic tasks, lower effort in such tasks, and in turn to repeated poor performance.

Children with academic difficulties have been shown to report lower academic self-efficacy (Multon et al., 1991; Klassen, 2002). In a meta-analysis, Multon et al. (1991) found that the association between self-efficacy and academic performance was stronger among low-achieving students than among typically achieving students. Even then, it has been reported that students with learning disabilities can approach academic tasks with self-efficacy beliefs that, while lower than of peers without learning disabilities, still in fact overstate their actual ability to complete an academic task (Klassen, 2002; Klassen & Lynch, 2007). On the other hand, Hirt et al. (2021) did not find a significant difference in self-efficacy between low-achieving and high-achieving students but did find one in intrinsic motivation.

As low self-efficacy is assumed to decrease persistence to work hard, especially when facing difficulties (Bandura, 1997), low self-efficacy can be especially harmful for children with learning difficulties, who need to practice harder than their typically learning peers to achieve academic skills. A lower self-efficacy in students with learning difficulties or learning disabilities is generally attributed to them having less access to efficacy-building positive experiences (Hampton & Mason, 2003). Students with difficulties in learning may have fewer opportunities to experience success than their peers (Hampton & Mason, 2003; Usher & Pajares, 2006). Moreover, long-standing previous research has suggested that teachers interact with and praise high-achieving students more, as well as afford them more opportunities to respond. Meanwhile, low-achieving students may receive disproportionate criticism (Brophy & Good, 1974).

This would suggest that to boost self-efficacy among students with learning difficulties or disabilities, special attention should be placed both on the challenge level of tasks and support in skill training, as well as on feedback and activities (Koponen et al., 2021). Recently, Koponen et al. (2021) noted that there is still a lack of knowledge about whether self-efficacy can be supported by providing positive source experiences, especially among children with learning difficulties or disabilities. If it is assumed that exposure to positive source experiences positively influences effort and persistence in learning situations, it would be important to provide these experiences especially to students with learning difficulties or poor learning outcomes (Koponen et al., 2021). Promoting regulation can offer teachers a way to support low-achieving students' learning processes, potentially improving learning outcomes, self-efficacy, and ultimately school engagement (Järvelä & Renninger, 2014).

3 Aim

The aim of this master's thesis is to explore the behavior of low-achieving students during a collaborative learning session. Previous research has identified the need to pay closer attention to individual students' contribution to collaboration (Panadero & Järvelä, 2015; Winne et al., 2010). Additionally, as proposed by Cohen (1994), research should aim to develop an understanding of the interaction of heterogeneous groups and the ways in which interaction in heterogeneous groups proves effective in assisting the learning of the low achiever.

For teachers to offer more efficient support during a learning process, and to facilitate effective collaborative processes among students, it is important to gauge the challenges faced during the collaborative learning process. In the study of collaborative learning and regulation, special needs perspectives are few and far between, but as learning difficulties or challenges in learning in general are not separate from collaborative settings, this thesis aims to explore that gap in research.

To explore low-achieving students' participation in the collaborative learning process, this thesis aims to examine student activity through the following questions:

1. How do low-achieving students participate in collaborative interaction?
2. How do low-achieving students participate in regulation of learning?

4 Methodology

4.1 Context and participants

Data collection was completed in a flipped classroom (see Jovanovic et al., 2019) collaborative learning setting during authentic mainstream education middle school physics classes in small groups of three or four members. The science topic was derived from the national physics curriculum and focused on the wave motion of light and sound. The students completed four 90-minute learning sessions. Additionally, students completed a collaborative exam session and an individual exam. Video data was captured using 360° cameras and microphone-recorded audio. The data collection was completed over a seven-week period.

Nine students (4 male, 5 female), or 10 % of the entire dataset with the lowest achievement level in the individual physics examination were identified from the complete dataset of 94 students. As data was collected in a small group learning setting, 22 groupmates of the low-achieving students were included in the subset of this study for a total of 31 students (15 male, 16 female) across nine small groups.

4.2 Inclusion criteria

The students scoring below the tenth percentile of the dataset in the individual examination, nine in total, were selected as the main study group in the present study. This group is henceforth referred to as *low-achieving*. The selection of this group was based solely on individual test achievement, and *low-achieving* in this context refers only to achievement in this examination.

Groups with no low-achieving students were not included in the present study. Two high-achieving students are denoted as such in the individual student participation figures (Figure 4; Appendices).

4.3 Data analysis

The present study utilizes a case study methodology to explore the complexity of student behavior in a classroom setting during a collaborative learning session. As noted in previous methodological research (Butler & Cartier, 2017; Yin, 2014), a case study approach allows for a detailed investigation of how these complex relationships occur and evolve in their authentic context.

Video data was analyzed in three phases. In the first phase, the entire video data was coded for type of interaction, and participation to interaction. In the second phase, the data was then coded for group-level regulation of learning. Phases 1 and 2 were performed between two researchers. The thesis author participated in Phase 2 of analysis focusing on identifying group-level regulation of learning, but not Phase 1, which had been completed previously (Järvenoja et al., 2020). In the third phase, regulatory episodes were coded for individual roles during regulation. Phase 1 established a 30-second segmentation throughout the data, on which the type of interaction and participation to interaction were coded.

4.3.1 Interaction type and participation

Prior to the present study, student interaction was observed from the video data and categorized in 30-second segments according to Table 2, either as metacognitive, socio-emotional, or off-topic interaction, or as task execution. As detailed in section 2.1, metacognitive interaction was specified as interaction aimed at planning, monitoring, or controlling cognitive processes. Thus, metacognitive interaction is differentiated from task execution such as discussion on task material and content, directly discussing task solutions, as well as any physical work towards task completion (Nelson, 1996). Task execution could also be coded without interaction taking place to indicate work towards task completion. Socio-emotional interaction was coded where students indicated affect or emotional charge. Socio-emotional interaction was not considered mutually exclusive with metacognitive interaction or any other activity, rather all types of interaction codes could occur within a single 30-second segment (Järvelä et al., 2016).

Table 2

Coding Scheme for Type of Interaction

Interaction type	Description	Example
Metacognitive interaction was coded when student interaction involved planning, monitoring, or controlling of cognitive processes.	Discussing task goals, task understanding, prior knowledge, procedures or strategies to solve tasks, evaluating task progress or overall progress, evaluating task solution.	"Do you know how to do this?" "I do not understand this task." "Everyone else is already done."
Socio-emotional interaction was coded when students expressed verbal or otherwise clear indicators of affect or made an emotionally charged comment.	Positive or negative content or tone of voice; smiling, laughing, joking, praising, singing or dancing; sarcasm, sighing, whining, groaning, criticizing, or arguing.	"Woohoo!" "I hate physics." "We are so going to fail this exam."
Task execution was coded to indicate concrete work towards task completion. No interaction was required.	Reading or discussing task material or content, executing task-related measurement or calculation, otherwise physically executing task experiment, writing down calculation or answer.	"Now, I will take a pencil… I can draw it, you hold [the ruler] in place." "Here is 1,75. So that's 100 centimeters and… 175 centimeters. There." "What was the answer to exercise 3?"
Off-topic interaction was coded when student interaction was not related to task.	Other school-related issues, leisurely activities and unrelated personal relations, research setting.	"Did you study for the health education exam?" "Come play soccer with me after school."

In addition to the type of interactivity, individual students' participation to interactivity was indicated. This code indicated which of the group members were verbally contributing within each 30-second segment. However, this coding did not indicate which individual student had contributed which type of interaction. Table 3 presents an adaptation of the kind of information produced by the interaction type and participation coding.

Table 3

Example of Interaction Type and Participation Coding

Time (segment)	Number of participants	Participants	Type of interaction
00:00–00:30	3	Student 1, Student 2, Student 3	Metacognitive interaction, socio-emotional interaction, off-topic interaction
00:30–01:00	2	Student 1, Student 3	Task execution, off-topic interaction

4.3.2 Group-level regulation

The emergence of group-level regulation was then observed from the previously identified interaction sequences in the video data. Group-level regulation could only be coded within segments containing metacognitive or socio-emotional interaction. Regulation of learning consisted of co- and socially shared regulation activities targeted to group members' cognition, motivation and emotions, and behavior (Hadwin et al., 2018). Accordingly, regulation of learning was coded when the group members faced a metacognitive, motivational, or emotional obstacle in their learning process and in consequence, regulation was carried out by an individual group member (co-regulation, see Table 4) or by shared strategic negotiation between group members (socially shared regulation, see Table 5), and furthermore, followed by a strategic change in action.

Table 4

Structure of a Co-Regulation Event

Student	Utterance/action	Function
	[Student 2 is inactive]	Obstacle in learning process
S1	Are you not writing this down?	Regulatory initiation
S2	Oh. I could, yeah.	Response
	[Student 2 starts writing down an answer]	Strategic change in action

Table 5

Structure of a Socially Shared Regulation Event

Student	Utterance/action	Function
	[The table is too crowded for instruments]	Obstacle in learning process
S1	Let's take our books over to the side.	Regulatory initiation
S2	No, let's not.	Shared strategic negotiation
S3	Yeah, we will.	
S1	Let's, because we don't have enough space.	
S2	But what if we have to check the book?	
S3	We won't have to.	
S1	Let's leave one book.	
S2	You're the smart one, you leave your book.	
	[Group leaves one book at the table, takes others away for extra space]	Strategic change in action

When regulation targeted emotions or motivation, it could be coded without a clear obstacle or change in action to allow for strategic maintaining and strengthening of already favorable motivational and affective conditions (Järvelä et al., 2008; Järvenoja et al., 2019). Table 6 presents an example of a basic regulation event where Student 1 maintains an already favorable group socio-emotional climate by praising the group effort. This initiation is preceded by typically progressing group work with no apparent obstacles to learning and is not followed by any strategic change in the task progress.

Table 6

Regulation Event Without a Clear Obstacle to Learning or Change in Action

Student	Utterance/action	Function
	[Students work on task]	No obstacle to learning
S1	We're so good at this!	Regulatory initiation
S2	Yeah!	Response
	[Continuation of task as previously]	No strategic change in action

The unit of analysis was a meaningful episode. An episode was coded to start when a regulatory initiation was observed and ended when the criterion of a regulation event could not be reached anymore. The coding scheme for group-level regulation is presented in Table 7.

Table 7

Coding Scheme for Group-Level Regulatory Events

Regulation type	Description	Example
Co-regulated learning (CoRL)	Co-regulated learning was coded when the following occurred: 1) Observation of an obstacle to learning process 2) Regulatory initiation from group member 3) No additional strategic content from other group members 4) Strategic change in action. When CoRL was targeted to emotions and motivation, it could be coded without a clear obstacle or change in action to allow the strategic activities aiming to maintain and strengthen the already favorable motivational and affective conditions.	[S1 is frustrated] S1: We are going to get an F. S2: No, we are not! We are getting an A.
Socially shared regulation of learning (SSRL)	Socially shared regulation of learning was coded when the following occurred: 1) Observation of an obstacle to group's learning process 2) Regulatory initiation from group member 3) Active shared strategic negotiation between at least two group members 4) Strategic change in action. When SSRL was targeted to emotions and motivation, it could be coded without a clear obstacle or change in action to allow the strategic activities aiming to maintain and strengthen the already favorable motivational and affective conditions.	[Students maintain motivational conditions] S1: "It's great that we are all participating." S2: "Yes, everyone participates!" S1: "...So then everyone is going to get an A." S3 [laughs]: "Yep!" S4 [laughs]: "Well, of course."

Interrater coding for the incidence and type of group-level regulation was performed for 10 % of the complete video data by another researcher. Reliability was assessed using Cohen's kappa. The mean kappa value for regulatory episodes was 0.79, which indicates substantial interrater agreement (Landis & Koch, 1977). 11 % of the data included in the subset of the current study was assessed for reliability as part of the interrater coding. The mean kappa value for the subset of the current study was 0.82.

4.3.3 Individual student participation and roles during regulation

Participation to metacognitive, socio-emotional, and off-topic interaction were examined on the individual level by calculating the proportional within-group participation as a percentage for all 31 students included in the analysis (see Appendices). To further understand the relationship of different interactions, Pearson's correlation coefficients were calculated for types of interaction combined for the 31 students. Participation to interaction was then compared between low-achieving (n = 9) and other students (n = 22).

Previously coded co-regulation and socially shared regulation were then examined on the individual level through the assignment of student roles to video recordings of regulatory episodes. This approach was taken to explore how low-achieving students contribute to group-level regulation of learning. Contributions to group-level regulation of learning were compared between achievement levels, as well as further explored among the low-achieving student group. Assignment of roles during regulation was done on the meaningful event level.

The coding scheme utilized was based on the categories by Törmänen et al. (2021), as well as Volet et al. (2017) whose original coding was primarily based on Benne and Sheats' (1948) functional roles and Chiu's (2000) productive roles. In essence, the roles of *follower* and *monitor* adapted from Volet et al.'s (2017) categorization were added to the Törmänen et al. (2021) model. The final coding scheme for student roles during regulatory episodes is presented in Table 8, followed by a brief outline of the coding decisions.

Table 8

Coding Scheme for Individual Roles During Regulation Events

Initiator	Contributor	Follower	Monitor	Target	Observer	Absent
Initiating regulation	Making additional regulatory contributions	Showing support or agreement with regulatory contributions	Calls attention to obstacle, progress, or emotional state	Target of co-regulation	Not participating in regulatory interaction	Momentarily physically absent

- An *initiator* was coded for each regulation event, as the group member making the primary initiative for group-level regulatory activity.
- Any students making additional suggestions or other contributions with new regulatory content were coded as *contributors*.
- Volet et al.'s (2017) *supporter* and *follower* categories were conflated under a single *follower* category for students expressing agreement with a previous regulatory contribution without making an original regulatory contribution.
- The role of *monitor* was assigned to any students making note of the group progress or an obstacle to progress, including calling attention to one's own emotional state or lacking task understanding, without making a regulatory contribution.
- The *target* category was assigned to a student who is the target of a co-regulatory initiation by another group member.
- A student was marked as an *observer* if they do not participate in the regulatory activity, including where a student continues executing or discussing the task or other issues not pertinent to regulation of learning simultaneously with the regulation event.
- A student was marked as *absent* when they are momentarily physically absent from the group during a regulation event but are in attendance for the session.

Students could be assigned more than one role in a regulatory episode if the nature of their contribution clearly spanned two different functions during an episode. Although the following examples are presented utterance-by-utterance for clarity, roles were not assigned to each utterance but rather the overall role of the student during a regulation episode. Interrater reliability was assessed for individual roles in 25 % of regulation episodes by another researcher and resulted in average Kappa value 0.86, indicating almost perfect agreement (Landis & Koch, 1977).

Table 9 presents a co-regulation episode in which Student 1 prompts inactive Student 2 to write down the answer to an exercise. In this episode, S1 is the initiator of co-regulation, while S2 is the target of co-regulation. Other group members do not take part in this regulation episode and are coded as observers.

Table 9

Example of Regulation Role Coding, Co-Regulation Episode

Student	Utterance	Role
S1	Are you not writing this down?	Initiator
S2	Oh. I could, yeah.	Target
S3	[Works quietly throughout]	Observer

Table 10 shows an example of regulation role coding in a socially shared regulation event. Student 1 showcases the *monitor* role by bringing attention to a problem without explicitly proposing a solution. Student 2 proposes a solution to the problem and is given the *initiator* role. Student 3 chimes in with meaningful additional contributions and is assigned the *contributor* role. Meanwhile, student 4 continues to work on the task throughout without participating in the regulatory interaction and is assigned the role of *observer*.

Table 10

Example of Regulation Role Coding, SSRL Episode

Student	Utterance	Role
S1	Hey, it would be nice if I could see the exercise, too!	Monitor
S2	Oops! [Grabs exercise sheet, looks to place it somewhere]	Initiator
S3	[laughs] Sorry!	Contributor
S2	We can… well, we can place the exercise sheet here, and everyone can take it when they need it.	Initiator
S3	As long as no one… neither of you… [trails off]	Contributor
S4	[Works quietly throughout]	Observer

5 Results

5.1 How do low-achieving students participate in collaborative interaction?

To establish a general outlook, an exploration of the nine small groups' interaction shows that over 30 sessions ($M = 3.33$ / group), metacognitive interaction ($f = 1432$) and socio-emotional interaction ($f = 1317$) are moderately correlated, and socio-emotional and off-topic interaction ($f = 661$) are strongly correlated, while metacognitive and off-topic interaction are only weakly correlated (Table 11). Overall, this shows that student interaction regularly includes both metacognitive and socio-emotional elements. Moreover, closer inspection suggests that socio-emotional interaction often went hand in hand with off-topic interaction, while students more rarely veered off topic when metacognitive elements were being discussed.

Table 11

Frequency and Correlation Between Interaction Types

Measure	*n*	*M*	*SD*	1	2	3
1. Metacognitive interaction	1432	47.73	16.54	—		
2. Socio-emotional interaction	1317	43.90	29.92	.596**	—	
3. Off-topic interaction	661	22.03	21.75	.303	.853**	—

** $p < .01$.

Groups' frequency of interaction is presented in Table 12. Group mean values for interaction type incidence per session varied heavily, ranging from 22.00 to 65.75 for metacognitive interaction, from 11.00 to 88.33 for socio-emotional interaction, and from 3.00 to 51.33 for off-topic interaction. Table 12 reveals differing profiles between groups. For example, Group 1 participates actively in metacognitive and socio-emotional interaction but not off-topic interaction. Group 3 engages actively in metacognitive interaction but noticeably less in socio-emotional and off-topic interaction. Meanwhile, Group 8 engages considerably more in socio-emotional interaction than other interaction types.

Table 12

Group-by-Group Total Frequency and Session Mean of Interaction Types

Group	No. of sessions	Metacognitive interaction		Socio-emotional interaction		Off-topic interaction	
		f	*M*	*f*	*M*	*f*	*M*
G1	4	216	54.00	169	42.25	39	9.75
G2	1	47	47.00	54	54.00	33	33.00
G3	4	184	46.00	59	14.75	30	7.50
G4	4	160	40.00	171	42.75	92	23.00
G5	3	93	31.00	33	11.00	9	3.00
G6	3	66	22.00	61	20.33	31	10.33
G7	4	263	65.75	217	54.25	95	23.75
G8	3	147	49.00	265	88.33	154	51.33
G9	4	256	64.00	288	72.00	178	44.50

Next, after some general remarks, the analysis was directed towards the individual level. For individual student participation, the results suggest that on average, low-achieving students participate somewhat less in metacognitive interaction (*M* = 33.93, *SD* = 15.39) than their peers (*M* = 41.73, *SD* = 18.49), but only negligibly more in socio-emotional interaction (*M* = 38.37, *SD* = 29.54) than their peers (*M* = 37.71, *SD* = 27.34). Likewise, for off-topic interaction, the participation for low-achieving students is narrowly higher (*M* = 21.22, *SD* = 22.03) than that of their peers (*M* = 19.05, *SD* = 20.01).

Independent samples Mann-Whitney *U* tests were performed to further investigate the differences in participation to interaction between low-achieving students and their student peers. Mann-Whitney U test was selected given the small and uneven samples. The independent samples Mann-Whitney *U* test results are presented in Table 13.

Table 13

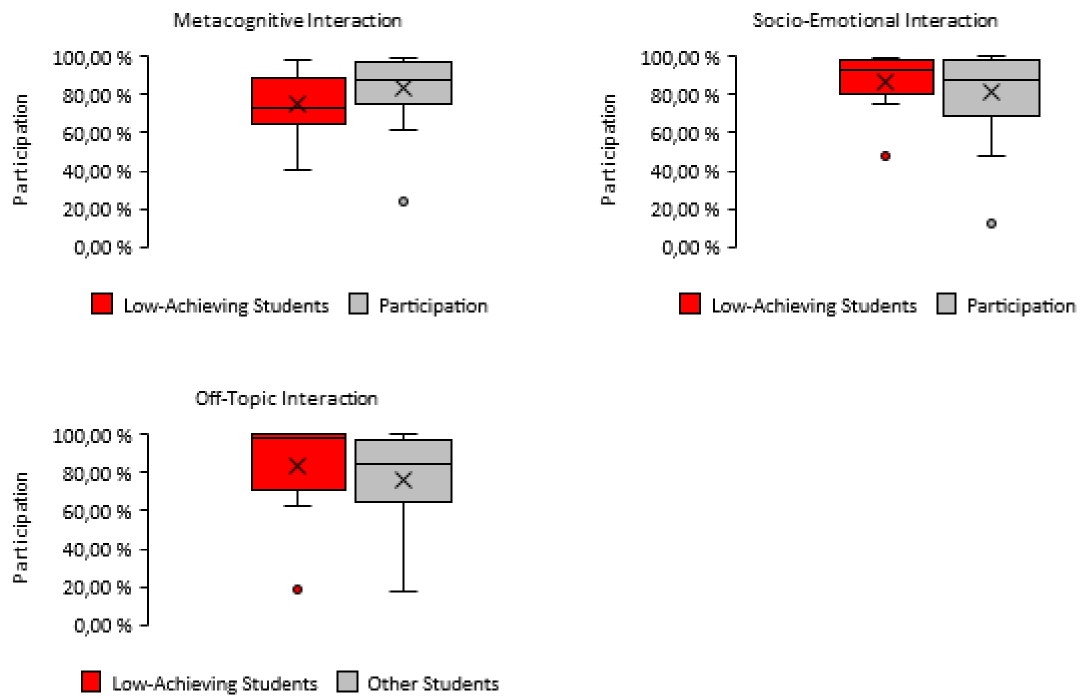
Participation to Interaction, Mann-Whitney U Test Results

Measure	Student group	*n*	*M* Rank	*U*	*z*	*p*
Metacognitive interaction	Low-achieving	9	14.39	113.50	0.631	.535
	Other	22	16.66			
Socio-emotional interaction	Low-achieving	9	16.06	98.50	-0.022	.983
	Other	22	15.98			
Off-topic interaction	Low-achieving	9	16.89	91.00	-0.348	.749
	Other	22	15.64			

Additionally, Figure 2 represents the proportional participation to within-group interaction as a percentage. Noteworthy from Figure 2 is the differences in distribution between groups in metacognitive interaction. Figure 2 also illustrates a highly negatively skewed distribution for low-achieving students' participation to off-topic interaction, as well as inactive outliers in each interaction type. Figure 2 also illustrates the relatively small mean differences between achievement groups in each interaction type.

Figure 2

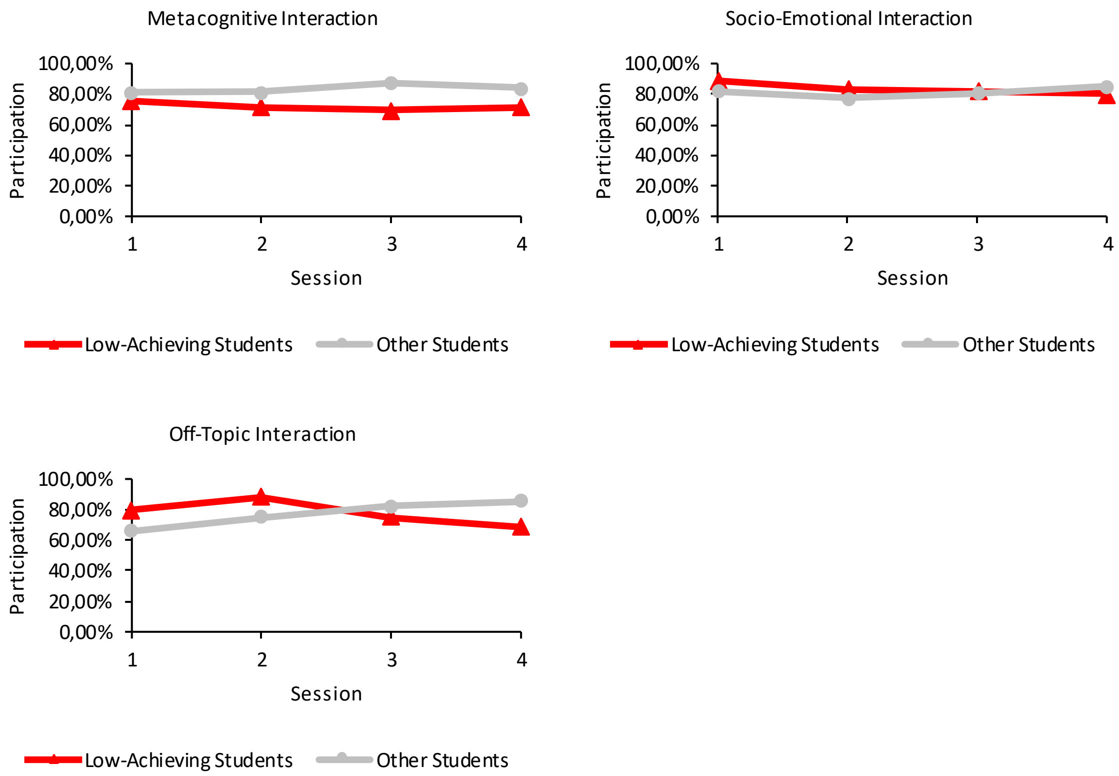
Participation to Interaction by Achievement Level



Subsequently, the session-to-session development of participation to interaction was examined. Figure 3 presents the participation to interaction session by session. Low-achieving student metacognitive interaction is lower in each session and does not develop over the four sessions. Meanwhile, participation to socio-emotional and especially off-topic interaction seems to decrease proportionally over time for low-achieving students, while increasing proportionally for other students.

Figure 3

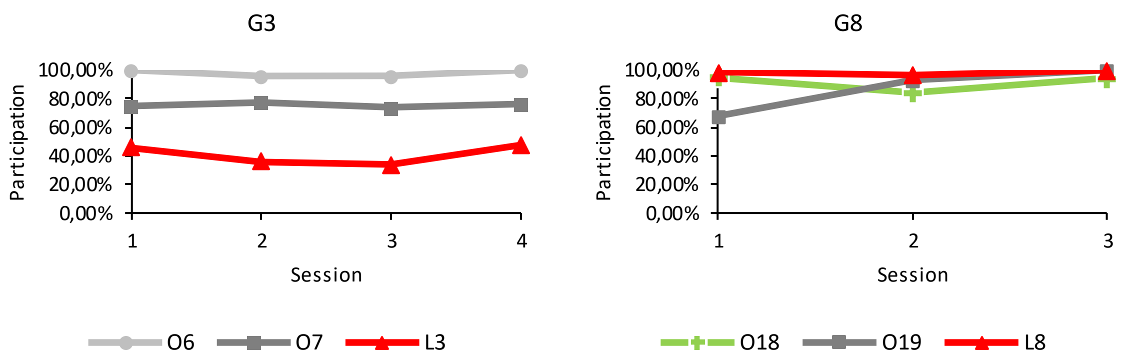
Session-by-Session Participation to Interaction by Achievement Level



Next, interaction was explored within small groups on an individual student level. Overall, the differences in group dynamics and interaction produce very different proportional participation within student groups (see Appendices). Figure 4 presents two very different examples of proportional participation to metacognitive interaction. In Group 3, the low-achieving student (red triangle marker) participates the least in metacognitive interaction throughout the four learning sessions. In Group 8, over three learning sessions the group's metacognitive interaction is more balanced in general, and the low-achieving student (red triangle marker) participates slightly more than a high-achieving student (green plus-sign marker).

Figure 4

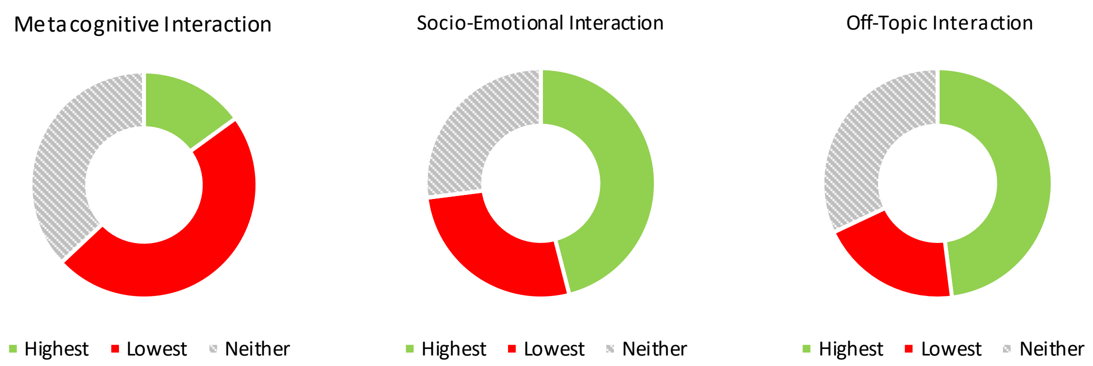
Example of Metacognitive Interaction in Two Groups With Differing Low-Achieving Student Participation



Between the nine small groups, over 27 sessions with a low-achieving student present, the low-achieving student had the highest within-group participation to metacognitive interaction in 4 sessions (15 %) and the lowest participation to metacognitive interaction in 13 sessions (48 %). For socio-emotional interaction, over 26 sessions (excluding one session where a group did not have sufficient socio-emotional interaction) a low-achieving student had the highest within-group participation in 12 sessions (46 %) and the lowest participation 7 sessions (27 %). Finally, for off-topic interaction, over 25 sessions (excluding two sessions where groups did not have sufficient off-topic interaction) a low-achieving student had the highest within-group participation in 12 sessions (48 %) and the lowest participation in 5 sessions (20 %). Figure 5 presents the proportional low-achieving student participation to types of interaction within respective small groups in terms of being highest in-group, lowest in-group, or neither highest nor lowest.

Figure 5

Low-Achieving Student Participation to Interaction Compared to Other Members of Group



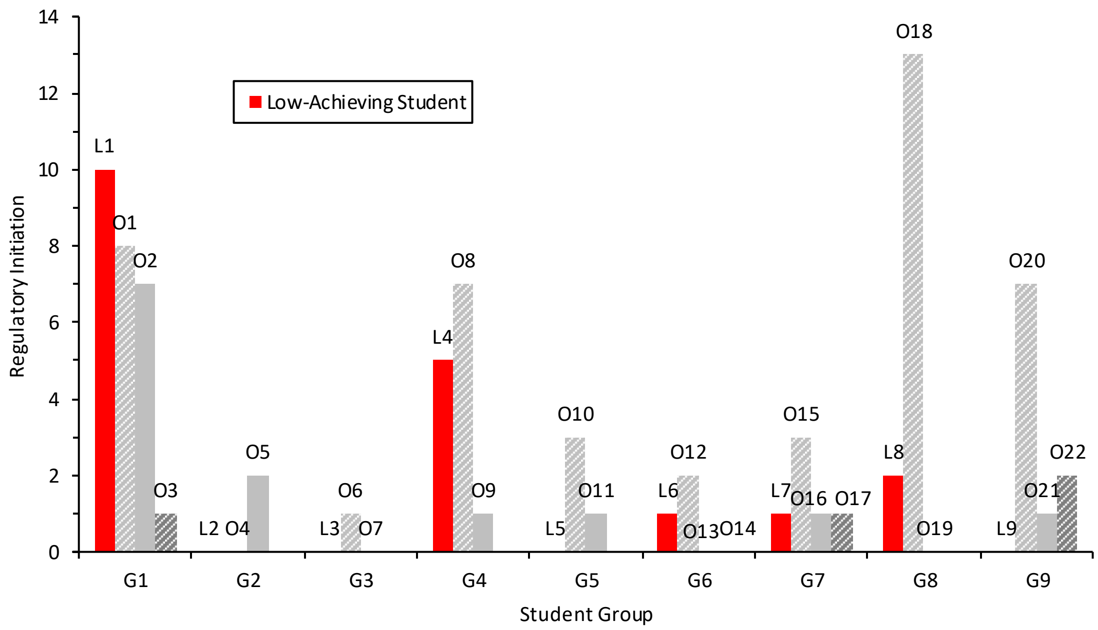
5.2 How do low-achieving students participate in regulation of learning?

Between the nine small groups, the student groups initiated co- or socially shared regulation of learning a total of 80 times. Low-achieving students initiated 19 out of 80 (24 %) regulation episodes. A single low-achieving student (student L1) performed 10 (53 %) of the 19 initiations. This student was the only low-achieving student who initiated a majority of their group's regulation episodes. In 4 of the 9 student groups, the low-achieving student did not initiate any regulation episodes.

Within respective small groups, the regulatory initiator role was performed by the same group member 48 out of 80 times, or 60 % of the time. This is to say that generally one student in any given group made a large majority of any regulatory initiations. The distribution of regulatory initiations made by individual group members is presented in Figure 6.

Figure 6

Distribution of Regulatory Initiations Made by Group Members

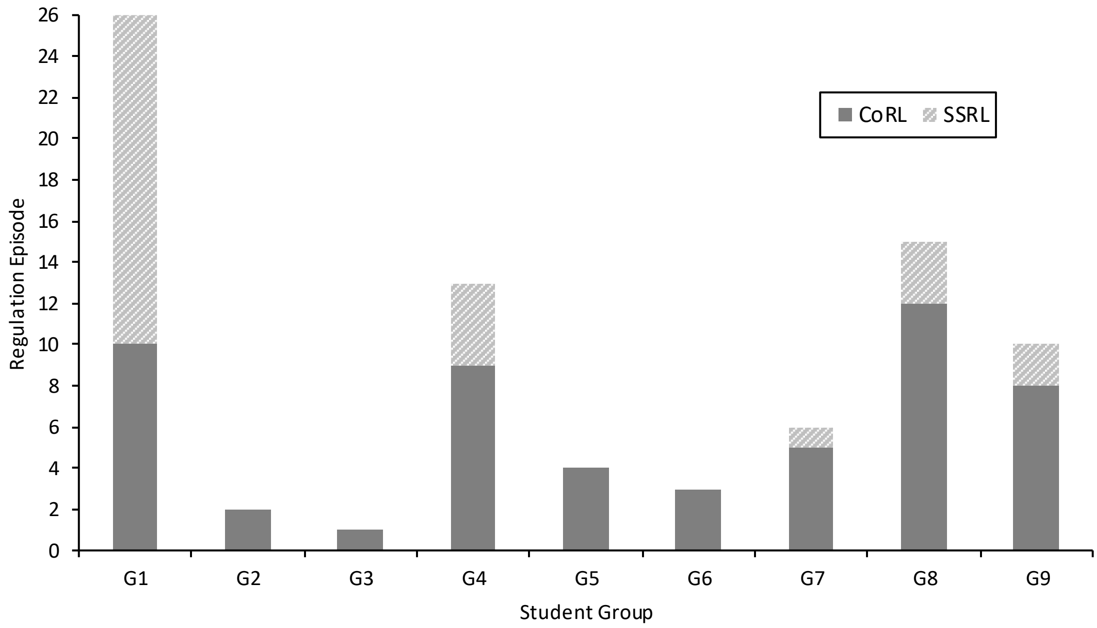


Note. An individual student identifier is provided with each column. Low-achieving student = L, other student = O.

The type of regulation was identified as co-regulation or socially shared regulation during pre-processing (Järvenoja et al., 2020). Overall, 54 of 80 episodes (67.5 %) were categorized as co-regulation, while the remaining 26 of 80 (32.5 %) were categorized as socially shared regulation. Similarly, of the 19 episodes initiated by low-achieving students 13 (68 %) were categorized as co-regulation, while the remaining six episodes (32 %) were categorized as socially shared regulation. Figure 7 presents how frequency of regulation types differed between groups.

Figure 7

Regulation Type Distribution in Groups



However, as shown in Table 14, the difference between mean values of regulation initiations between the two groups is less than one. The *observer* category for the average-to-high achievement group seems to have been skewed by an individual student who did not take part in regulation or much of the interaction in general.

Table 14

Regulation Role Performance by Achievement

	Low-achieving students		Other students	
Role	*M*	*SD*	*M*	*SD*
Initiator	2.11	3.37	2.77	3.44
Contributor	0.89	1.17	1.00	1.72
Follower	0.44	0.73	0.73	1.39
Monitor	0.44	0.73	0.59	1.05
Observer	1.33	1.50	2.45	3.78
Target	1.56	1.67	1.45	1.90
Absent	0.56	1.33	0.41	1.14

At face value, the low-achieving group seems to have been slightly less active during regulation. However, no significant differences were found in the performance of roles during regulation between the two achievement groups. The Mann-Whitney *U* test results are presented in Table 15.

Table 15

Mann-Whitney U Test Results for Regulation Role Performance

Measure	Student group	*n*	*M* Rank	*U*	*z*	*p*
Initiator	Low-achieving	9	13.72	119.50	0.916	.379
	Other	22	16.93			
Contributor	Low-achieving	9	16.44	95.00	-0.195	.881
	Other	22	15.82			
Follower	Low-achieving	9	15.78	101.00	0.105	.949
	Other	22	16.09			
Monitor	Low-achieving	9	15.67	102.00	0.154	.915
	Other	22	16.14			
Observer	Low-achieving	9	15.06	107.50	0.381	.716
	Other	22	16.39			
Target	Low-achieving	9	17.00	90.00	-0.410	.716
	Other	22	15.59			
Absent	Low-achieving	9	16.44	95.00	-0.253	.881
	Other	22	15.82			

Overall, the mean number of regulatory roles performed by an individual student over the course of the learning sessions is low. Most of all, this indicates that the mean number of regulation episodes for seventh graders tends to be low, and most of them are initiated by the same group member. After the *initiator* role, which was assigned for every regulation episode, the next most common roles were *observer* and *target*.

Table 16 shows individual low-achieving students' role performance during regulation episodes. Each low-achieving student is part of a different small group, so the number of total regulation role performances shows a considerable disparity between different small groups. Generally, low-achieving student activity in regulation seems to follow the total number of regulation role performances, as can be seen with students L1, L4, and L8. This reflects the overall regulation activity of the small groups. Meanwhile, students L2, L3, and L9 never have what could be considered an active role in a regulation episode, performing only the roles of *observer* and *target* or being *absent*.

However, student L2 only took part in one session included in the study. Similarly, student L3 was part of a group that only regulated their learning once with L3 present. Student L9 on the other hand is away from the group during four separate regulation episodes, and the *target* of co-regulation in the remaining two.

Table 16

Individual Low-Achieving Student Role Performance During Regulation

Student Role	L1	L2	L3	L4	L5	L6	L7	L8	L9
Initiator	10	0	0	5	0	1	1	2	0
Contributor	2	0	0	2	0	0	1	3	0
Follower	1	0	0	2	1	0	0	0	0
Monitor	0	0	0	0	2	0	1	1	0
Observer	0	1	1	1	1	0	2	5	0
Target	0	1	0	3	0	2	1	5	2
Absent	1	0	0	0	0	0	0	0	4
Total	14	2	1	13	4	3	6	16	6

Finally, the 19 initiator role performances by low-achieving students were analyzed thematically according to the aim of the initiated regulation episode. Four main aims were identified (Table 17). Most often, regulatory initiations dealt with proposing changes to task procedures or strategies. Next, students aimed to respond to group members' negative emotions, and prompt inactive group members to participate in the group work. Fourth, students aimed to strengthen a positive group atmosphere by praising the group or otherwise promoting positivity unprompted.

Table 17

Description of Regulation Episodes Initiated by Low-Achieving Student (N = 19)

Aim of regulation	Example	Frequency, *n* (%)
Proposing task procedure or strategy	"Chinese, Greek, Korean… Should we turn on Korean?" *"There are no Finnish subtitles. Turn on English ones, so we can at least understand a bit better."*	7 (36.8 %)
Managing negative emotion	"Why does my table look like this? Yours is much nicer." *"It does not matter what it looks like. It is more about the information."*	5 (26.3 %)
Prompting inactive group member	*"Are you not writing this down?"* "Oh. I could, yeah."	4 (21.1 %)
Strengthening positive atmosphere	*"We are done with all the exercises!"* "Woo!"	3 (15.8 %)

6 Discussion

The aim of this thesis was to explore how low-achieving students participate in collaborative interaction, and in regulation of learning. For interaction, the results suggest that low-achieving students may participate in metacognitive interaction less than their peers, but this result could not be shown to be significant. For regulation of learning, the results indicate that low-achieving student roles in regulation events are not necessarily directly linked to achievement level. Rather, regulation activity seems to depend not only on individual differences, but potentially on group dynamics and composition. It seems however, that as shown by previous research (Cohen, 1994), some low-achieving students tend to take a passive role in interaction, as well as in initiating regulation of learning.

6.1 Participation to interaction

Results on participation to interaction give some indication that low-achieving students may participate somewhat less in metacognitive interaction than their peers. While in this study, significant differences could not be reached, recent research with the same dataset has shown that the frequency of metacognitive interaction is linked to achievement (Haataja et al., 2022). However, research on low-achieving students in the field is somewhat sparce and further research on the topic would be beneficial.

In general, interaction varied heavily between groups and between interaction types (Table 12). Groups seemed to demonstrate several profiles of interaction. Some groups participated actively in metacognitive and socio-emotional interaction but not off-topic interaction. Other groups engaged actively in metacognitive interaction but noticeably less in socio-emotional and off-topic interaction. Meanwhile, one engaged considerably more in socio-emotional interaction than other interaction types. On the other hand, some groups participated very evenly across interaction types, whereas some groups interacted comparatively little across the board. These differences could result from group differences in familiarity between group members, or

When comparing low-achieving students with their own groupmates, it appears that low-achieving students are somewhat more likely to be the least active group member participating in metacognitive interaction. On the other hand, some low-achieving students seem to be more active than other group members especially in socio-emotional and off-topic interaction. However, while achievement level seems to play at least some part in participation to metacognitive interaction, generally participation to interaction appears very dependent on individual characteristics and group composition. For example, students at the same achievement level can be at the extreme opposite ends of extroversion and introversion, or one might be in a group with strangers while another is in a group with close friends.

Results also suggest that average-to-high achieving students' participation to off-topic interaction may increase session-by-session, while low-achieving students' off-topic interaction appears higher to begin and then evens out. This may suggest that average-to-high achieving students start discussing off-task more freely as they either start to feel more comfortable with the group, tire of the tasks over time, or as the completion of the tasks nears. Meanwhile, this progression does not seem to take place among low-achieving students, who for example may already enter the task with lower engagement or self-efficacy, while others see a temporal development in task engagement over time. Interaction sequences and temporal development have been gaining ground in the field in recent years, and understanding such processes better is a good objective for future research (Azevedo, 2014; Chiu & Lehmann-Willenbrock, 2016).

6.2 Participation to regulation of learning

The results on participation to regulation suggest that initiation of regulation is mostly dominated by one student in a small group. This finding could reflect previous research suggesting that students with high social status or high achievement level tend to assume a dominant position in small group discussion (King, 1993). However, this dominant group member was the low-achieving student in one out of the nine small groups. As the statistical significance of achievement level could not be shown, statistical testing should be repeated with a larger student sample and the with this thesis serving as prospective discussion for future research.

It is evident in the results (see Figure 6), that two students, most of all student L1 and to a lesser extent student L4, were considerably more active in initiating regulation than other low-achieving students. A possible explanation to this could be that these students have low content knowledge in physics, but high teamwork skills. Student L1 was also absent from two learning sessions, which could support a dip in content knowledge. Further attention should be paid on the mediating factors that affect activity in interaction and regulation, especially when mediating low academic achievement.

For type of regulation and individual student roles, the groupwise regulation type distribution (Figure 7) together with the overall regulation role performances (Table 16) suggest that most episodes were simple co-regulation episodes with an initiator, a target of co-regulation, and an uninvolved group member. These findings are strongly in line with previous research showing that co-regulation takes place considerably more than socially shared regulation, especially among young students whose regulation in general tends to be low-level by nature (Malmberg et al., 2015, 2017).

Interestingly, the distribution of regulation to co- and socially shared regulation initiations made by low-achieving students and their peers was found to be identical between the two achievement groups – 68 % CoRL, 32 % SSRL in both achievement groups. This finding further supports previous research stating that co-regulation takes place more regularly than socially shared regulation (Hadwin et al., 2017; Malmberg et al., 2015, 2017), but also suggests that deviations in this distribution may be more dependent on other, perhaps group-level factors than necessarily individual achievement level.

Although the thematic exploration of the aims of low-achieving students' regulation initiations (Table 17) was limited given that it only consisted of 19 episodes, it is worth noting that the biggest of the four identified themes was related to task procedures and strategies. It could be that this was simply the broadest individual category identified, but previously it has been suggested that low group performance is linked to regulating simple task performance more so than higher-level group processes (Järvelä et al., 2013; Malmberg et al., 2015; Rogat & Linnenbrink-Garcia, 2011).

In future research, a larger scale comparison between achievement groups' regulation themes could be worthwhile, to explore if a tendency to engage in low-level regulation is duplicated on the individual level. Previous research has also suggested that differences in engagement between high- and low-level processes could be affected by factors like a positive emotional atmosphere (Pekrun et al., 2002; Volet et al., 2009). This further suggests that exploration of mediating factors for achievement level could be valuable.

Meanwhile, it is worth noting that while low-achievers did not significantly differ from peers regarding regulation episode roles, the results suggest that low-achieving students tend to not make many regulatory initiations. Moreover, it is evident that low-achieving students' activity in regulation increases with their respective groups' regulation activity. Conversely, students appearing the most inactive generally represent groups that do not actively regulate learning.

Previous research (e.g., Isohätälä et al., 2017; Ucan, 2017; Volet et al., 2017) has shown that participation plays a key role in group level regulation of learning. On the other hand, Isohätälä and colleagues (2017, 2020) have found that this participation varies based on the need to coordinate learning activity, for example. This suggests that attention should be paid to increased support for implementing self- and group-level regulation in general (Järvelä et al., 2015; Järvenoja et al., 2020), and to selecting appropriate learning tasks that necessitate constructive small group collaboration (Cohen, 1994; Järvenoja et al., 2020).

Furthermore, since low-achieving student activity in regulation fluctuated considerably from group to group, it appears activity may not necessarily depend on achievement level, but more so on group composition and individual differences. In efforts to facilitate regulation of learning, attention should therefore also be paid on effective group composition (Cohen, 1994; Webb, 2009) and providing scaffolds for regulation of learning especially to groups that do not spontaneously regulate learning. Previous research in the field has extensively discussed the importance of teachers' role in providing scaffolds, namely, to support constructive interaction and regulatory activity in small groups (e.g., Dillenbourg, 1999; Hadwin et al., 2005; Molenaar et al., 2014).

6.3 Research ethics and validity considerations

With data collected as part of a research project prior to the thesis process, data collection was completed by researchers adhering to the contemporary data protection regulations. Consent forms were gathered from all participants. Data protection regulations were followed in informing participants and completing the data collection. Identifiable data was stored and handled confidentially, and given the nature of the data, has not been made openly available. However, to support transparency and open science principles, metadata of the dataset has been made available at Etsin Research Dataset Finder (Järvelä et al., 2021). Throughout the thesis process, storing the data was done according to good scientific practice. In reporting the analysis and results, participant anonymity was protected by using identifiers.

Some limitations are to be considered concerning the dataset and the subsequent coding procedures. First, much of the complete test group performed well in the individual examination and the test performance scores were heavily negatively skewed. Understandably, this is an issue when researching low achievement. Even with a relatively large dataset, the sample size could therefore not be increased while maintaining a low achievement perspective. To maintain a legitimate and relevant research setting from the perspective of special education, limiting the selection of the low-achieving student sample was also an important ethical consideration.

At the same time, this limitation on sample size considerably limited the statistical significance of the study. Given that, it must be recognized that the quantitative methods explored were somewhat misguided, even if the test selection was made with this limitation in mind (Lenth, 2001). While the present dataset allowed for a rich exploration of the topic, a larger sample with more homogeneous achievement would be valuable for subsequent research on low achievement. However, considering the relatively large size of the original sample in this study, finding such a sample could prove difficult in a natural classroom setting.

Secondly, the base interaction type coding did not accurately represent the types of individual utterances, but rather whether an individual spoke during an interaction sequence. Hence, individual participation to interaction types could only be estimated. The likely outcome of this would be one favorable to an inactive student. While the granularity level of individual utterance types would have been quite arduous given the relatively large dataset, it would have more accurately revealed individual inactivity in interaction.

In addition to interactivity coding, utterance-level coding of student roles during regulatory episodes could have allowed for a more accurate and fluid categorization and could be used in subsequent research if an increased accuracy is desired. However, while this type of categorization is interpretational, the validity of the regulation role coding is supported by an interrater reliability coding, which resulted in a strong average Kappa value (0.86). Overall, this thesis could have benefited from a more qualitative approach, but nevertheless, the study serves as a good starting point to further research with a focus on low achievement.

7 Conclusion

In the context of CSCL and SRL, research focusing on low-achieving students continues to be lacking. However, for a random sample of mainstream education students to support focus on low-achieving students, larger sample sizes are needed to perform quantitative testing. Meanwhile, the field could benefit from efforts to broaden the understanding of low achievement in this specific context. Further study of the individual differences and traits that mediate low achievement could prove fruitful. In the meantime, a systematic review of research literature dealing with the collaboration and regulation processes of low-achieving students or groups could also be a worthwhile endeavor to move in this direction.

Together with existing research, this thesis has highlighted the multifaceted nature of regulation of learning and its surrounding concepts. Results of this study suggest that in many groups, most regulation initiations come from the same group member. Taking on this active role in a group could be linked in part with achievement but identifying other factors could help mediate students' hesitancy to participate more actively. Many students do not initiate any regulation, but low-achieving students did not significantly differ from other students in this regard. It can be said, however, that among many other students, low-achieving students seem to initiate relatively few regulation episodes and do not usually lead the group interaction or regulatory activity. Rather, low-achieving students seem more likely to take a back seat in favor of at least one more active group member.

For teaching, it would be important to provide scaffolds for regulation, as well as for explicitly recognizing learning processes and identifying regulatory strategies. Attention should also be paid on effective forms of small group collaboration, suitable collaborative tasks, and support for constructive engagement and interaction. Furthermore, teachers should look to identify students and groups who underachieve in collaborative settings, fail to engage in productive collaboration, or do not regulate their learning, so that appropriate scaffolding can be provided.

References

Adams-Wiggins, & Rogat, T. K. (2014). Other-regulation in collaborative groups: Implications for regulation quality. *Instructional Science, 42*, 879–904. https://doi.org/10.1007/s11251-014-9322-9

Ashman, A. F. (2003). Peer mediation and students with diverse learning needs. In A. F. Ashman, & R. M. Gillies (Eds.), *Co-operative learning: The social and intellectual outcomes of learning in groups* (pp. 87–102). Routledge.

Azevedo, R. (2014). Issues in dealing with sequential and temporal characteristics of self- and socially-regulated learning. *Metacognition and Learning, 9*, 217–228. https://doi.org/10.1007/s11409-014-9123-1

Bachour, K., Kaplan, F., & Dillenbourg, P. (2008). Reflect: An interactive table for regulating face-to-face collaborative learning. In P. Dillenbourg, & M. Specht (Eds.), *Times of convergence: Technologies across learning contexts* (pp. 39–48). Springer. https://doi.org/10.1007/978-3-540-87605-2_5

Baird, G. L., Scott, W. D., Dearing, E., & Hamill, S. K. (2009). Cognitive self-regulation in youth with and without learning disabilities: Academic self-efficacy, theories of intelligence, learning vs. performance goal preferences, and effort attributions. *Journal of Social and Clinical Psychology, 28*(7), 881–908. https://doi.org/10.1521/jscp.2009.28.7.881

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.

Bandura, A. (2000). Exercise of human agency through collective efficacy. *Current Directions in Psychological Science, 9*(3), 75–78. https://doi.org/10.1111/1467-8721.00064

Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *Journal of the Learning Sciences, 9*(4), 403–436. https://doi.org/10.1207/S15327809JLS0904_2

Barron, B. (2003). When smart groups fail. *Journal of the Learning Sciences, 12*(3), 307–359. https://doi.org/10.1207/S15327809JLS1203_1

Brophy, J. E., & Good, T. L. (1974). *Teacher-student relationships: Causes and consequences*. Holt, Rinehart & Winston.

Butler, D. L., & Cartier, S. C. (2017). Advancing research and practice about self-regulated learning: The promise of in-depth case study methodologies. In D. Schunk, & J. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed., pp. 352–369). Routledge.

Chiu, M. M. (2000). Group problem-solving processes: Social interactions and individual actions. *Journal for the Theory of Social Behaviour, 30*(1), 26–49. https://doi.org/10.1111/1468-5914.00118

Chiu, M. M., & Lehmann-Willenbrock, N. (2016). Statistical discourse analysis: Modeling sequences of individual actions during group interactions across time. *Group Dynamics: Theory, Research, and Practice, 20*(3), 242–258. https://doi.org/10.1037/gdn0000048

Cohen, B. P., & Arechavala-Vargas, R. (1987). *Interdependence, interaction and productivity*. Working Paper 87–3. Stanford University.

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1–35. https://doi.org/10.3102/00346543064001001

Dillenbourg, P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and computational approaches* (pp. 1–19). Elsevier.

Dillenbourg, P., Baker, M., Blaye, A., & O'Malley, C. (1996). The evolution of research on collaborative learning. In E. Spada, & P. Reimann (Eds.), *Learning in humans and machine: Towards an interdisciplinary learning science* (pp. 189–211). Elsevier.

Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning. In N. Balacheff, S. Ludvigsen, T. de Jong, A. Lazonder, & S. Barnes (Eds.), *Technology-enhanced learning* (pp. 3–19). Springer. https://doi.org/10.1007/978-1-4020-9827-7_1

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential concept, state of the evidence. *Review of Educational Research, 74*(1), 59–100. https://doi.org/10.3102/00346543074001059

Goffman, E. (1959). *The presentation of self in everyday life*. Doubleday.

Grau, V., Lorca, A., Araya, C., Urrutia, S., Ríos, D., Montagna, P., & Ibaceta, M. (2018). Socially shared regulation of learning and quality of talk: Age differences in collaborative group work in classroom contexts. *New Directions for Child and Adolescent Development, 162*. https://doi.org/10.1002/cad.20261

Haataja, E., Dindar, M., Malmberg, J., & Järvelä, S. (2022). Individuals in a group: Metacognitive and regulatory predictors of learning achievement in collaborative learning. *Learning and Individual Differences, 96*, 102146. https://doi.org/10.1016/j.lindif.2022.102146

Hadwin, A. F., Järvelä, S., & Miller, M. (2017). Self-regulation, co-regulation and shared regulation in collaborative learning environments. In D. Schunk, & J. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed., pp. 65–84). Routledge.

Hadwin, A. F., Wozney, L., & Pontin, O. (2005). Scaffolding the appropriation of self-regulatory activity: A socio-cultural analysis of changes in teacher–student discourse about a graduate research portfolio. *Instructional Science, 33*, 413–450. https://doi.org/10.1007/s11251-005-1274-7

Hampton, N. Z., & Mason, E. (2003). Learning disabilities, gender, sources of efficacy, self-efficacy beliefs, and academic achievement in high school students. *Journal of School Psychology, 41*(2), 101–112. https://doi.org/10.1016/S0022-4405(03)00028-1

Heikkilä, A., Lonka, K., Nieminen, J., & Niemivirta, M. (2012). Relations between teacher students' approaches to learning, cognitive and attributional strategies, well-being, and study success. *Higher Education, 64*, 455–471. https://doi.org/10.1007/s10734-012-9504-9

Heikkilä, A., Niemivirta, M., Nieminen, J., & Lonka, K. (2011). Interrelations among university students' approaches to learning, regulation of learning, and cognitive and attributional strategies: A person oriented approach. *Higher Education, 61*, 513–529. https://doi.org/10.1007/s10734-010-9346-2

Heinimäki, O.-P., Volet, S., & Vauras, M. (2020). Core and activity-specific functional participatory roles in collaborative science learning. *Front Line Research, 8*(2), 65–89. https://doi.org/10.14786/flr.v8i2.469

Herbst, T. H. H. (2020). Gender differences in self-perception accuracy: The confidence gap and women leaders' underrepresentation in academia.

Hewitt, M. P. (2015). Self-efficacy, self-evaluation, and music performance of secondary-level band students. *Journal of Research in Music Education, 63*(3), 298–313. https://doi.org/10.1177/0022429415595611

Hirt, C. N., Karlen, Y., Merki, K. M., & Suter, F. (2021). What makes high achievers different from low achievers? Self-regulated learners in the context of a high-stakes academic long-term task. *Learning and Individual Differences, 92*, 102085. https://doi.org/10.1016/j.lindif.2021.102085

Iiskala, T., Vauras, M., Lehtinen, E., & Salonen, P. (2011). Socially shared metacognition of dyads of pupils in collaborative mathematical problem-solving processes. *Learning and Instruction, 21*(3), 379–393. https://doi.org/10.1016/j.learninstruc.2010.05.002

Isohätälä, J., Järvenoja, H., & Järvelä, S. (2017). Socially shared regulation of learning and participation in social interaction in collaborative learning. *International Journal of Educational Research, 81*, 11–24. https://doi.org/10.1016/j.ijer.2016.10.006

Isohätälä, J., Näykki, P., & Järvelä, S. (2020). Convergences of joint, positive interactions and regulation in collaborative learning. *Small Group Research, 51*(2), 229–264. https://doi.org/10.1177/1046496419867760

Isohätälä, J., Näykki, P., Järvelä, S., Baker, M. J., & Lund, K. (2021). Social sensitivity: A manifesto for CSCL research. *International Journal of Computer-Supported Collaborative Learning*. https://doi.org/10.1007/s11412-021-09344-8

Järvelä, S., & Hadwin, A. F. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist, 48*(1), 25–39. https://doi.org/10.1080/00461520.2012.748006

Järvelä, S., Järvenoja, H., & Veermans, M. (2008). Understanding the dynamics of motivation in socially shared learning. *International Journal of Educational Research, 47*(2), 122–135. https://doi.org/10.1016/j.ijer.2007.11.012

Järvelä, S., Järvenoja, H., & Malmberg, J. (2021). *CLEVER – Making Complex Learning processes Visible for Enabling Regulation: Change human behavior for learning success*. University of Oulu. https://doi.org/10.23729/fa61790c-1929-4408-9869-47d236255880

Järvelä, S., Järvenoja, H., Malmberg, J., & Hadwin, A. F. (2013). Exploring socially shared regulation in the context of collaboration. *Journal of Cognitive Education and Psychology, 12*(3), 267–286. https://doi.org/10.1891/1945-8959.12.3.267

Järvelä, S., Järvenoja, H., Malmberg, J., Isohätälä, J., & Sobocinski, M. (2016). How do types of interaction phases of self-regulated learning set a stage for collaborative engagement? *Learning and Instruction, 43*, 39–51. https://doi.org/10.1016/j.learninstruc.2016.01.005

Järvelä, S., Kirschner, P. A., Panadero, E., Malmberg, J., Phielix, C., Jaspers, J., Koivuniemi, M., & Järvenoja, H. (2015). Enhancing socially shared regulation in collaborative learning groups: Designing for CSCL regulation tools. *Educational Technology Research and Development, 63*, 125–142. https://doi.org/10.1007/s11423-014-9358-1

Järvelä, S., & Renninger, K. A. (2014). Designing for learning: Interest, motivation, and engagement. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 668–685). Cambridge. https://doi.org/10.1017/CBO9781139519526.040

Järvenoja, H., Malmberg, J., Törmänen, T., Mänty, K., Haataja, E., Ahola, S., & Järvelä, S. (2020). A collaborative learning design for promoting and analyzing adaptive motivation and emotion regulation in the science classroom. *Frontiers in Education, 5*, 111. https://doi.org/10.3389/feduc.2020.00111

Järvenoja, H., Näykki, P., & Törmänen, T. (2019). Emotional regulation in collaborative learning: When do higher education students activate group level regulation in the face of challenges? *Studies in Higher Education, 44*(10), 1747–1757. https://doi.org/10.1080/03075079.2019.1665318

Jenkins, J. R., Antil, L. R., Wayne, S. K., & Vadasy, P. F. (2003). How collaborative learning works for special education and remedial students. *Exceptional Children, 69*(3), 279–292. https://doi.org/10.1177/001440290306900302

Johnson, D. W., & Johnson, R. T. (1986). Mainstreaming and cooperative learning strategies. *Exceptional Children, 52*(6), 530–561. https://doi.org/10.1177/001440298605200608

Johnson, D. W., & Johnson, R. T. (1990). Cooperative learning and achievement. In S. Sharan (Ed.), *Cooperative learning: Theory and research* (pp. 23–37). Praeger.

Jovanovic, J., Mirriahi, N., Gašević, D., Dawson, S., & Pardo, A. (2019). Predictive power of pre-class activities in a flipped classroom. *Computers & Education, 134*, 156–168. https://doi.org/10.1016/j.compedu.2019.02.011

Jurik, V., Gröschner, A., & Seidel, T. (2013). How student characteristics affect girls' and boys' verbal engagement in physics instruction. *Learning and Instruction, 23*, 33–42. https://doi.org/10.1016/j.learninstruc.2012.09.002

King, L. H. (1993). High and low achievers' perceptions and cooperative learning in two small groups. *The Elementary School Journal, 93*(4), 399–416. https://www.jstor.org/stable/1002019

Klassen, R. M. (2002). A question of calibration: A review of the self-efficacy beliefs of students with learning disabilities. *Learning Disabilities Quarterly, 25*(2), 88–102. https://doi.org/10.2307/1511276

Klassen, R. M., & Lynch, S. L. (2007). Self-efficacy from the perspective of adolescents with LD and their specialist teachers. *Journal of Learning Disabilities, 40*(6), 494–507. https://doi.org/10.1177/00222194070400060201

Koponen, T., Aro, T., Peura, P., Leskinen, M., Viholainen, H., & Aro, M. (2021). Benefits of integrating an explicit self-efficacy intervention with calculation strategy training for low-performing elementary students. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.714379

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159–174. https://doi.org/10.2307/2529310

Latané, B., Williams, K., & Harkins, S. (1979). Many hands make light the work: The causes and consequences of social loafing. *Journal of Personality and Social Psychology, 37*(6), 822–832. https://doi.org/10.1037/0022-3514.37.6.822

Lenth, R. V. (2001). Some practical guidelines for effective sample size determination. *The American Statistician, 55*(3), 187–193. https://doi.org/10.1198/000313001317098149

Li, Y., Qiu, L., & Sun, B. (2021). School engagement as a mediator in students' social relationships and academic performance: A survey based on CiteSpace. *International Journal of Crowd Science, 5*(1), 17–30. https://doi.org/10.1108/IJCS-02-2020-0005

Lodewyk, K. R., Winne P. H., & Jamieson-Noel, D. L. (2009). Implications of task structure on self-regulated learning and achievement. *Educational Psychology, 29*(1), 1–25. https://doi.org/10.1080/01443410802447023

Malmberg, J., Järvelä, S., & Järvenoja, H. (2017). Capturing temporal and sequential patterns of self-, co-, and socially shared regulation in the context of collaborative learning. *Contemporary Educational Psychology, 49*, 160–174. https://doi.org/10.1016/j.cedpsych.2017.01.009

Malmberg, J., Järvelä, S., Järvenoja, H., & Panadero, E. (2015). Promoting socially shared regulation of learning in CSCL: Progress of socially shared regulation among high- and low-performing groups. *Computers in Human Behavior, 52*, 562–572. https://doi.org/10.1016/j.chb.2015.03.082

Marshman, E. M., Kalender, Z. Y., Nokes-Malach, T., Schunn, C., & Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? *Physical Review Physics Education Research, 14*(2), 020123. https://doi.org/10.1103/PhysRevPhysEducRes.14.020123

Meijer, J., Veenman, M. V. J., & van Hout-Wolters, B. H. (2006). Metacognitive activities in text-studying and problem-solving: Development of a taxonomy. *Educational Research and Evaluation, 12*(3), 209–237. https://doi.org/10.1080/13803610500479991

Molenaar, I., Sleegers, P., & van Boxtel, C. (2014). Metacognitive scaffolding during collaborative learning: A promising combination. *Metacognition and Learning, 9*, 309–332. https://doi.org/10.1007/s11409-014-9118-y

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30–38. https://doi.org/10.1037/0022-0167.38.1.30

Näykki, P., Järvelä, S., Kirschner, P. A., & Järvenoja, H. (2014). Socio-emotional conflict in collaborative learning: A process-oriented case study in a higher education context. *International Journal of Educational Research, 68*, 1–14. https://doi.org/10.1016/j.ijer.2014.07.001

Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist, 51*(2), 102–116. https://doi.org/10.1037/0003-066X.51.2.102

Nissen, J. M. (2019). Gender differences in self-efficacy states in high school physics. *Physical Review Physics Education Research, 15*(1), 013102. https://doi.org/10.1103/PhysRevPhysEducRes.15.013102

Nurmi, J.-E., Aunola, K., Salmela-Aro, K., & Lindroos, M. (2003). The role of success expectation and task-avoidance in academic performance and satisfaction: Three studies on antecedents, consequences and correlates. *Contemporary Educational Psychology, 28*(1), 59–90. https://doi.org/10.1016/S0361-476X(02)00014-0

Panadero, E., & Järvelä, S. (2015). Socially shared regulation of learning: A review. *European Psychologist, 20*(3), 190–203. https://doi.org/10.1027/1016-9040/a000226

Patrick, H., & Middleton, M. J. (2002). Turning the kaleidoscope: What we see when self-regulated learning is viewed with a qualitative lens. *Educational Psychologist, 37*(1), 27–39. https://doi.org/10.1207/S15326985EP3701_4

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educational Psychologist, 37*(2), 91–105. https://doi.org/10.1207/S15326985EP3702_4

Perry, N. E., & Winne, P. H. (2013). Tracing regulation in collaborative tasks. In S. Volet, & M. Vauras (Eds.), *Interpersonal regulation of learning and motivation: Methodological advances* (pp. 45–66). Routledge. https://doi.org/10.4324/9780203117736

Prince, D., & Nurius, P. S. (2014). The role of positive academic self-concept in promoting school success. *Children and Youth Services Review, 43*, 145–152. https://doi.org/10.1016/j.childyouth.2014.05.003

Pulford, B. D., & Colman, A. M. (1997). Overconfidence: Feedback and item difficulty effects. *Personality and Individual Differences, 23*(1), 125–133. https://doi.org/10.1016/S0191-8869(97)00028-7

Putnam, J., Markovchick, K., Johnson, D. W., & Johnson, R. T. (1996). Cooperative learning and peer acceptance of students with learning disabilities. *The Journal of Social Psychology, 136*(6), 741–752. https://doi.org/10.1080/00224545.1996.9712250

Razzouk, R., & Johnson, T. (2012). Shared cognition. In N. M. Seel (Ed.), *Encyclopedia of the sciences of learning*. Springer. https://doi.org/10.1007/978-1-4419-1428-6_205

Resnick, L. B. (1991). Shared cognition: Thinking as social practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition*. American Psychological Association. https://doi.org/10.1037/10096-018

Rogat, T. K., & Adams-Wiggins, K. R. (2015). Interrelation between regulatory and socioemotional processes within collaborative groups characterized by facilitative and directive other-regulation. *Computers in Human Behavior, 52*, 589–600. https://doi.org/10.1016/j.chb.2015.01.026

Rogat, T. K., & Linnenbrink-Garcia, L. (2011). Socially shared regulation in collaborative groups: An analysis of the interplay between quality of social regulation and group processes. *Cognition and Instruction, 29*(4), 375–415. https://doi.org/10.1080/07370008.2011.607930

Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. In C. O'Malley (Ed.), *Computer supported collaborative learning* (pp. 69–97). Springer. https://doi.org/10.1007/978-3-642-85098-1_5

Salazar, A. J. (1996). An analysis of the development and evolution of roles in the small group. *Small Group Research, 27*(4), 475–503. https://doi.org/10.1177/1046496496274001

Salmela-Aro, K., & Upadyaya, K. (2014). School burnout and engagement in the context of demands–resources model. *Educational Psychology, 84*(1), 137–151. https://doi.org/10.1111/bjep.12018

Schunk, D. H., & DiBenedetto, M. K. (2016). Self-efficacy theory in education. In K. R. Wentzel, & D. B. Miele (Eds.), *Handbook of motivation at school* (2nd ed., pp. 34–54). Routledge. https://doi.org/10.4324/9781315773384

Schunk, D. H., & Mullen, C. A. (2012). Self-efficacy as an engaged learner. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 219–235). Springer. https://doi.org/10.1007/978-1-4614-2018-7_10

Shachar, H. (2003). Who gains what from co-operative learning: An overview of eight studies. In A. F. Ashman, & R. M. Gillies (Eds.), *Co-operative learning: The social and intellectual outcomes of learning in groups* (pp. 103–118). Routledge.

Sinha, S., Rogat, T. K., Adams-Wiggins, K. R., & Hmelo-Silver, C. E. (2015). Collaborative group engagement in a computer-supported inquiry learning environment. *International*

Journal of Computer-Supported Collaborative Learning, 10, 273–307. https://doi.org/10.1007/s11412-015-9218-y

Slavin, R. E. (2014). Cooperative learning and academic achievement: Why does groupwork work? Anales de Psicología, 30(3), 785–791. https://doi.org/10.6018/analesps.30.3.201201

Stoeckel, M. R., & Roehrig, G. H. (2021). Gender differences in classroom experiences impacting self-efficacy in an AP Physics 1 classroom. *Physical Review Physics Education Research, 17*(2), 020102. https://doi.org/10.1103/PhysRevPhysEducRes.17.020102

Törmänen, T., Järvenoja, H., & Mänty, K. (2021). All for one and one for all – How are students' affective states and group-level emotion regulation interconnected in collaborative learning? *International Journal of Educational Research, 109*, 101861. https://doi.org/10.1016/j.ijer.2021.101861

Ucan, J. (2017). Changes in primary school students' use of self and social forms of regulation of learning across collaborative inquiry activities. *International Journal of Educational Research, 85*, 51–67. https://doi.org/10.1016/j.ijer.2017.07.005

Usher, E. L., & Pajares, F. (2006). Sources of academic and self-regulatory efficacy beliefs of entering middle school students. *Contemporary Educational Psychology, 31*(2), 125–141. https://doi.org/10.1016/j.cedpsych.2005.03.002

Van der Stel, M., & Veenman, M. V. J. (2010). Development of metacognitive skillfulness: A longitudinal study. *Learning and Individual Differences, 20*, 220–224. https://doi.org/10.1016/j.lindif.2009.11.005

Volet, S., Summers, M., & Thurman, J. (2009). High-level co-regulation in collaborative learning: How does it emerge and how is it sustained? *Learning and Instruction, 19*(2), 128–143. https://doi.org/10.1016/j.learninstruc.2008.03.001

Volet, S., Vauras, M., Salo, A.-E., & Khosa, D. (2017). Individual contributions in student-led collaborative learning: Insights from two analytical approaches to explain the quality of group outcome. *Learning and Individual Differences, 53*, 79–92. https://doi.org/10.1016/j.lindif.2016.11.006

Vygotsky, L. S. (1978). *Mind in society*. Harvard UP.

Wang, M.-T., Chow, A., Hofkens, T., & Salmela-Aro, K. (2015). The trajectories of student emotional engagement and burnout with academic and psychological development: Findings from Finnish adolescents. *Learning and Instruction, 36*, 57–65. https://doi.org/10.1016/j.learninstruc.2014.11.004

Webb, N. M. (1997). Assessing students in small collaborative groups. *Theory Into Practice, 36*(4), 205–213.

Webb, N. M. (2009). The teacher's role in promoting collaborative dialogue in the classroom. *Educational Psychology, 79*(1), 1–28. https://doi.org/10.1348/000709908X380772

Webb, N. M. (2013). Information processing approaches to collaborative learning. In C. E. Hmelo-Silver, C. A. Chinn, C. K. K. Chan, & A. O'Donnell (Eds.), *The international handbook of collaborative learning* (pp. 19–40). Routledge.

Wentzel, K. R., & Caldwell, K. (1997). Friendships, peer acceptance, and group membership: Relations to academic achievement in middle school. *Child Development, 68*(6), 1198–1209. https://www.jstor.org/stable/1132301

Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Erlbaum.

Winne, P. H., & Hadwin, A. F. (2012). The weave of motivation and self-regulated learning. In D. H. Schunk, & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (2nd ed., pp. 297–314). Routledge.

Winne, P. H., Hadwin, A. F., & Gress, C. (2010). The learning kit project: Software tools for supporting and researching regulation of collaborative learning. *Computers in Human Behavior, 26*, 787–793. https://doi.org/10.1016/j.chb.2007.09.009

Xin, J. F. (1999). Computer-assisted cooperative learning in integrated classrooms for students with and without disabilities. *Informational Technology in Childhood Education Annual, 10*, 61–78.

Yin, R. K. (2014). *Case study research: Design and methods* (5th ed.). SAGE.

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339. https://doi.org/10.1037/0022-0663.81.3.329

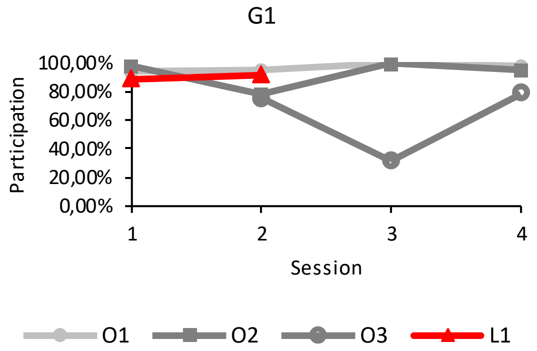
Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

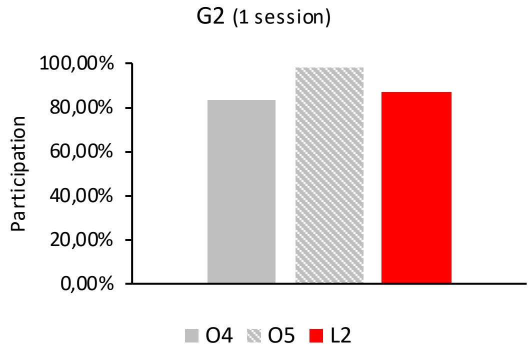
Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal, 23*(4), 614–628. https://doi.org/10.3102/00028312023004614

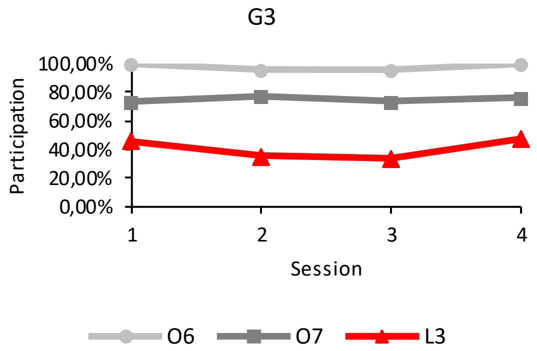
Zimmerman, B. J., & Schunk, D. H. (2008). Motivation: An essential dimension of self-regulated learning. In D. H. Schunk, & B. J. Zimmerman (Eds.), *Motivation and self-regulated learning: Theory, research, and applications* (pp. 1–30). Erlbaum.

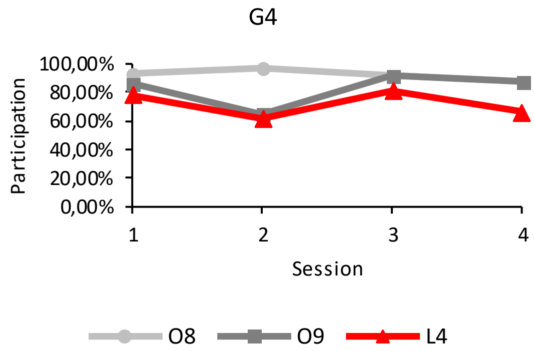
Appendix 1

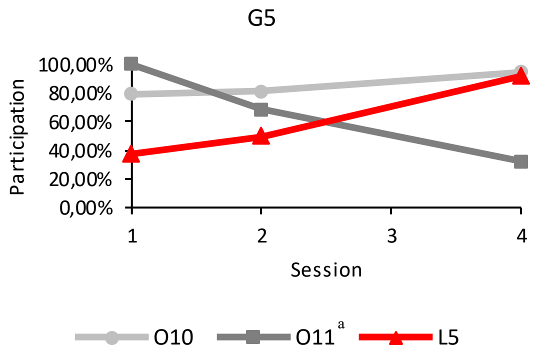
Within-Group Session-by-Session Participation in Metacognitive Interaction

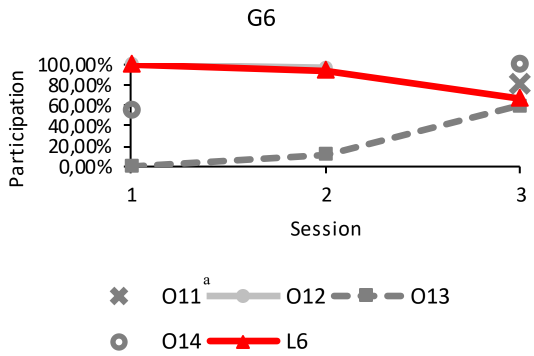


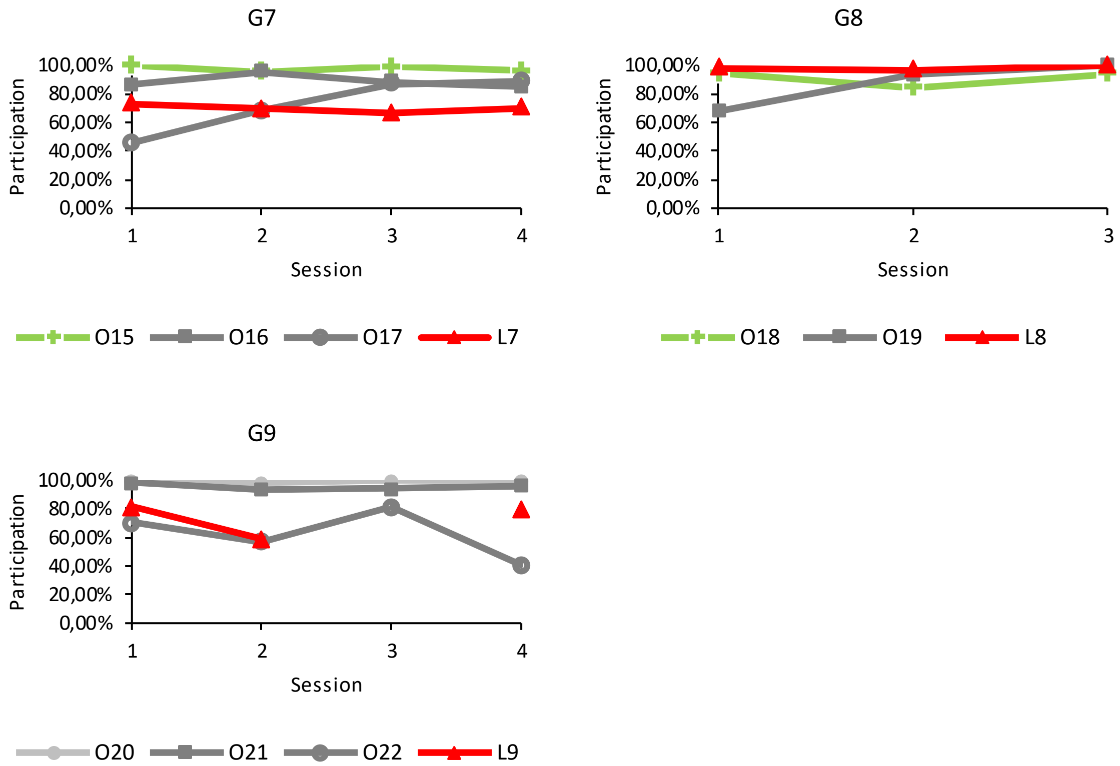










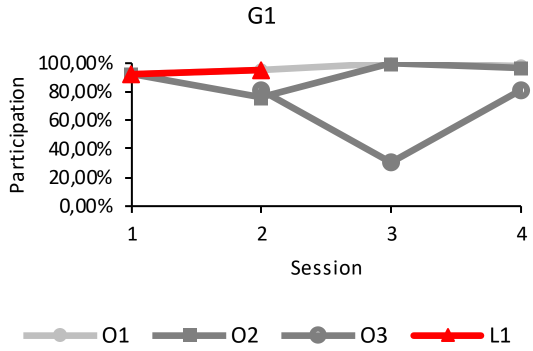


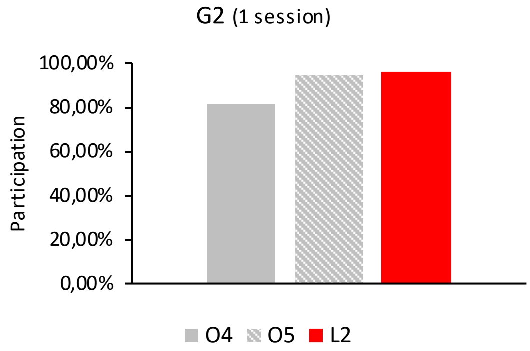
Note. Red triangle marker for low achiever, green plus marker for high achiever.

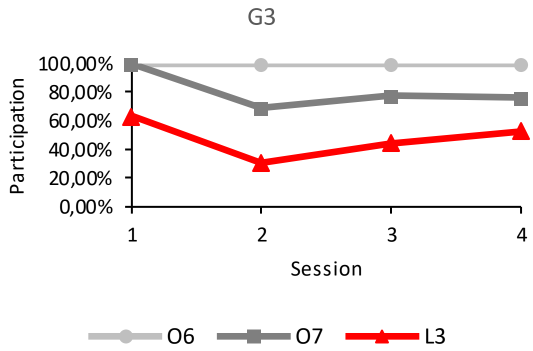
[a] Student O11 spends sessions 1, 2, and 4 in Group 5, and session 3 in Group 6.

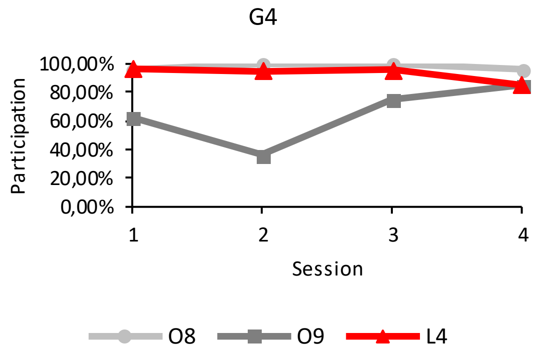
Appendix 2

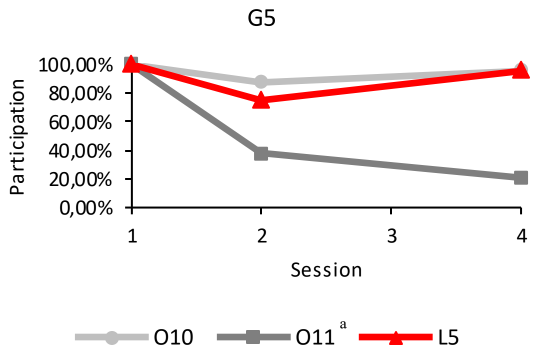
Within-Group Session-by-Session Participation in Socio-Emotional Interaction

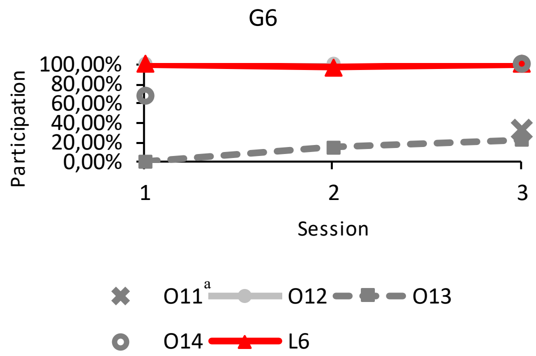


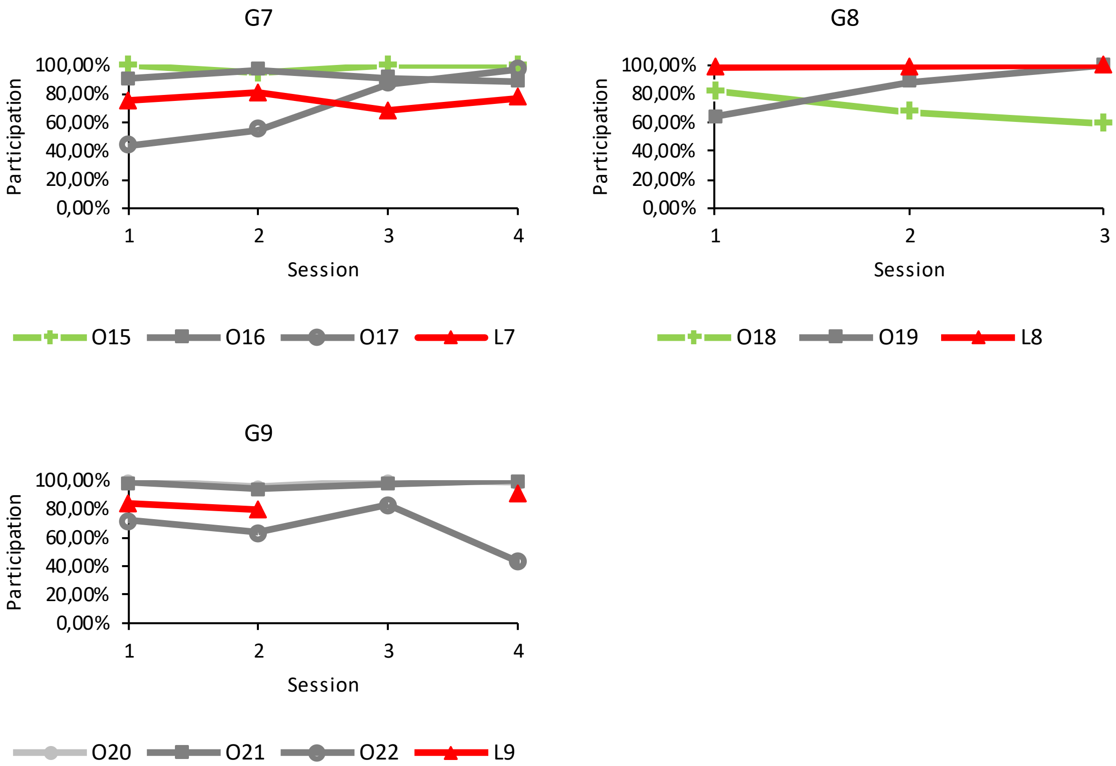










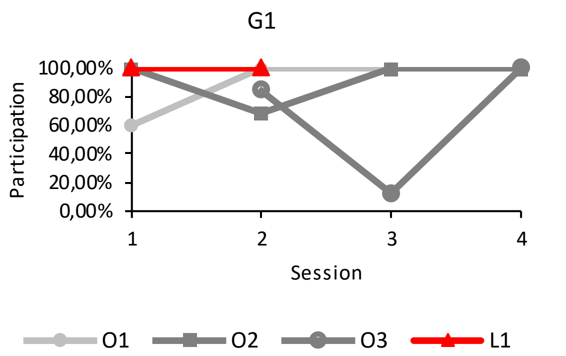


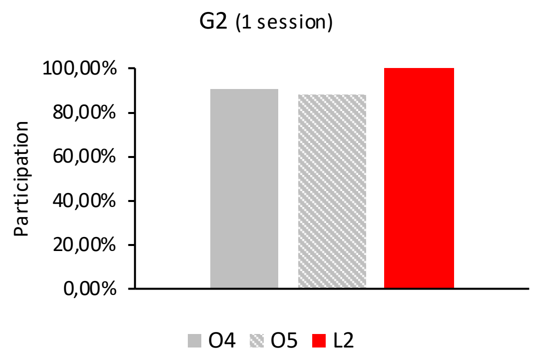
Note. Red triangle marker for low achiever, green plus marker for high achiever.

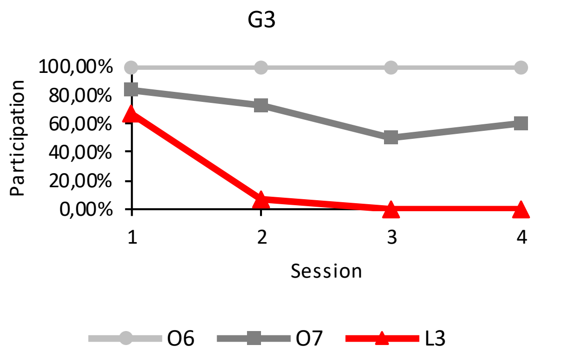
[a] Student O11 spends sessions 1, 2, and 4 in Group 5, and session 3 in Group 6.

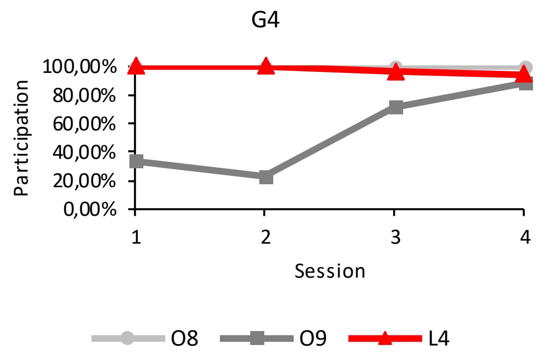
Appendix 3

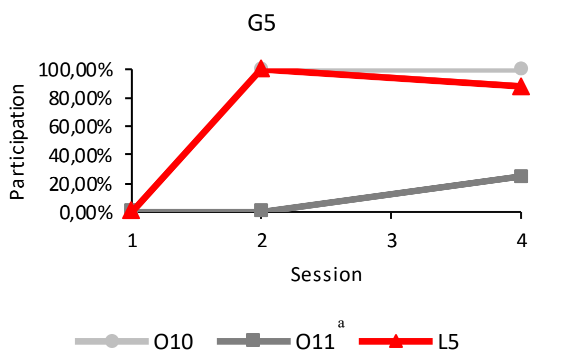
Within-Group Session-by-Session Participation in Off-Topic Interaction

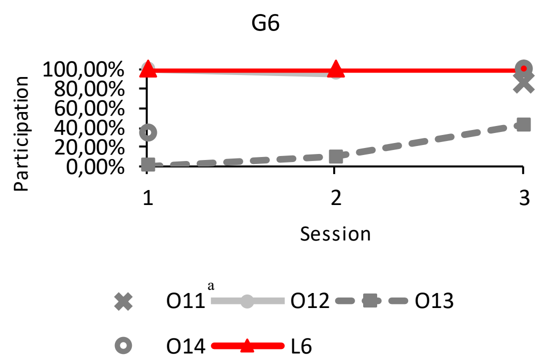


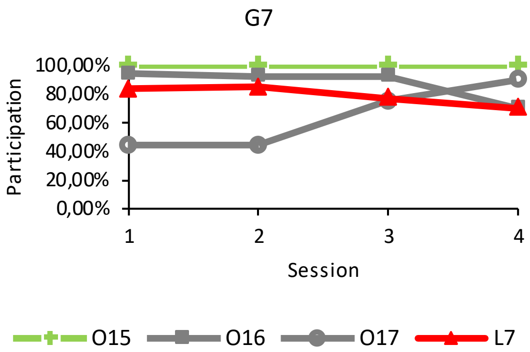


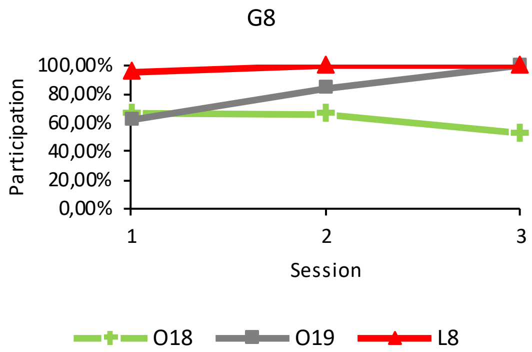


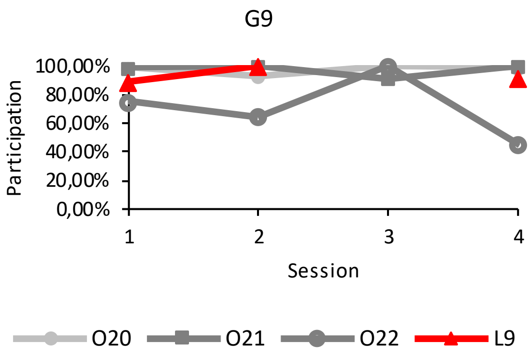












Note. Red triangle marker for low achiever, green plus marker for high achiever.

[a] Student O11 spends sessions 1, 2, and 4 in Group 5, and session 3 in Group 6.