Santur, Pablo

PRODUCTIVE DISCIPLINARY ENGAGEMENT CHARACTERISTICS OF THE HIGHEST AND LOWEST PERFORMANCE OF A GROUP

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KASVATUSTIETEIDEN TIEDEKUNTA

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The concept of engagement has gained relevance in recent decades due to being positively correlated with student achievement (Pekrun & Linnebrink-Garcia, 2012; Greene, Miller, Crowson, Duke, & Akey, 2004; Marks, 2000). Researchers have reached a certain consensus in understanding engagement as a meta-construct encompassing at least three dimensions: behavior, emotion, and cognition (Fredricks et al., 2004). However, only few studies have analyzed engagement with a process-oriented approach, measuring the evolution of the different facets during collaborative interaction.

Integrating elements from the Productive Disciplinary Engagement (Engle & Conant, 2002) and Self-Regulated Learning frameworks, Rogat, Cheng, Hmelo-Silver, Adeoye, Gomoll, Traynor, & Lundh, (2019a) developed a rubric including 5 dimensions of engagement: behavioral (Beh), collaborative (Col), socio-emotional (SoE), meta cognitive (MeC) and disciplinary (Dis). Using this criterion, the present study explores teacher education students' productive disciplinary engagement during mathematical tasks. Moreover, the sessions with the highest and lowest learning scores of one group during a mathematics course. Later, these are referred as High-performance session (HPS) and Low Performance session (LPS), respectively.

Using a process-oriented approach, interaction analysis was used to code the video recordings of the group in both sessions. The coding was done observing the second-by-second variations in each dimension. Every event identified was assigned with one of four levels of quality (low, moderate-low, moderate, or high). Next, a co-occurrence analysis was used to examine the simultaneous variations between dimensions. Finally, the study was later extended to the individual level using inductive analysis, looking for reasons to explain the quality-levels of engagement reached by the group in each session.

The results indicate more consistent higher quality-levels for all facets of engagement in the HPS, and moderate levels in the LPS. In regard of the co-occurrence of quality-level variations of engagement, in both sessions were found four pairs of dimensions that varied synchronously more often (Col-Dis, Beh-Col, Soe-Col, and SoE-Dis) and two less often (MeC-Beh and MeC-SoE). Some features found to influence on the quality-level of engagement were group composition, pre-task knowledge, and the use of the collaborative script.

For researchers, these findings support the claim of engagement as a meta construct composed by different components and provide empirical results for the rubric used by Rogat et al. (2019a). For teachers and educators, this study provides insights to better design of collaborative interactions, providing support for the development of individual and group regulatory skills to increase the quality of engagement.

Keywords: Productive Disciplinary Engagement; Collaborative learning; Collaborative engagement

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1. Introduction

Collaborative learning is gaining more and more research interest as students and employees work together in order to create new knowledge and understanding for various complex problems. However, studies have shown that collaboration does not always lead to productive outcomes (Kumpulainen & Wray, 2002; Barron, 2003; Määttä, Järvenoja & Järvelä, 2012). One reason for it is that the group members may not be equally participating and contributing to the group and for its activities (Kerr & Bruun, 1983; Salomon & Globerson, 1989; Hämäläinen & Arvaja, 2009). In that sense, the concept of engagement has gained recent relevance to study the process of participation in group learning activities (Sinha, Rogat, Adams-Wiggins & Hmelo-Silver, 2015; Rogat, Cheng, Hmelo-Silver, Adeoye, Gomoll, Traynor & Lundh, 2019a, 2019b).

Previous studies have defined engagement in learning as a combination of group members' behavioral, cognitive and emotional engagement (Fredricks, Blumenfeld & Paris, 2004). Engagement has been studied in an individual level, by using concepts such as student engagement or study engagement (Appleton, Christenson & Furlong, 2008; Lawson & Lawson, 2012). Those studies have, for example, aimed to capture the reasons for students to disconnect from school (Finn, 1989; Appleton et al., 2008; Furlong & Christenson, 2008). Although student engagement is a useful concept in this regard, the main interest in this research is to explore and understand engagement as a part of on-going group activities.

The conceptualization of the construct of engagement has been developed in recent years. In this way, the understanding of the concept has changed from the initial, general and unspecific definitions (Mosher & McGowan, 1985), to current classifications including four (Reeve, 2013) and up to five dimensions (Sinha et al., 2015; Rogat et al., 2019a, 2019b) of engagement. The dimensions that have been used in describing engagement are behavioral, emotional, cognitive, agentic, academic or psychological among others. However, beyond the differences, a certain consensus has been reached among researchers in understanding engagement as a meta-construct encompassing at least three dimensions: behavior, emotion and cognition (Fredricks et al., 2004).

Different studies have proved the benefits that each dimension have for student's success. Thus, behavioral engagement has a strong link with student achievement (Marks, 2000), and impacts positively in school completion (Voelkl, 2012). This means that those students able to build constructive bonds with school are more likely to en-

gage in class, obtain better grades and avoid disruptive behaviors. By its side, emotional engagement is certainly impacted by positive emotions (Heddy & Sinatra, 2013), and it is positively related to achievement (Pekrun & Linnebrink-Garcia, 2012). Finally, cognitive engagement has proven to directly predict student achievement (Greene, Miller, Crowson, Duke, & Akey, 2004), and lead to increased motivation (Guthrie, Wigfield & Barbosa, 2004). Despite these findings, researchers have highlighted the conceptualization and measurement of one dimension, rather than the interplay between different dimensions of the meta-construct (Ryu & Lombardi, 2015; Fredricks et al., 2004).

Recently, few studies (Sinha et al., 2015; Rogat et al., 2019a, 2019b) have used a process-oriented approach to explore the interplay between dimensions of engagement in collaborative learning settings. Unlike individual engagement, the study of collaborative engagement demands a higher complexity (Järvelä, Järvenoja, Malmberg, Isohätälä & Sobocinski, 2016) due to the influence of social and contextual factors (Järvelä, Volet, & Järvenoja, 2010). However, since engagement is not an isolated event, but a dynamic and evolving process, some authors propose a dynamic and interactive relationship between different spheres such as school-related activities, classroom activities, or learning activities (Skinner & Pitzer, 2012; Lawson & Lawson, 2013).

So, it is important to attend the call to explore collaborative engagement (Järvelä et al., 2016), that address how the different dimensions of the interactions fluctuate during group interactions (Isohätälä, Näykki & Järvelä, 2019). The focus of collaborative engagement will specifically contribute to two lines of research: a) the constructivist forms of learning in school settings (O'Donnell & Hmelo-Silver, 2013), which have led to a higher number of interactions among students, where individuals need to engage with their peers (Pekrun & Linnenbrink-Garcia, 2012), and b) collaborative learning activities in different levels, due to their constant presence in formal and informal learning contexts (Skinner & Pitzer, 2012).

In consequence, the present study aims to explore the quality level of collaborative engagement of teacher education students' during mathematical tasks. Thus, the results will provide benefits for different stakeholders. First, this study provides empirical evidence of taxonomy of engagement and rubric developed by Rogat et al (2019a), paving the way for future studies in different groups and fields. The study also benefits both educators and students. For educators, a clearer understanding of engagement will help them to better enhance and assess student's connection in collaborative learning contexts (Christenson et al., 2008; O'Farrell, Morrison, & Furlong, 2006; Appleton et

al., 2008). All teacher's efforts will in turn benefit students, by helping them to develop skills such as problem solving, communicating, and thinking critically, important requirements for students to engage fully and effectively in groups (Stahl, 2006). Finally, considering the effect of engagement in learning outcomes and student achievement in general, learning the ways to engage in group activities, may also benefit students' overall learning outcomes (Furlong & Christenson, 2008).

2. Literature Review

Currently, there is a consensus among researchers to understand engagement as a meta construct with different dimensions (Fredricks et al., 2004; Appleton et al. 2008, Christenson, Reschly & Wylie, 2012), such as behavioral, emotional, and cognitive. However, there is still an ongoing discussion about the number of dimensions, and the features of each one. In the following review will be presented the main contributions to shape the concept, the different approaches, and their range of action.

In the evolution of the concept, the research field has progressed from early understandings of "engagement" and "school engagement", to more recent concepts like "student engagement" (Appleton et al., 2008) or "collaborative group engagement" (Sinha et al., 2015). These differences are also related to a change in the grain or level of the studies (Sinatra et al., 2015; Skinner & Ptizer, 2012). Thus, the studies vary from measuring engagement of students with different activities related to school (Fredricks at al., 2004; Finn, 1989), to study students' engagement as individual learners (Appleton et al., 2008; Reeve, 2013), and measuring the engagement of groups of learners during collaborative activities (Sinha et al., 2015; Rogat et al., 2019b). This responds to the different levels where engagement can be studied (Skinner & Ptizer, 2012), from individual relationship to the school, to learning processes. However, since each level encompasses different and particular processes, will also be presented the specific features of collaborative learning interactions, and the models of engagement that better suit to address those needs.

2.1. Evolution of the concept of engagement

Early definitions of engagement are characterized for being broad in their description or relying on more robust concepts. An example of the former is found in a study by Natriello (1984, as cited in Appleton et al, 2008), in which student engagement is defined as "student participation in the activities offered as part of the school program". On the other hand, evidencing some of the overlapping issues with the construct of motivation, Libbey (2004, p. 278) define academic engagement it as the "extent to which students are motivated to learn and do well in school".

While the first definition emphasizes student's behavioral aspects (participation), the latest underscore the internal forces (motivation) driving students to learn. Later definitions integrated both internal and external facets more explicitly. Thus, Skinner

and Belmont (1993, p. 572) defined engagement as a "sustained behavioral involvement in learning activities accompanied by positive emotional tone", while Audas and Willms (2001, p. 12) explained it as the "extent to which students participate in academic and nonacademic activities and identify with and value the goals of schooling".

Addressing the complexity of the concept, Fredricks et al. (2004) presented a tripartite taxonomy. Thus, after an extensive literature review, the authors went beyond single components, presenting engagement as a meta-construct with three different yet interrelated dimensions. The dimensions include behavioral engagement (e.g. positive conduct and absence of disruptive behaviors, involvement in learning and academic tasks, and participation in school related activities), emotional engagement (e.g. affective reactions of students during classroom, with the teacher, or with the overall school), and cognitive engagement (e.g. investment in learning and self-regulatory strategies). The relevance of the study relies in setting a basis for future research, by unveiling the complexity of the construct. Thus, the study provided a richer characterization of student's engagement, integrating rather than studying each dimension as a separate construct.

Following this line of research and linking the work in engagement with the dropout intervention, Reschly and Christenson (2006) developed a four-type categorization, considering behavioral, psychological, cognitive and academic engagement. Similarly, Furlong and Christenson (2008) developed a four-type categorization including academic, behavioral, cognitive and affective components. Even though both taxonomies resemble many of the facets mentioned by Fredricks et al. (2004), they also establish important differences.

Among the similarities, the behavioral, psychological/affective and cognitive dimensions resemble many of the facets mentioned by Fredricks et al. (2004) (e.g. classroom participation or attendance for behavior, and sense of relatedness or affective connections at school for psychological/affective). Similarly, academic engagement is related to time on task, credits earned and homework completion. Appleton et al. (2008) support the inclusion of academic engagement considering its consistency with findings correlating high rates of time spent in learning with student achievement (Fisher & Berliner, 1985), and the variation of engagement according to specific tasks and along different grades (Marks, 2000).

Even though, Furlong and Christenson (2008) do not establish deeper differences with the tripartite scheme proposed by Fredricks et al. (2004), the taxonomy by

Reschly and Christenson (2006) does. For example, by including boredom within the cognitive dimension, while for Fredricks et al. (2004) is an indicator of emotional engagement. Even more, although both studies analyze the work of Finn (1989), they differ in its allocation. While Fredricks and colleagues (2004) consider time on task a feature of the behavioral dimension, and insufficient to explain high engagement, Reschly and Christenson (2006) put it into the academic dimension, keeping on the behavioral dimension other variables, such as attendance, voluntary classroom contribution, and extracurricular participation.

Also developing a four-type categorization of engagement, Reeve and Mei Tseng (2011) added agency to the tripartite taxonomy of Fredricks et al. (2004). Thus, agentic engagement refers to "students' constructive contribution into the flow of the instruction they receive" (Reeve & Mei Tseng, 2011). Testing their hypothesis, the authors ran a study collecting survey data from 365 Taiwanese high-school students, measuring the four dimensions of engagement (behavior, cognition, emotion and agency). When correlating the results with student's academic achievement, agentic engagement explained unique and meaningful variance, that the other variables did not. Despite the positive results, other authors claimed for more research to sustain this categorization (Lawson & Lawson, 2012; Sinatra, Heddy, & Lombardi, 2015).

In a posterior study, Reeve (2013) added higher accuracy to the concept. Thus, acknowledging the unilateral student's contributions do not necessarily improve learning conditions, he integrated into agentic engagement elements from transactional (Sameroff, 2009) or dialectical (Reeve, Deci & Ryan, 2004) activities. In this way, he stressed the iterative nature of the relationship student – teacher, where the actions of each one affect the other, as well as the learning outcomes. Differentiating it from behavioral engagement, the author highlights that "agentic engagement is intentional, purposive student-initiated action to render the learning environment to become more motivationally supportive" (Reeve, 2013, p. 581).

Focusing on the connections between emotions and engagement, Pekrun & Linnenbrink-Garcia (2012) developed a five-category classification, including behavioral, social-behavioral, cognitive, cognitive-behavioral, and motivational dimensions. Narrowing some components of the categorization by Fredricks et al. (2004), they consider as behavioral engagement only the effort and persistence invested to complete a task, while the social-behavioral dimension relates to peers' collaboration and high-quality social interactions. Likewise, they also divide the cognitive processes in two: cognitive

engagement, which relates to more automatic cognitive process (such as memory and attention processes), and cognitive-behavioral engagement, which relates to the purposeful use of higher cognitive skills (e.g. problem solving skills), metacognitive and self-regulation strategies. Finally, they include motivational engagement as the last dimension, relating it to the processes to initiate and sustain goal-directed academic effort.

At this point, the taxonomies presented before include in their categories, variables that can be applied to study engagement in a micro level (e.g. individual engagement during a learning activity) to a macrolevel (e.g. group of students engaged with a school) (Azevedo, 2015; Sinatra, Heddy & Lombardi, 2015). The breadth of the concept has led some authors to claim for a positive discrimination between the concepts of *school engagement* and *student engagement* (Appleton et al. 2008; Lawson & Lawson, 2012). This is, differentiating between engaging students as learners as compared to the different levels in which schools can engage students (sports, clubs, governance).

Even though the categorizations reviewed can be used to measure engagement as learners, they also can be applied to study the engagement of students in different spheres of engagement within the school (Skinner & Ptizer, 2012). On the other hand, the taxonomies studies by Sinha et al. (2015) and Rogat et al. (2019a, 2019b) are circumscribed specifically to capture the level of engagement of students as learners, and in collaborative learning settings. However, before reviewing them, I will introduce the concepts of collaborative learning, socially shared regulation, and productive disciplinary engagement, which provide the foundations for the work of Rogat et al. (2019a), whose taxonomy serves as the basis for the present study.

2.2. Main concepts to measure engagement in collaborative settings

2.2.1. Collaborative Learning

From a socio-constructivist approach, learning is a social process of knowledge construction through interaction (Bonk & Cunningham, 1998). This process implies sharing and negotiating different perspectives to create a knowledge artifact and to attain a joint understanding (Roschelle, 1992; Stahl, 2006). Thus, collaborative learning boosts a deep understanding of learners with the process of negotiations and discussions leading to broaden individual knowledge which cannot be achieved by oneself (Dillenbourg, 1999).

There is a robust body of evidence supporting the value of collaborative learning over individual learning (Tudge & Rogoff, 1980; Wertsch, 1985; Slavin, 1989; Kuhn, 2001; Koschmann, 2003). However, collaborative learning does not occur spontaneously (Barron, 2003) but rather emerge as a confluence of different elements such as: types of interactions among group members, as well as symmetry of action, knowledge or status (Dillenbourg, 1999). Therefore, the process is not exempt of challenges. For example, the need of trust to increase collaborative performances (Kreijns, Kirschner, & Vermeulen, 2013), negative socio-emotional interactions can diminish collaborative learning (Linnenbrink-Garcia, Rogat, & Koskey, 2011; Näykki, Järvelä, Kirschner, & Järvenoja, 2014), the need to discuss emotions to recognize and resolve challenges (Järvenoja & Järvelä, 2013; Näykki et al., 2014; Bakhtiar et al., 2017), or the need to make thinking visible so socially shared metacognition takes place (Hurme, Merenluoto & Järvelä, 2009).

Considering all the factors aforementioned, the study of engagement in collaborative settings demands a higher complexity over the individual expression of the phenomena (Järvelä, Järvenoja, Malmberg, Isohätälä & Sobocinski, 2016). This complication responds to the influence of social and contextual factors on the engagement level (Järvelä, Volet, & Järvenoja, 2010), like the interaction between learners (Miyake & Kirschner, 2014), the socioemotional processes required to group regulation (Linnenbrink-Garcia, Rogat, & Koskey, 2011), or the need for sharing information and sustaining a synchronized activity (Roschelle & Teasley, 1995). Addressing these factors, the theory of Self-Regulated Learning provides a useful framework to study the strategies used by individuals and groups to overcome the challenges aforementioned (Järvelä et al., 2016). Next, its main components will be reviewed.

2.2.2. Socially Shared Regulation of Learning

Emphasizing the agency of learners, and recognizing them as constructors of their own knowledge, the self-regulated learning (SRL) models (Zimmerman; 2000; Hadwin, Järvelä, & Miller, 2011 or Boekaerts, 1996 among others) consider the regulatory processes exerted by the individuals or groups to reach a goal. In order to achieve this, the SRL process includes different facets of learning, such as: behavioral, motivational, cognitive, meta-cognitive, and emotional or affective (Panadero, 2017). Thus, when pursuing a learning goal, an individual can regulate either their motivation or cognition in order to accomplish the task.

Self-regulated skills are appropriated by learners by interacting with more experienced others, within the frame of context and culture. An example of this is coregulation, in which learners sharing a common problem-solving ground exchange regulatory activity and thinking. (Hadwin & Oshige, 2011). Expanding this concept to a whole group, leads to the concept of Socially Shared Regulation (SSR), which considers not individual by group regulation. Thus, the goals and standards are co-constructed by all group members, as well as the regulatory activity to reach them (Hadwin & Oshige, 2011).

Some authors have pointed out the tension between the concepts of self—regulated learning and engagement (Azevedo, 2015; Järvelä & Renninger, 2014). On the individual level, the issue was addressed by Reeve (2013), who aware of the resemblance of agentic engagement with some dimensions of Self-Regulated Learning (SRL), clarified the differences between both concepts, considering goals, context and relationship between teachers and students. Thus, SRL theory considers as a final goal for students to self-regulate themselves. So, teachers are external factors that foster learner's self-regulated skills, through modeling or social guidance. On the other hand, agentically engaged students constantly work collaboratively with the teachers to create a learning environment more appealing to them. It can be concluded that while the former focuses on the individual, the second focuses in the context.

Also, in regard of the differences between SRL and engagement frameworks, Wolters and Taylor (2012) deepened in the understanding of their relationship, by analyzing their similarities and differences. Thus, they compared the model of SRL by Pintrich and colleagues (Pintrich, 2004; Pintrich & De Groot, 1990 ; Pintrich, Wolters, & Baxter, 2000; Pintrich & Zusho, 2002; Wolters, 2003; Wolters, Pintrich, & Karabenick, 2005), and the tripartite conception of engagement: behavior, emotion and cognition, proposed by Fredricks et al. (2004). Among the similarities, Wolters and Taylor (2012) included: a) a shared understanding that high cognitive engagement follows the use of SRL skills, b) comparable criteria to measure cognition (even considering in some cases the use of SRL strategies as indicator of cognitive engagement), c) a strong correlation of positive emotions for high emotional engagement and SRL, and d) a shared view for both frameworks of the relevance of students overt behaviors for academic functioning. On the contrary, some differences between frameworks are related to a) different treatments of concepts (e.g. sense of belonging, self-efficacy, help-seeking, or identity), b) different attention given to behavioral forms of engagement (e.g. course taking, partici-

pation in extracurricular activities, and graduation), c) distinct understanding and classification of motivation (clearly related to self-regulated processes, but still not well established in engagement research), d) the centrality of personal agency (extremely highlighted in SRL framework, but scarcely considered in engagement research), and e) a slight disparity in the significance and reach ascribed to different types of metalevel knowledge (e.g. cognition and motivation).

Considering this proximity between concepts, Järvelä, et al. (2016) argued that the use of SRL framework can complement the study of engagement. Their claim is based on the clear process depicted by SRL models on student learning, including different facets, such as: cognitive, meta-cognitive, motivational and socio-emotional. Even though different constructs of SRL have been included in the dimensions of engagement (Fredricks et al., 2004; Christenson & Anderson, 2002; Sinatra et al., 2015), in many cases the operational definition of cognitive engagement overlaps with self-regulated constructs. In my understanding, Rogat et al. (2019a) integrate successfully both frameworks by differentiating between the activities related to co-regulatory and SSR activity, from those related to the use of a discipline. For the latest, they created the disciplinary engagement category, based upon the concept of Productive Disciplinary Engagement, presented below.

2.2.3. Productive Disciplinary Engagement

Emerging from design-based research, Engle and Conant (2002) developed the Productive Disciplinary Engagement (PDE) framework. Similar to the distinction made by Fredricks et al. (2004) between behavioral and cognitive engagement, Engle and Conant (2002) sustain that engagement entails the active, intense and responsive interaction of group members, but it does not necessarily mean that the participants are engaged with the disciplinary problems related to the specific task. Therefore, they posit that for a group to be disciplinary engaged there must be "some contact between what students are doing and the issues and practices of a discipline's discourse" (Engle & Conant, 2002, p. 402). Finally, this disciplinary engagement is productive if students make progress in managing the discipline to fulfill the task they address. In this way, the concept of productivity is delimited by the discipline, the specific task and the topic (Engle, 2012).

In order to foster PDE, Engle and Conant (2002) proposed four interrelated and sequenced principles, namely problematizing, authority, accountability and resources.

These principles could be used across different learning environments and disciplines to support collaborative learning processes. Problematizing refers to provide a genuine uncertainty related to the discipline in some way responsive to the learner's own interests or motivations. Thus, to resolve this uncertainty students need to have a level of agency. For this, Engle (2012) establishes three levels: a) recognizing students as authors of their own ideas, b) becoming contributors to the ideas of others, and c) gradually gaining socially recognition for the influence of their ideas on others. However, this agency needs to be balanced with accountability, the third principle. Accountability refers to the need that student's ideas need to make sense regarding the relevant work of others. This do not refer to provide "correct" responses, but to articulate their intellectual contribution within the discipline of the task at hand. Finally, for the previous principles to work, students must have access to enough resources to complete the task (e.g. time, materials, books, etc.).

In summary, the principles of PDE aim to encourage and give agency to students to take on intellectual problems, where they make intellectual progress, accountable for others and for disciplinary norms and supported by enough resources (Engle & Conant, 2002). This abstract definition of the principles responds to provide them of enough flexibility to be adapted to different learning environments, in regard of disciplines, classrooms, and sociocultural practices (Kumpulainen, 2014; Engle, 2012).

Although the PDE provided a frame of reference shared by educators and researchers to understand teaching and learning practices within and across different settings (Kumpulainen, 2014), the authors (Engle & Conant, 2002) did not develop specific instruments to measure it, relying mostly on the criteria of teachers and researchers. However, this task was tackled by the authors of the studies presented in the following section, which constitute the basis for the present study.

2.3. Measuring engagement in collaborative settings

After reviewing the characteristics and challenges in collaborative learning settings, as well as the contribution of the Self-Regulated Learning and Productive Disciplinary Engagement frameworks, the taxonomies by Sinha et al (2015) and Rogat et al. (2019a, 2019b) will be presented. In addition to addressing the collaborative engagement study, these studies also share a methodological change from most of the previous research. First, considering engagement as a process, rather than a static phenomenon (Järvelä et al., 2016; Kumpulainen, 2014), they do not take isolated samples at a single point, but

rather observe the evolution of the different dimensions of the meta-construct of engagement throughout one or more classes. Second, instead self-assessment reports, in the three studies videos were used to analyze the interaction among participants, examining the quality of engagement for each of the categories in 5-minute segments.

Sinha et al. (2015) developed a taxonomy of engagement considering four dimensions: behavioral, social, cognitive, and conceptual-to-sequential. As in previous cases, behavioral engagement relates to sustained on-task behavior during academic activity. On the other hand, resembling Pekrun & Linnenbrink-Garcia (2012) they create new subdivisions for Fredricks et al. (2004) categories of cognition and emotion. First, like the social-behavioral engagement described in Pekrun & Linnenbrink-Garcia (2012), Sinha et al. (2015) define social engagement as referring to the quality of group socio-emotional interaction during the collaborative process. Similarly, they also decompose the previous conceptualization of cognition, differentiating the activities related to planning and monitoring of the task, from those related to the use of domain specific content. Thus, cognitive engagement focuses on student's use of cognitive strategies such as planning, monitoring, and evaluation when accomplishing the task.

Sinha et al. (2015) developed the latest category based on the work by Gresalfi, M., Barab, S., Siyahhan, S., and Christensen, T. (2009), considering conceptual-to-sequential engagement to the use of domain-specific content and disciplinary practices as tools to solve problems. The concept describes the different facets of student's interaction with content. For this Gresalfi et al. (2009) considered three levels: procedural, conceptual and sequential. In the former level, students use procedures in an accurate way, but without deeper understanding of the underlying reasons that explain them. In the next level, conceptual engagement entails both procedures and the reasons to apply them. Finally, in consequential engagement students also consider the implications of such procedures in obtaining certain outcomes.

In their study, Sinha and colleagues (2015) compared 10 groups of 7^{th} graders when using different modeling tools and hypermedia to explain the causes for fish death in a local pond. Thus, the high-quality engagement group performance was characterized by high-quality levels in the cognitive and conceptual-to-consequential engagement when modeling. This is they planned and monitor their performance, using domain-specific content and disciplinary practices to solve the problem, and reflected after completing the task. On the contrary, the low-quality engagement group displayed low-quality scores in all forms of engagement, provoked by initial ineffective planning and a

decision to work on the task individually. Thus, the study concluded that behavioral engagement (on-task behavior) and social engagement (respectful and responsive interactions among group members) fostered high quality cognitive engagement, which then facilitated consequential engagement.

Also focused on capturing the evolution of engagement during collaborative interactions, Rogat et al. (2019b) developed a model of engagement, integrating the different contributions to the definition of construct with the Productive Disciplinary Engagement approach (Engle & Conant, 2002). Accordingly, the authors built five categories of engagement: behavioral, social, emotional, metacognitive and disciplinary.

Similar to previous researchers (Reschly & Christenson, 2006; Furlong & Christenson, 2008; Pekrun & Linnenbrink, 2012; Sinha et al., 2015), Rogat et al. (2019b) include persistence and effort investment towards to completion in the behavioral component. On the other hand, expanding the social-behavioral and social dimensions, developed by Pekrun & Linnenbrink-Garcia (2012) and Sinha et al. (2015) respectively, Rogat and colleagues divide social interactions evaluations in two categories. Thus, emotional engagement relates to the maintenance of a respectful and cohesive climate by all team members, while social engagement is the coordinated and responsive interaction of the group. Finally, the two last categories are interesting for integrating explicitly the contributions of the research in Self-Regulated Learning and Productive Disciplinary Engagement. Thus, Rogat et al. (2019b) posit the metacognitive engagement, which is related to the Socially Shared Regulation (SSR) and Co-Regulation processes, and the disciplinary engagement categories, which refers to the contributions to intellectual progress involving integrated conceptual and disciplinary activity.

Using three-point quality indicators for each dimension, the authors (Rogat et al., 2019b) coded two segments of two groups and then compared the variations in the levels. Comparing the findings for both groups, no correlation was found between the social and emotional categories of engagement and the disciplinary category. Worth mentioning, these preliminary results form part of a larger study with middle school students, with tasks related to modeling, design, and argumentation in math, science, and engineering classes.

Taking many of the categories of the previous classification, Rogat et al. (2019a) developed a five-categories taxonomy to measure engagement in collaborative settings. Thus, the categories are behavioral, collaborative, socio-emotional, metacognitive and disciplinary engagement. Like this, the authors differentiate between the coordinated

and responsive interactions among group members (collaborative engagement), from the contributions related to intellectual progress (disciplinary engagement), and the climate generated by group interactions (socio-emotional engagement). Likewise, another change from the previous rubric (Rogat et al., 2019b) is the use of an additional level of quality in the disciplinary category.

In consequence, Rogat et al. (2019a) define high-quality group engagement as "making collective intellectual progress by making connections among core conceptual ideas and disciplinary practices during authentic activity" (Rogat et al., 2019a). Definition that I choose for the development of the present study. The reasons for this selection are two: One: integrating the frameworks of Self-Regulated Learning (SRL) and Productive Disciplinary Engagement with the studies of engagement, resolves the tension between the constructs of SRL and engagement, while answers to the claim of Boekaerts (2016) for synthesis in the following studies of engagement. Two: since in both studies (Rogat et al. 2019a, 2019b), the authors did not present a complete analysis for the rubrics developed, this thesis will work as empirical evidence of this tool for interaction analysis with video material. Hoping that future studies work upon this taxonomy, this will contribute to the creation of a corpus of studies easy to compare between them (Sinatra et al., 2015).

3. Aim and objectives

The aim of this study is to explore collaborative engagement in a case group of teacher education students during mathematical tasks. The focus is to explore engagement considering the group as unit of analysis, looking at the variations of quality in the different dimensions of engagement (behavior, collaboration, socio-emotional, meta-cognitive and disciplinary) along a collaborative learning activity. For this purpose, it was used a case study approach (Yin, 2008) to study one group of students, during their lowest and highest academic performance in one course about Mathematics Education.

According to the aforementioned, the present study was guided by the following research questions:

RQ1: What is the quality of engagement in two collaborative learning session (high-performance and low-performance session)?

RQ2: Is individual participation in triggering high quality engagement events corelated with the level of group engagement?

RQ3: What contributes to Productive Disciplinary Engagement in collaborative learning settings?

RQ4: What characterizes the interplay of dimensions of in two collaborative learning sessions (high-performance and low-performance session)?

4. Research methods

4.1. Data collection and participants

The data for this study was collected in the PREP21 project (Preparing teacher students for the 21st century learning practices), funded by the Academy of Finland. The main aim of the project was to analyze collaborative learning in the context of preparing teacher education students for 21st century learning practices. The material was collected in 2015 including video records, complemented with situation specific questionnaire data. For this study, video recordings were the main source of data.

The participants of the study were first year Intercultural Teacher Education students from the University of Oulu, which collaborated along 6 sessions in groups of 3 to 4 members. The class included both Finnish and international students. Due to absences, all groups do not have videos from all sessions. In consequence, to choose the group for the present study, I considered only the videos of the four groups which used English in their discussions. In total, the material recorded for these groups lasted over 17 hours.

The data was collected during a Mathematics Education course. The topics of the sessions covered collaborative learning, mathematical problem solving and pedagogical discussions. According to each session the subjects were: Arithmetic algorithms and base ten blocks, Fractions, Spatial thinking, Geometry and measurement, and Learning difficulties in mathematics.

The teachers of the course together with the researchers of PREP21 project developed written scripts for the students to follow during each session. The scripts included the sequence of collaborative and individual tasks for the group in each session, and also integrated a set of questions at the beginning, middle and end of the task, both on individual and group level (see Table 1).

To assess group performance, the teacher used the Structure of the Observed Learning Outcome (SOLO) Taxonomy (Biggs & Collins, 1982) to evaluate groups' collaboration and pedagogical skills as well as content knowledge. SOLO Taxonomy includes 5 different grades (0 to 4), ranging from a poor performance of the group (skip the task, fail in doing it or achieve it independently), to a high quality performance (co-construction of knowledge, overcoming challenges together, and reflecting about the pedagogical relevance of the task).

Table 1. Script group questions

Stage	Questions
Beginning of the session	1. What is the purpose of the task? 2. What kind of feelings does the task arouse? 3. What kind of strengths does your group have? 4. What is the goal of your group work? 5. How do you plan to work?
Middle of the session	1. How has your work progressed? 2. What kind of feelings does your work arouse? 3. What kind of challenges are you currently facing? 4. How will you proceed from here on?
End of the session	1. How would you evaluate your work as a group? 2. How did you reach your result(s)? 3. What helped or hindered reaching your goals? 4. How did you overcome possible challenges?

Considering previous findings that correlate high-quality engagement with learning outcomes and student achievement (Greene, 2015; Appleton et al., 2008; Furlong & Christenson, 2008; Greene et al., 2004; Fredricks et al., 2004), the group's results were searched for the highest and lowest scores. It was found that one group scored the highest and lowest grades in the sessions one and two, which length 64 and 58 minutes, respectively.

With all members present in both performances, the group achieved in the first session (later referred as high-performance session) a grade of 3.75/4 points for pedagogical discussion and collaboration, and 3.5/4 for content discussions. On the other hand, in the second session (later referred as low-performance session) they got 1.83/4 and 2.33/4, respectively. I chose this group as the case group and analyzed their engagement in the two sessions in detail, using the video recordings.

4.2. Data analysis

Video was chosen as the main source for this study due to its capacity to capture the details within the temporal organization of an activity (Suchman & Trigg, 1993). Likewise, for its many benefits and reduced limitations (Jordan & Henderson, 1995; Roschelle, Jordan, Greeno, Katzenberg, & Del Carlo, 1991; Heath, 1986). Among the

former can be mentioned to reduce possible observer bias, since it allows an unlimited number of viewings, and a source for detailed and recurrent analysis. Even though, the influence of camera on participants, or bias created by the camera movement are potential concerns, previous studies have demonstrated that they are attenuated by the quick habituation of participants to the camera, and a stationary position of the camera respectively.

The videos were reviewed using the interaction analysis method. This choice was based on three reasons: 1) interaction analysis is a useful method to look for mechanisms through which participants build and employ social and material resources to discuss, negotiate and build knowledge (Jordan & Henderson, 1995), 2) consider both verbal and non-verbal signs, which occur in all group learning process (Branco, Pessina, Flores, and Salomao; 2004; Barron, 2003), and 3) share with the rubric developed by Rogat et al. (2019a) the understanding of learning as a distributed and ongoing social process in which learning occur in the interaction between participants (Jordan & Henderson, 1995).

Using this approach, the material was reviewed, dividing each session in different events according to every dimension. This is, in a specific time lapse, the different dimensions can sustain one or more levels of quality. Therefore, their evolution during lessons may follow different patterns. After this process was completed, were identified the points with higher quality-level, and the total time that the group spend in each quality level per dimension.

Later, to explore the individual reasons that support the levels of quality reached by the group in each session, the videos were reviewed developing an inductive analysis. This is, using "detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data by an evaluator or researcher" (Thomas, 2006, pp. 238). This led to identify three elements that influence the level of engagement in both sessions: group composition, pre-task knowledge and use of the script.

Finally, the interplay of dimensions was studied using a co-occurrence analysis (Vartiainen, Nissinen, Pöllänen, & Vanninen, 2018). Thus, the relationships between dimensions were measured according to their simultaneous variation in the level of quality.

In summary, the study used video material to perform interaction, inductive interaction and co-occurrence analysis, focusing on both group an individual level. Thus, the comparison between performances was done after completing the following steps:

1. create a preliminary division of events, considering the variations in quality for all five dimensions,
2. assign a quality-level for each segment, refining the previous division,
3. identify the events with the highest quality level for all dimensions (later referred as high-quality engagement events),
4. identify and count the variations of quality level for each dimension in regard of similar variations in the others,
5. select one specific segment of each video with the higher number of high-quality engagement events in each session,
6. analyze the role of each member, regarding the high-quality engagement events and the whole session, and
7. compared the results of both performances.

4.2.1. Dimensions of engagement

In the first part of the analysis were identified different engagement dimensions (behavioral, collaborative, socio-emotional, meta-cognitive and disciplinary) from the video data. During the video annotations, the identity of the team members was replaced by the letters A to D, to preserve their anonymity. The videos were reviewed looking for events in each engagement dimension, without a specific timeframe, aiming to capture the moment-to-moment fluctuations in the level of engagement (Sinha et al., 2015). In this phase, I described students' interactions in terms of their on-task group discussions, lack of interaction, evaluation of previous work and reviewing instructions (see Table 2).

Once the engagement events were identified in both sessions, they were coded according to the engagement dimensions developed by Rogat et al. (2019a), which consider different levels of quality of engagement for five dimensions. The categories include behavioral, collaborative, and socio-emotional aspects, as well as meta-cognitive and disciplinary activity.

Table 2. Identification and coding of the engagement events

Beginning of the event			End of the event			Length (sec)	Description of the event
Hours	Min	Sec	Hours	Min	Sec		
0	14	30	0	14	47	17	B explains again her point. A, C and D pay attention to B. C and D reply.
0	14	48	0	14	57	9	B continue talking to C. A looks at them. D writes something, then watch the blocks and finally touch them.
0	14	58	0	15	23	25	B continue talking with C (continue) D counts the blocks. A detours her eyesight towards D. Then A takes a block from the hundreds to the tens. D confirms verbally that is a ten. A replace 10 blocks of ten for 1 of hundred. A and D keep eye contact.
0	15	24	0	15	29	5	B continue talking with C (continue) A and D are off task (most of the time for D).
0	15	30	0	15	50	20	B continue talking with C (continue). A and D join the discussion. D points out they need to teach children the rules of the game (no more than 10 blocks in each column of the sheet). C gives an example. A interrupts C to ask if the solve the operation they should start from the units. D confirms.
0	15	51	0	16	8	17	C talks to A. C repeats what has been told, providing examples. B scratch her head. D remains silent, and look around.
0	16	9	0	16	15	6	D paraphrases what has been told, in order to clarify it.
0	16	16	0	16	42	26	C ilustrates her example with the blocks. B laughs quietly of some mistakes of C with the blocks. D remain silent, interviening at the end of the conversation to give it for conclude.
0	16	43	0	16	50	7	The group begins with the exercise 1C (273+149) D asks to go for the next question. All agree. C complains that is quite simple and suggests to do a -1 task. No replies. Then she says the numbers they need to look for: 273 and 149.

a. Behavioral engagement

The behavioral engagement dimension refers to the degree the group persist to complete the task, investing effort, even in the face of challenge. It has three levels of quality: low, moderate, and high.

The high level of behavioral engagement refers to the group showing a sustained on-task activity. This might be either via oral contributions, active listening or playing a supporting role. On the opposite, the low level of behavioral engagement is characterized by off-task behavior or very limited on-task activity. For example, when joking in off-task interactions, or when group members attempt to deviate their peer focus from the task. Finally, the moderate level of behavioral engagement has a predominant on-task behavior, with intermittent off-task activity.

b. Collaborative engagement

The collaborative engagement dimension refers to the coordination and responsiveness of the group during negotiation or knowledge co-construction. It has three levels of quality: low, moderate, and high.

In the high-quality level of collaborative engagement, the group evidences coordinated interactions. Diversity of perspectives are solicited and integrated, or they are rejected with rationale. On a physical level, there is evidence of eye-contact and spatial closeness. On the other side, during the low-quality level of collaborative engagement, the group interactions are uncoordinated. Members are unresponsive to each other contributions, and their interaction is characterized by limited eye contact and spatial distancing. The moderate level of collaborative engagement presents mixed interactions or inconsistent evidence of high-quality interaction. Alternatively, their coordination is limited, taking the first response without further discussion.

c. Socio-emotional engagement

The socio-emotional engagement dimension alludes to the quality of the climate generated by the group during interaction. As the previous dimensions, it has three levels of quality: high, moderate, and low. At the highest level of socio-emotional engagement, group interactions are respectful and cohesive, promoting a feeling of psychological safety for all team members. This does not dismiss the expression of negative emotions (such as tension or frustration), but they are alleviated, preserving the safe climate.

On the other hand, the low-quality level of socio-emotional engagement is characterized by a negative climate, with evidence of disrespect and low cohesion among group members. Finally, the moderate quality of socio emotional engagement encompasses neutral interactions or a mixed climate with evidence of both previous levels.

d. Metacognitive engagement

The meta-cognitive engagement dimension encompasses the group socially shared regulation and co-regulation activities focused on content and/or practice. This relates to regulation aimed at maintaining on-task behavior, monitoring of group process, time management, productive emotions, and following task directions.

A high-quality meta-cognitive engagement in this dimension relates to an effective group goal setting, planning, monitoring and evaluation. Groups' criteria exceed from task requirements to focus on high-quality understanding. For example, consider-

ing an alternative perspective or explanatory model, or summarizing their common understanding before turning to the next task.

On the other hand, in the moderate quality of engagement in the metacognitive dimension, regulation, planning and monitoring are effective but merely driven towards task completion. Also, evaluation might occur or not. If so, it is brief and focuses on minimal task requirements.

Likewise, a low-quality metacognitive engagement is related to ineffective group regulation which impede task progress or evaluation after task-completion. This includes group's inability to set goals or planning, late planning or a recurrent return to regulation with limited task progress, emphasis on behavioral regulation in detriment of other regulation, or lack of time at the end of the task for evaluation.

The absence of regulation is not interpreted as necessarily low-quality. In some cases, this deficiency can indicate low quality regulation, such as when disengaged without regulatory attempts to return to task. Thus, the presence/absence of regulation has separate ratings. Quality of metacognitive engagement is thus rated only when regulation is present.

e. Disciplinary engagement

The disciplinary engagement dimension refers to the group new contributions to make intellectual progress to complete the task. Thus, it involves integrated conceptual and disciplinary activity.

In this engagement dimension four levels of quality are considered: low, moderately low, moderate, and high. In the low-quality level of disciplinary engagement, group interactions are limited or null (e.g. off-task). In the next level (moderately-low) the group interaction is characterized by a lack of application. The contributions may be either fragmented or focused on the mere repetition of concepts or processes. In the moderate-quality level, the contributions of the group involve some elaboration of content or practices, but with a minimal application to the task/problem. Finally, on the high-quality level, the contributions generate a significant intellectual progress towards task completion. Also, the group explicitly identify how their content and/or practice activity generates the needed knowledge to solve the task.

4.2.2. Event coding

After the engagement events were marked, each dimension (behavioral, collaborative, socio-emotional, meta-cognitive and disciplinary) was assigned with a level of quality (low, moderate low, moderate or high). If during the process it was found a variation in the quality-level of one dimension within an event, the event was split in two. Thus, the quality-level of one dimension could remain the same through several events, while another dimension could vary event after event (see Table 3).

Example of the event coding

All the group members are discussing ideas about of how to solve a mathematical problem. The climate for group working is positive, the ideas presented are related to the topic, and the group members are also reviewing and discussing their previous problem-solving attempts. All the engagement dimensions (behavioral, collaborative, socio-emotional, meta-cognitive and disciplinary) are in a highest-level. However, as far the conversation continues one member disengage and do something else without distracting their peers. Even though most of the group persist on the discussion, one member abandons it. Therefore, a new event is created with a lower level of quality of engagement for the behavioral and collaborative dimensions.

Table 3. Events coding: quality-level per dimension

Beginning of the event			End of the event			Dimensions of engagement				
Hours	Min	Sec	Hours	Min	Sec	Behavioral	Collaborative	Socio-emotional	Metacognitive	Disciplinary
0	14	30	0	14	47	High	High	High	High	High
0	14	48	0	14	57	Moderate	Moderate	Moderate	High	High
0	14	58	0	15	23	High	Moderate	High	High	High
0	15	24	0	15	29	Low	Low	Moderate	High	High
0	15	30	0	15	50	High	High	High	High	High
0	15	51	0	16	8	Moderate	Low	Moderate	Moderate	High
0	16	9	0	16	15	High	Low	Moderate	High	Moderate
0	16	16	0	16	42	High	Low	Moderate	Moderate	Moderate
0	16	43	0	16	50	Moderate	Low	Moderate	Moderate	Moderately low

During the sessions, the facilitators (teachers and researchers) were also present in the classroom situation. Their presence is marked during the analysis as external factors to the group. The facilitators contribute to interactions in different ways, for example, providing general group work instructions (e.g. complete the reflection part), providing information about the data collection (e.g. record your names in the camera),

or advising for the mathematical task (e.g. to what to take into account for a Math operation). However, since their participation is external to the group, their interactions were recognized as part of the event, but no level of quality was assigned.

During the event coding, it became clear that in different moments of the sessions, the group sustained the highest quality of Productive Disciplinary Engagement during one or more consecutive events. To differentiated them from events with different quality levels, as well as from the name of the framework, I named these individual or consecutive events as high-quality engagement events (HQE).

The next phase of the analysis was to explore the quality level of each dimension (behavioral, collaborative, socio-emotional, meta-cognitive and disciplinary) in HPS and LPS. In practice, for each dimension, the duration of all the events with the same level (low, low-moderate, moderate or high) were counted. This was done to be able to compare HPS and LPS sessions.

4.2.3. High-Quality Engagement events

After the coding was completed, the events with the highest rates in all five dimensions were identified and denominated as High-Engagement Events (HQE). In this study, HQE events are characterized by a positive, attentive, and beneficial interaction of all group members. The group members are monitoring their progress while sustaining in a joint discussion towards making intellectual progress to complete the task. Since active listening is also a way to be engaged, it is not mandatory that all members contribute verbally at the same time to the group discussion, but they are all focused in the conversation.

Next an example of the group interaction in one of the HQE during the HPS is presented. The group is learning how to teach the basic mathematical operations to children, using a board with four columns and a set of blocks with different colors. The materials include four kind of blocks, each with a different value. The “units” blocks are represented by yellow cubes. The “tens” blocks are formed by 10 “units” cubes aligned in a line, forming one single green batten. A “hundred” block is a light blue square of the size of 100 “units”. Finally, the “thousands” block is a red cube of the size of 10 “hundred” blocks stacked one upon another. The transcribed dialogue corresponds to the moment after they used the blocks to solve the operation: 2000 – 194.

Transcription 1: High-quality engagement event

(33:42)

A: (to C) But it is true, we did not answer your question. How we can...?

C: Yeah, how do we explain that to children?

A: I mean I was like...

C: ... a bit confused...

A: Yeah, bit confused... because it is... it is in my mind, so how can you explain that?... But... I mean...

D: I can explain that: we took out the fours first.

C: Yeah!

B: And how...?

A: How you can take...? I mean it is very...

C: It is complicated, I think it is...

A: I have it in my mind like one hundred...

D: (taking one of the "thousands" block) But I think you can make it visually, because you have the squares. You want to take out four. (pointing four squares in the "thousands" block)

C: We can take a red one, making it blue and green and yellow at the same time.

B: It is a bit confusing

D: You can do it in steps.

C: You can take 6 out, and you will have 9 hundred and 4.

D: I think we do it in steps. You can ask them: Ok, you want to take out 4, so what would you do? So, they can´t physically take out four, so they have to convert one.

(D changes one "thousands" block for 10 "hundreds")

D: Ok, but you still can take out four. So, you have to convert it (hundred block) into that (ten blocks). You can't... so you have to do it.

C: Ah...

B: (to C) So, you made it quicker.

C: ... but the slower one would be easier.

(34:58)

The transcribed example shows the situation where group members are reflecting over their progress and aiming to reach a deeper understanding. Despite the difficulties of group member A to express her thoughts, the other group members support her. Also, members C and D discuss about the best way to present the process to children, while A and B have brief verbal comments that evidence their participation in the discussion. Finally, the outcome is summarized to have a common understanding.

4.2.4. Analysis of interplay between dimensions

To study the correlation between level of quality and dimensions, a smaller part of both lessons was considered for further examination (Sinha et al., 2015; Rogat et al., 2019b). Later, based on these findings, both sessions were re-examined with co-occurrence analysis (Vartiainen et al., 2018), to examine if the patterns of joint variation were sustained along the session.

The criteria to choose the section with richer characteristics to isolate for deeper analysis (Sinha et al, 2015; Vuopala, Näykki, Isohätälä, & Järvelä, 2019), was the video segment with higher number of high-quality engagement events (HQE). Since the script was divided by tasks, the HQE were overlapped with the exercises completed for the group each session (see Figures 1 and 2). Thus, from the low-performance session (LPS) it was selected the exercise 8, in which the group worked for 13min 43sec, reaching 6 HQE. On the other hand, from the high-performance session (HPS) was selected the exercise 2D, in which the group reached 5 HQE during the 7min 9sec they worked on it.

When reviewing the segments, were found several points of co-occurrence of variations in the quality-level in different dimensions. To confirm if these simultaneous variations were only related to the segment or a pattern repeated through the session, a co-occurrence analysis was run for both sessions. In figures 1 and 2 are showed the points of variations of quality occurred in both sessions.

For clearer differentiation between dimensions, each one was isolated to study its simultaneous variations of quality-level with the others. For example, considering all variations in quality-level of the behavioral dimension in the HPS, were counted how many times it changed simultaneously with itself, as well as with the collaborative, socio-emotional, metacognitive, and disciplinary dimensions. This created different relationships between dimensions, that were later compared.

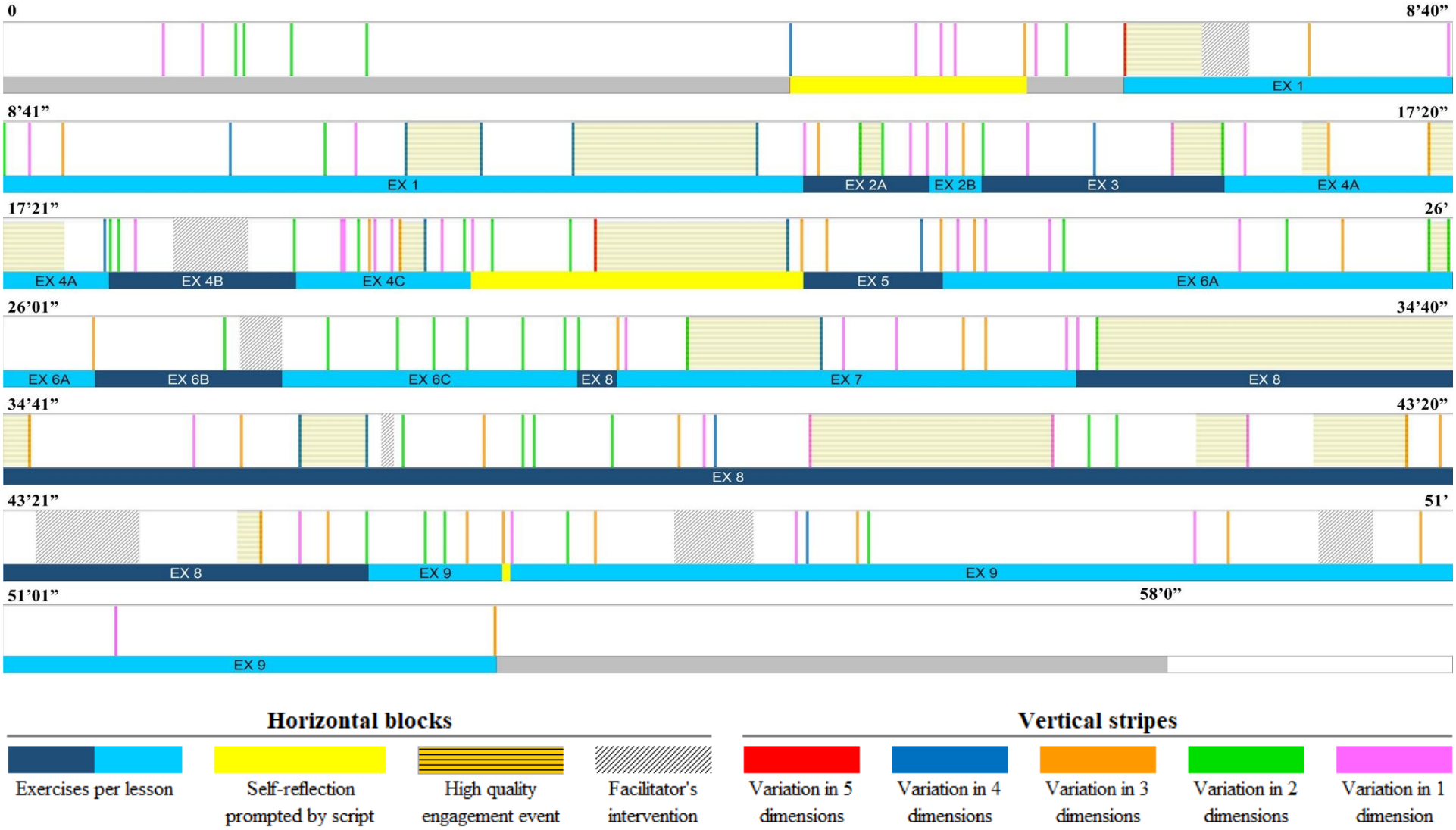

Figure 1. Number of dimensions varying during transitions within quality levels of engagement in Low Performance Session

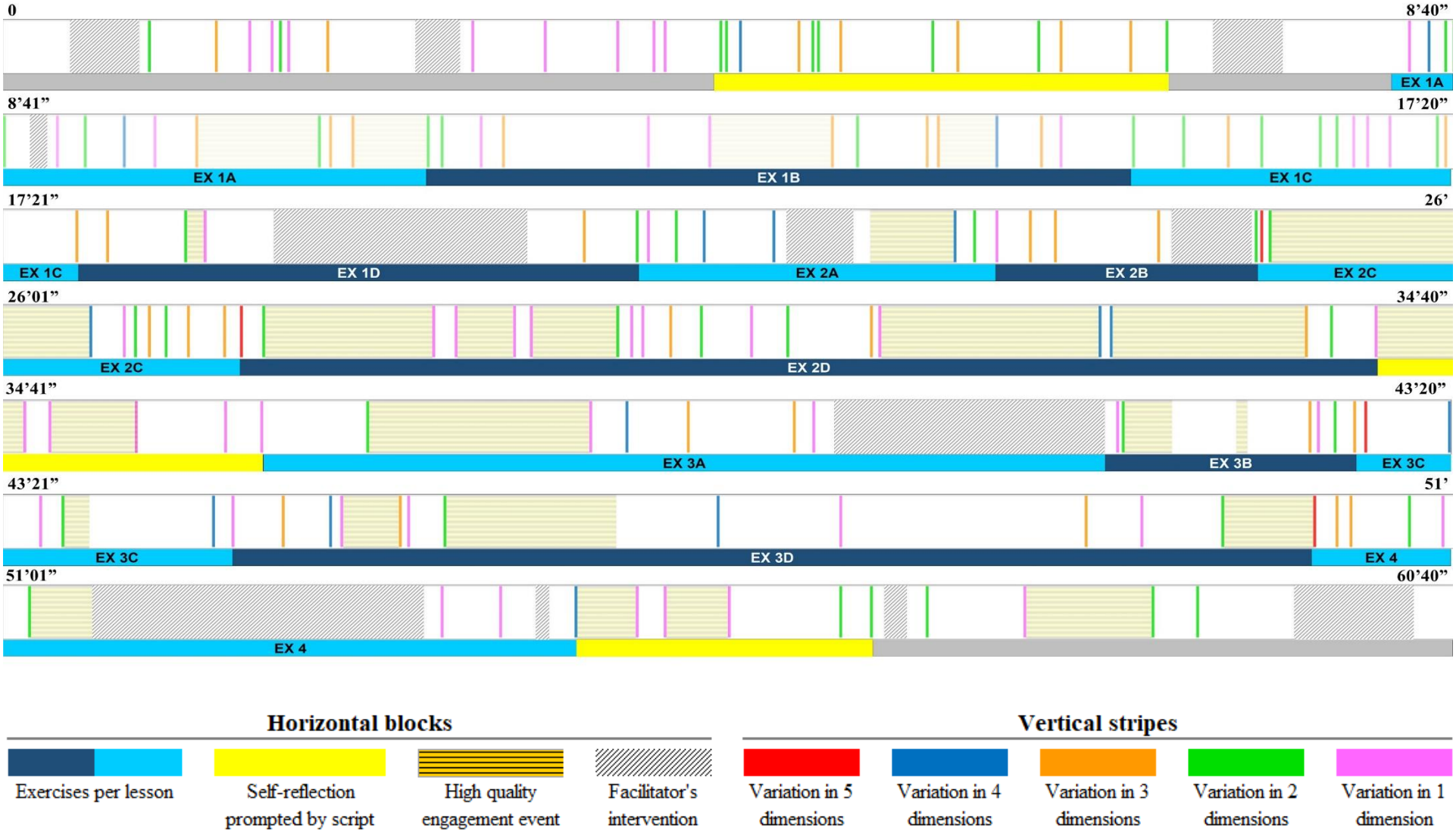

Figure 2. Number of dimensions varying during transitions within quality levels of engagement in High Performance Session

5. Results

5.1. RQ1: What is the quality of engagement in two collaborative learning sessions (high-performance and low-performance session)?

The results of this study show that in total 42 high-quality engagement events (HQE) were identified. When compared results between sessions, the high-performance session (HPS) had a slightly higher presence of HQE both in number and length of HQE.

Thus, the HPS included 25 HQE whereas the low-performance sessions (LPS) included 17 HQE. In total, the HQE lasted 15 minutes and 30 seconds for the HPS, representing 25.65% of the time of the session. In the case of the LPS, the HQE lasted 10 minutes and 41 seconds for LPS, the equivalent to 19.2% of the time of the session.

Table 4. Quality level of engagement per dimension in High Performance Session (HPS) and Low Performance Session (LPS)

Level of quality	Behavioral		Collaborative		Socio - emotional		Meta - cognitive		Disciplinary	
	HPS	LPS	HPS	LPS	HPS	LPS	HPS	LPS	HPS	LPS
Absence							31.2%	50.7%		
Low	2.8%	8.7%	15.9%	24.7%	0.5%	0.0%	3.9%	3.6%	17.4%	21.0%
Moderate low									9.9%	19.7%
Moderate	37.6%	56.8%	35.4%	41.1%	34.5%	47.4%	16.7%	15.7%	20.8%	22.3%
High	59.6%	34.5%	48.7%	34.2%	65.0%	52.6%	48.2%	30.0%	51.9%	37.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

When compared the quality levels of engagement in HPS and LPS (see Table 4), the results indicate that in the HPS, the group sustained more consistently the top-quality level of engagement. Thus, in the behavioral, socio-emotional, and disciplinary dimensions, the group spent more than 50% of the working time of the session in the highest quality level of engagement. Nearly also in the collaborative and meta-cognitive dimensions.

On the other hand, in the LPS the highest quality level of engagement was sustained more often only for the socio-emotional and disciplinary dimensions, while for the behavioral and collaborative dimensions, it was the moderate level of quality. By its side, for the metacognitive dimension, during most of the working time the group did not register metacognitive activity.

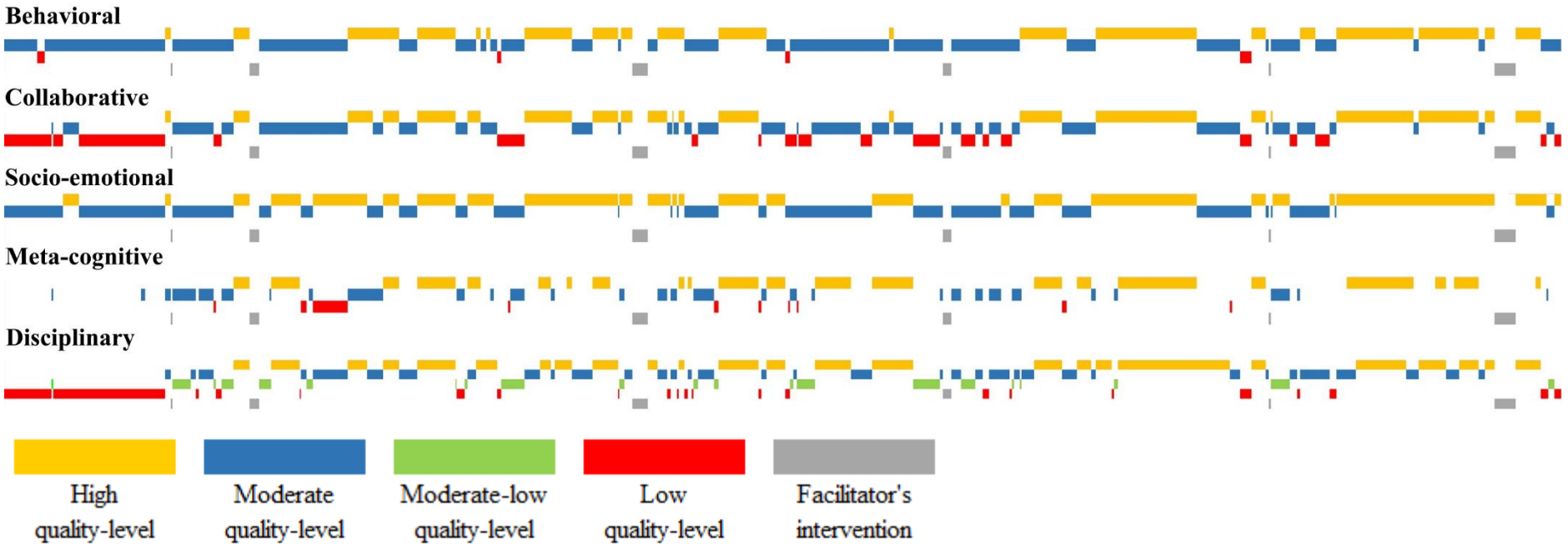

Figure 3. Levels of quality of engagement in Low Performance Session per dimension

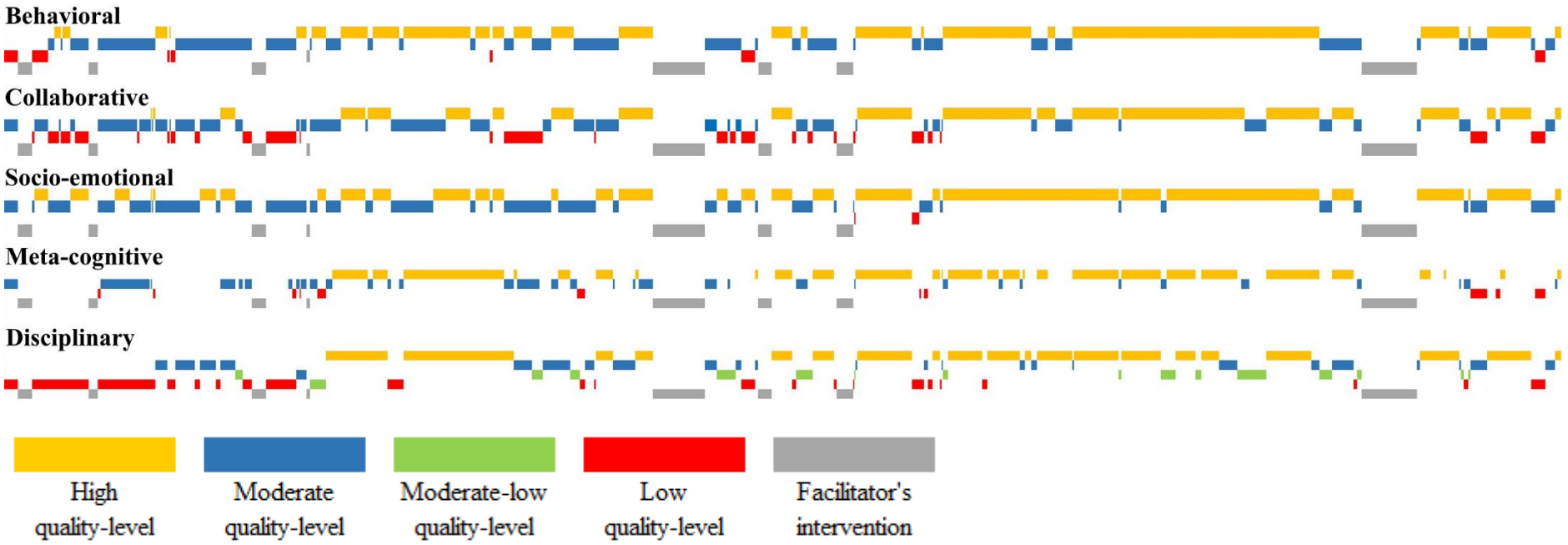

Figure 4. Levels of quality of engagement in High Performance Session per dimension

Focusing on the evolution of the dimensions through the lessons (see Figures 3 and 4), the high-quality level of engagement is sustained with more consistency for all categories in the second half of the class. In regard of each dimension, the behavioral engagement dimension began in both sections with a predominance of the moderate level of quality. However as far the session progressed, the process differed between sessions. In the HPS, the group sustained most of the time a high-quality behavioral engagement, with few events of moderate quality-level. Whereas, in the LPS, was the opposite: the moderate-quality level predominated with sporadic short events of high-quality.

Regarding collaborative engagement, both sessions began with events having a low level of quality. However, they evolved in different ways. In the HPS, the low-quality events occurred at the beginning and were intermittent until they eventually disappear, being replaced by high-quality-level events. Whereas, in the LPS, the low-quality events had sporadic but sustained presence along the whole session. Specially at the middle of the session, interspersed with events of moderate quality.

For the socio-emotional dimension, there is a predominance at the beginning of both sessions of events with a moderate quality-level of engagement. However, in the LPS they last longer. Also, while in the LPS the moderate and high quality-levels alternate throughout the whole session, in the HPS, the alternation lasts until the middle of the session, from where the group sustains the high-quality level of socio-emotional engagement.

On the meta-cognitive dimension, there is a higher presence of meta-cognitive events in HPS. Likewise, in the HPS the frequency of events at the highest quality level is higher in the second and third quarters of the session. On the other hand, even though the high-quality predominates over the other levels in events for the LPS, they do not form chunks, but are evenly distributed throughout the session.

Finally, for the disciplinary dimension, the group began both sessions with a thread of low-quality events. Even though in the HPS it lasted longer, then jumped to the high-quality level, which is sustained most of the rest of the session. For the LPS, the thread is also left, but the quality-level of the following events oscillates evenly between the moderate- and high-quality levels.

5.2. RQ2: Is individual participation in triggering high quality engagement events corelated with the level of group engagement?

In the sessions studied, the results showed a relationship between distributed participation in triggering the HQE and level of collaborative engagement. Thus, in the high-performance session (HPS), the group members participated more equally when triggering HQE, as opposed to the low-performance session (LPS).

In the Figure 5 are showed the distribution of the HQE during both sessions, indicating the focus of the activity in the metacognitive dimension, either planning the task, or reflecting about the content. In this regard, it is important to mention that if there is a sequence of events forming an HQE and the focus of the metacognitive activity changed, then it was considered an HQE with mixed activity.

So, during the HPS the group sustained a positive collective interaction, achieving a balance in their individual participation in triggering the HQE. Thus, the 25 HQE indicated, encompassed in total 30 events at the peak level of engagement. From that number, members A and B triggered 7 events each (23.3%), member C five (16.7%), and member D, eleven (36.7%). On the other hand, the struggle of the group to complete the exercises in the LPS was also evidenced in the number of events triggered by each member. Thus, from 17 HQE, member D triggered eight HQE (47.1%), while members B and C triggered four each (23.5%), and member A triggered only one (5.9%).

When analyzing the relationship between the focus in content or task, in both session the HQE included a high level of activity related to content reflection over task completion. Thus, from the 30 events included in the HQE in the HPS, 10 (33.3%) were related to task completion, while 20 (66.7%) to content reflection. Similarly, from the 17 events in the LPS, 3 (17.6%) were related to task completion, while 14 (82.4%) to content reflection.

The reasons that explain these differences are related to individual and collective factors. In the next section, three are explored in regard of both levels: group composition, collaborative script, and pre-task knowledge.

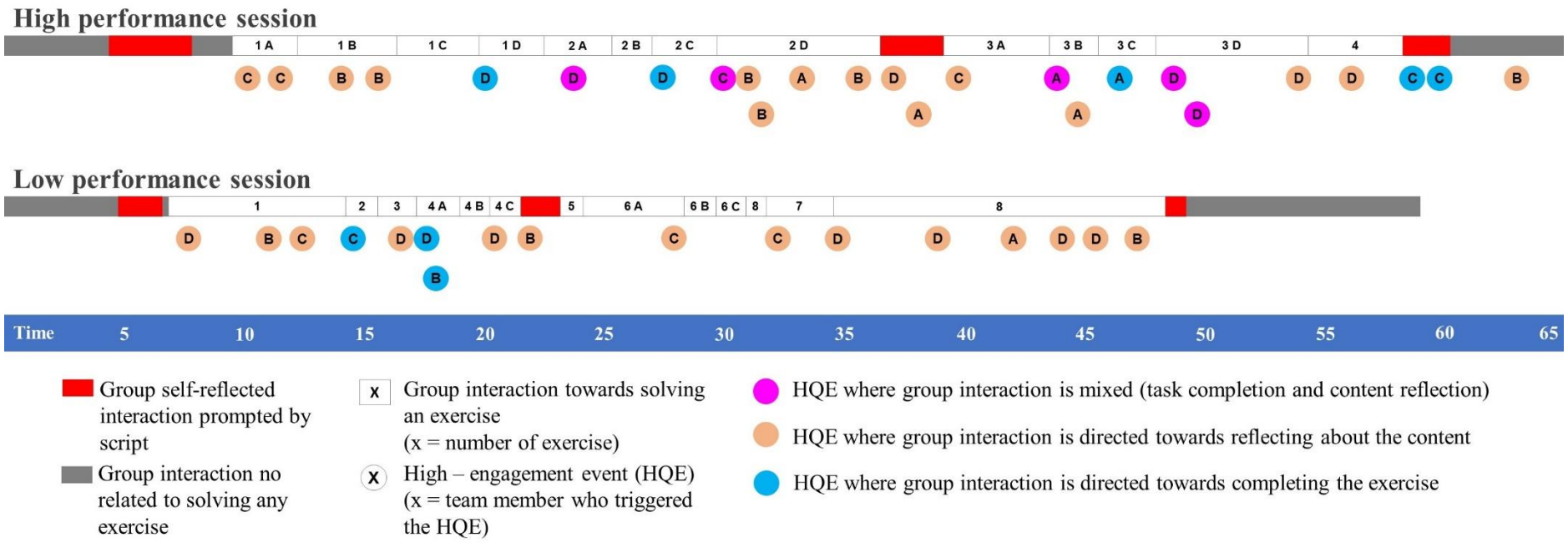

Figure 5. High Quality Engagement events in High Performance Session and Low Performance session, according to time of the session, number of exercise and member triggering the event

5.3. RQ3: What contributes to promote productive disciplinary engagement in collaborative learning settings?

A set of different elements come together to explain the higher level of engagement of one group. Based on the results of the present study three main factors' for promoting high-quality engagement are explored in more detail, namely group composition, collaborative script, and pre-task knowledge. Next, each one of them will be explored.

5.3.1. Group composition

In both sessions, high-performance (HPS) and low-performance (LPS), the group members sustained high levels of quality in their behavioral and socio emotional engagement. However, were their different approaches and paces during task completion which brought the discussion to a higher level of disciplinary engagement. For example, the results of individual level inductive interaction analysis indicate that some of the group members had a stronger orientation towards completing the task (as fast as possible), while the others oriented the discussion to a deeper pedagogical understanding of the learning possibilities for the tools given (counting blocks or pizza cakes). Similarly, some of the group members took a more active role, which was the key to activate the group. This was visible especially at the beginning of the high-performance session (HPS).

The different preferences and levels of participation displayed by group members are evident when reviewing their individual contribution to trigger the high-quality engagement events (HQE) (see Figure 5). During the HPS, where the group completed all exercises and sustained a positive collaborative interaction, their individual participation in triggering the HQE is more balanced. In regard of their individual goal for the task, member B' interest in deep understanding of the tools is reflected in the 10 HQE triggered related to content and 1 to task completion. On the other hand, member D, who triggered almost equal number of HQE related to content and task-completion in the HPS, changed his focus in the LPS, where the group struggled due to lack of knowledge related to the topic of the session. Thus, in that session he triggered 7 HQE related to content and only 1 about task-completion.

To complement the overall perspective, next an example of the aforementioned in the HPS is presented (see Transcription 2). Few minutes after member C left the group task, the rest of the group agrees to operate the blocks decomposing the big numbers into smaller ones and then operate. But when C joins the group again, she solves a

problem not decomposing the blocks but placing the result on the board (doing the operation mentally). Member B indicates the change and takes the lead. However, when beginning to solve the exercise, members C and D point out that she is not fully decomposing the number. C retakes the lead again and operate on the same way. However, B insists and clarify her point by operating the blocks. When her point is understood, C operates the blocks and finalize the exercise. Next, the transcription of the interaction when member B defends again her point.

Transcription 2: High Performance Session

(30:59)

B: *But I am... I was subtracting just 4.*

D: *Yeah, just 4. We are just doing the 4.*

B: *But I was... but you have to change it first.*

C: *You got to get 4 from 2 thousand.*

B: *Well, that doesn't... You can't take four (pointing to the thousands block).*

C: *See, we just take one, two, three, four (pointing to four units in the surface of the thousand block). We take this four and we have another 6 in...*

D: *Where are you getting 4 from? If we have two thousand minus 194.*

C: *Yeah, two thousand minus 4 first, and then minus 90, and minus one hundred.*

B: *So, I was doing minus 4. So, there is 1996 left. And I was going to place this number.*

D: *Yeah, you could do it that way.*

C: *But that is still going from the front to the back.*

B: *Not really. We are subtracting 4.*

D: *Yeah, we are subtracting 4.*

C: *Ok, ok, ok...*

B: *So...*

C: *Why those there? (pointing to the tens)*

D: *Yeah, that is the leftover. We subtract the 4 from 2 thousand. Now we are subtracting nine.*

C: *No, we are going to subtract nine-ty.*

D: *Ninety, sorry*

C: *(taking the green blocks from the tens) One, two, three, four, five, six, seven, eight, nine... that is ninety.*

D: *Ok, and now we subtract the one.*

C: *(taking the blue block) and now the hundred. That is one thousand, eight hundred and six.*

B: *Taran!*

(32:23)

Since member C had strong mathematical skills and a high participative attitude, sometimes she resolved the operation skipping steps, so the intervention of the other members helped to attenuate her impetus and create a common pace and explore more in deep the possibilities of the learning tools. In this case, the interaction with member B elucidated that they were completing the operation in a way that children may not understand. Then, dividing the operation in small steps give them insights about a most suitable procedure to follow. This situation triggered later metacognitive activity, appearing in even three posterior HQE.

If member C was focused on completing the task, sometimes omitting important details in regard of the pedagogical use of the tool, member B was the opposite. Even though she did not actively participate in all discussions at the beginning of the first session (HPS), she was actively engaged in and pay special attention to the usages of the tools for teaching mathematics. In fact, 90.9% of all the HQE triggered by her I both sessions were related to this issue. Despite a couple of failed attempts to monitor group task (e.g. reading aloud task instructions or detecting an error), she actively participated when the exercise completion process was unclear as it can be seen in the previous transcription 2.

From all participants, member A was the one who struggled the most with mathematical content. This was evidenced when expressing her perceived self-efficacy in relation to the topic (*I mean, I will always be confused with the math*). However, she also felt able to express her doubts (*That is the way to do the multiplications? Like additions?*), opinions (*I like this way of the division*), and feelings to the group (*think that it was important to explain it step by step, because for the last one I was confused*). She also participated actively during the interaction, either monitoring the different approaches to complete the task (*You want to do that five times? That is long. There is no other way to do it?*), some other members actions (*No, no, no… what are you doing?*), or that all group doubts are resolved (*But we did not answer your question*).

Finally, member D assumed a leadership role in the group. Even though his active participation led him to interact mainly with member C, he also tried to keep a common group pace (*Are you guys on the same slide than us?*), and guide the group (*No, we are not there yet. So now we do the rest of the questions... (showing the section of the booklet to his mates) "continue working on the following tasks"*). Also, he contributed to elucidate his peer's opinions or feelings. This can be seen in the following transcription of the group responding the script questions about their feelings related to the task:

Transcription 3: High Performance Session

(37:22)

D: How do you guys feel?

C: Happy (laughs) that we got it done... without fighting.

A: I think that it was important to explain it step by step, because for the last one I was confused... (...) I mean, I will always be confused with the math.

(B, C and D laugh)

D: When we got trouble or confusion or something you were not scare to say so. And then we just slowed down.

(38:02)

Although member D sustained active and guiding participation in the LPS, some issues diminish his engagement and performance, like that of his companions, as it will be presented in the following point.

5.3.2. Pre-task knowledge

Another factor that impacted in the level of quality of engagement, it is named in this study as pre-task knowledge. Thus, sufficient pre-task knowledge can contribute positively to high quality engagement, whereas the lack of pre-task knowledge can contribute negatively to high quality engagement. For example, even though the group sustained in average a positive interactive environment with quality levels of engagement between moderate and high, in the second session (LPS) the group atmosphere was affected due to a lack of common understanding about the topic. This affected specially to member A, who struggled to sustain her behavioral engagement after the first quarter of

the session, diminishing the behavioral and collaborative engagement of the whole team.

At the beginning of the LPS it was found more than over than two minutes of interaction where the group attempted to establish a common ground before approaching to the task. These episodes are useful to present the positive environment reached, as well as the lack of understanding of members B and (specially) A.

Transcription 4: Low Performance Session

(07:06)

D: *So, we want to turn a mixed fraction into a normal fraction. Do you guys know what a mixed fraction is?*

C: *Yeah*

A: *No.*

C: *Like one and two thirds.*

D: *Yeah! So, an improper fraction is when the higher number is on top. So, like 3 over 2. This is an improper fraction. A mixed fraction is one and a half.*

B: *Ah, okay.*

(…)

D: *You guys know how to do it…? Like mathematically, just in paper.*

C: *(quietly) Yeah*

(D looks at B and A, and so do they, but without any response. D takes his booklet and directed towards them to explain. A pays total attention, while B organizes the cakes)

D: *So, if you want to turn this one into this one, you multiply these two. You multiply the denominator with the number and then add the numerator. So, two times one is two plus one is three. Three over two.*

A: *Ah, okay.*

(D writes on his booklet)

D: *So, if we have five and one third…*

A: *You have to do five multiplied…*

D: *Three times five is fifteen plus one*

A: *Sixteen*

D: *We got sixteen over three.*

A: *Ah okay.*

B: *It was a long time ago.*

A: Yeah!

(08:59)

Immediately after this interaction, they start to solve the first task (change a mixed fraction into a fraction). Then, they struggle to find the correct representation of the fraction 3/2, and how to differentiate it off from the representation of 1 1/2. Member D takes the lead and gives different options (Figure 6), but members C and B find them confusing. Also, member A offers a representation: putting 3 third-cakes on top of 2 half-cakes. Member B replies with a critic look while the other members barely comment it. The discussion continues, but member A stops participating in the discussion, and member D reduce his contributions.

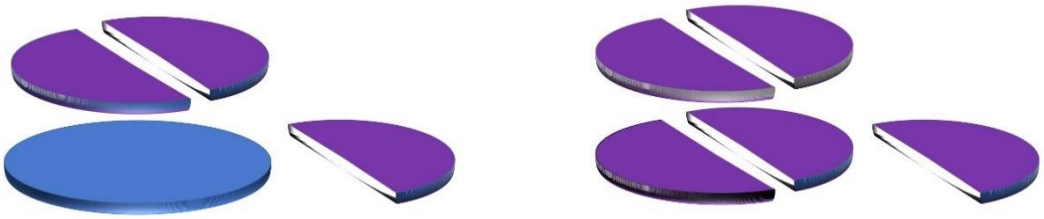

Figure 6. Representations of cakes made by group member C during Low Performance session

After this first exercise, member A had an intermittent participation, assuming most of the time a silent role. When her group members were explaining something, her body position and look evidenced a full engagement with the interaction. However, the quality of her engagement was diminished as the session progressed, evidenced in attitudes like laying back, yawning, or checking her cellphone. Thus, when responding the scripted questions at the middle of the session, member A do not participate in the interaction (see Transcription 5) but showing in her body expressions evidence of her poor engagement and discomfort. Pattern that is repeated during the whole session.

Transcription 5: Low Performance Session

(21:35)

D: Open PREP21 script and discuss the second set of questions…

(A reviews the questions and snorts)

D: How was our progress?... Pretty quick.

(A smiles ironically)

B: But first there were some misunderstandings (quite laugh)

C: Yeah, but then we understood how they work. So, we went pretty quick after that...

(C takes the instructions for the session)

C: (reading) Continue working on the mathematics tasks.

(...)

(D does not pay attention to C and continue reading the questions)

D: What challenges are we facing?

C: Not many.

D: No, I don't think so.

(22:12)

Even if member A was the one who suffer the most with this lack of mathematical understanding about fractions, this also affected the other team members. For example, the most complicated exercise for the group in the LPS was to divide two fractions. It took them almost 15min, or 25% of the whole time of the session. Since the beginning of the exercise they evidenced their lack of deep understanding in different moments, like the one transcribed next.

Transcription 6: Low Performance Session

(34.40)

D: Can you explain that rule with the meta values... with the manipulatives? I would do that.

C: I don't know. I think that is just a trick.

D: We shouldn't teach tricks.

C: If we say two divided by a quarter, the trick is to say two multiplied by four over one. But how would you do that with the manipulatives?

(...)

A: How would you do it in another way the division? Because I learned only that.

C: I didn't learn any other method. I just learned this one.

B: Just learned the rule.

C: Yeah, I never learned how to do this. I always learned how to change it to multiplication.

(35.15)

Even though the group reached several HQE during the LPS, their lack of understanding about the topic, seem to impede them of further progress. It also undermined the quality of engagement of the whole group and specially of member A.

5.3.3. Collaborative script

Finally, the third element identified that promoted high-quality engagement in the present study was the characteristics of the collaborative script. The script included the sequence of tasks for the group in each session, as well as a set of questions at the beginning, middle and end of the task. The scripts provided for the sessions affected the emergence of HQE in relation to two elements: prompts for self-reflection and level of guidance.

a. Prompts for self-reflection

In the script of both sessions, were included a set of questions to promote student's self-reflection about their advances and strategies to achieve them (see Näykki et al., 2017). In total, 5 high-quality engagement events (HQE) were triggered by these questions, 4 in the HPS and 1 in the LPS. In both cases, the questions at the beginning of the session did not trigger any HQE from the group.

The value of these moments was their impact to create group awareness about their emotional state and progress. However, not in both sessions the group reacted the same to the script questions. In the HPS team members showed a thoughtful reflection, summarizing their main findings as well as the strategies followed. This can be seen in the Transcription 3 at the middle of the session, or in the following one at the end of the task:

Transcription 7: High Performance Session

(59:00)

C: How will you evaluate your work as a group? (smiling openly) Five.

D: Pretty good

C: Yeah! Because I think we manage to do all the questions in time, and we figured out how to use the counting blocks

D: (...) we tried like trial and error, we tried different methods before...

C: (...) and we got a couple of methods that work, like not just one method that works, so that is pretty good.

(59:23)

On the other hand, during the LPS these interactions are characterized by a lack of engagement expressed in ironic comments (see Transcription 8 below), superficial responses, lack of participation or even attempts to shorten the reflection (member C in Transcription 5). Furthermore, even though the questions were clearly indicated in the script, at the end of the LPS the group skipped them, not making any effort to review their completion.

Transcription 8: Low Performance Session

(5:08)

D: What kind of feelings does this task arouse?

(...)

C: (ironic and quietly) excitement

D: ... excitement, intrigued

B: It is interesting

D: (unintelligible)

(C laughs of D's response)

C: That is weird.

A: Nothing? (laughs)

(05:39)

These findings suggest that even though the script questions may trigger the group self-reflection and increase their awareness, it is not enough when the quality level of group engagement is low. So, more direct external help may be needed in cases as such.

b. Level of guidance

As teacher students, the participants had to reflect about the use of manipulatives to teach mathematics to children in both sessions. Thus, in the HPS they had to learn how to use counting blocks to teach children the basic mathematical operations, while in the LPS they had to use manipulatives to teach about fractions. Even though both sessions progressed from easy to more elaborated tasks, they differ in the level of guidance offered.

In the HPS, the tasks followed the sequence: addition, subtraction, multiplication, and division. Thus, it asked students to complete operations like 136+23, 2000-194, 234*5 or 112/9. On the other hand, even though the tasks for the LPS replicated the same progression, it gave more open tasks, such as: changing a mixed fraction into a fraction and vice versa, addition and subtraction of mixed fractions, or multiplying fractions by integers.

Since the guidance was more open, the group struggled more to identify the main concepts (such as improper fraction, mixed fraction, or integer), and elaborate upon them. Thus, as it was seen in the transcription 4, from the early moments of the session, the group had to invest time to establish a common ground. Also, as it was seen in Transcription 6, even the more skilled team members did not have a deep understanding about the meaning of some operations with fractions, which they learned how to solve just by applying a "trick".

5.4. RQ 4: What characterizes the interplay of dimensions of engagement in two collaborative learning sessions (high-performance and low-performance session)?

As mentioned in the methods section, to respond this question were chosen the exercises 2D and 8 from the high- and low-performance session, respectively. Both tasks demanded a significant time-investment, also including transitions between quality-levels in the different dimensions and high-quality engagement events (HQE). Thus, before analyzing the similarities and differences between the engagement components, a narrative of both exercises is presented.

5.4.1. Segment of the high performance session

In this session, the task demands from students to complete the operation 2000-194, using four different blocks, with different colors and sizes. These are thousands (red), hundreds (blue), tens (green) and units (yellow). Taking units blocks as a basis, the other blocks have both the value and size of the numbers of units they represent. Thus, for example, a “tens” block is formed by 10 “units” cubes aligned in a line, or the “hundred” block is a square of the size of 100 “units”. Over the table, the group also have a board with four columns, one for each of the blocks mentioned.

The exercise begins with the whole group clearing the board and placing the two thousand blocks to start the exercise. Then, they follow member C who operates the blocks to solve the exercise. Completing the operation mentally, she tries to place on the board the result of the operation. She does it with the "thousands" and "hundreds" blocks and asks member A to place the "tens" blocks. However, member A place 10 blocks, clearly not following the line of thought. Member C corrects her, and member B complains they are not following the order agreed in the previous exercises (from units to thousands). Member D supports her claim and member B takes the lead and operates the blocks. However, when member D indicates that they are still operating from thousands to units, member B lacks response and member C take the blocks back.

Then, member C repeats the same operation and member B insists on the difficulty of completing the operation mentally. Member B explains what she was going to do before: placing the numbers to complete the operation subtracting four units, from two thousand. She does it, and then member D give the instructions, while member D operates the blocks. Finally, when completing the exercise, they write on their booklets.

At that point, member C asks member B how to explain the exercise to children. Member D interrupts the interaction, asking for the rule about mathematical operations. Members A and C give him some instruction, but later member C explains him in detail. Meanwhile, members A and B discuss about how they complete the operation. After this, member D tries to continue to the check-up section indicated in the script, but member A points out they have not responded to member D question. Member A also expresses her confusion when they are placing the results on the board, and not using the blocks to it. Member D explains they divided the operation in steps, subtracting first the units, then the tens and finally the hundreds. Member A insists that is still confusing, and members C and B point out that operating in parallel the units, tens and hundreds is mentally demanding. Then, member D clarifies that they need to do it physically. So, if they ask children to take out four units from one thousand, they cannot do it, so they will need to turn them into hundreds, tens, and units successively. The group agreed it is a good solution. Then, member B highlights a rule of the tool, and this triggers another reflection about how to complete the exercise, so it is easy to understand for children.

5.4.2. Segment of the low performance session

In this session, the group needs to complete different mathematical operations using fraction cakes. First, the group starts in a good mood after having completed the previous exercise. Member D calls to complete the division, and then discuss with member C how to solve the operation on paper, while members A and B pay attention.

Member C solves the operation using a trick she learned, but when asked to complete it using the manipulatives, she has no idea. Member A asks for different ways to solve the operation, but she is not fully integrated into the conversation. However, the conversation keeps going and following the request of member D, the group sets a simple exercise: 2 divided by quarters. By physically putting the quarters cakes on top of the unit cakes, they reach a solution: 8. However, member C points out that the result should be 8 units, not 8 quarters. Then the group debates if the response fully addresses the questions or not. Members C and D explain to B and A why the response is not complete, because when they divide a number by a fraction the number gets bigger, and not smaller. Then, member C presents a different approach to the problem: how many quarters can fit into two wholes? She continues the discussion with member D, while members A and B disengage from the interaction.

Members C and D look for help from the facilitator, and he asks them to wait a little bit. After a short disengagement episode, member D asks to complete a simpler operation: 4 divided by 2. While they are completing it, the facilitator asks the whole class to complete the script questions. Members A and B call to do it, but member D points out they already did it. He confirms with the facilitator and then the group goes back to the exercise.

Member B asks for a verbalization of the question, what she got from member C. Immediately after, member C offers a possibility to solve the exercise, but she is not convinced it is correct. The other group members do not fully follow her. She organizes the quarter cakes to complete two units. Member A asks for the difference compared to what was done before. Member C provides an answer. Member D highlights it does not totally match with his representation of the question. Member C repeats that the response should be in units and not in quarters, and member B clarifies this for member A. Then member D clarifies that they are struggling because of the value of the quarter cake, compared to the response they are looking as units.

For further clarification, member D asks to do the operation 2/3 divided by 1/4. Operating the blocks, members B and C reach to an answer different (2 1/6) to the one got in paper by member D (2 2/3). Trying to find out an explanation, they reach a dead end. Member D leaves the table and goes for the facilitator. Members A and C goes briefly off-task. Member B offers an explanation considering that the remainders of 2 quarters fit into 2/3 is equivalent to 2/3 of 1/4. Member D comes back with the facilitator. Member B presents her finding, and the facilitator suggests using the question to find the answer and leaves. Member D asks to repeat the process, so member B does.When reaching the result member B points out the difficulty of that work for children. The conversation is not followed. Then member C express in a funny way the complication of using the fraction cakes. All group members then focus on writing on their booklets.

5.4.3. Evolution of dimensions during the segments

Now the evolution of the quality levels in all dimensions for both segments will be explained (see Figure 7). Each dimension will be discussed, articulating the variations in the quality of engagement with the narratives presented previously.

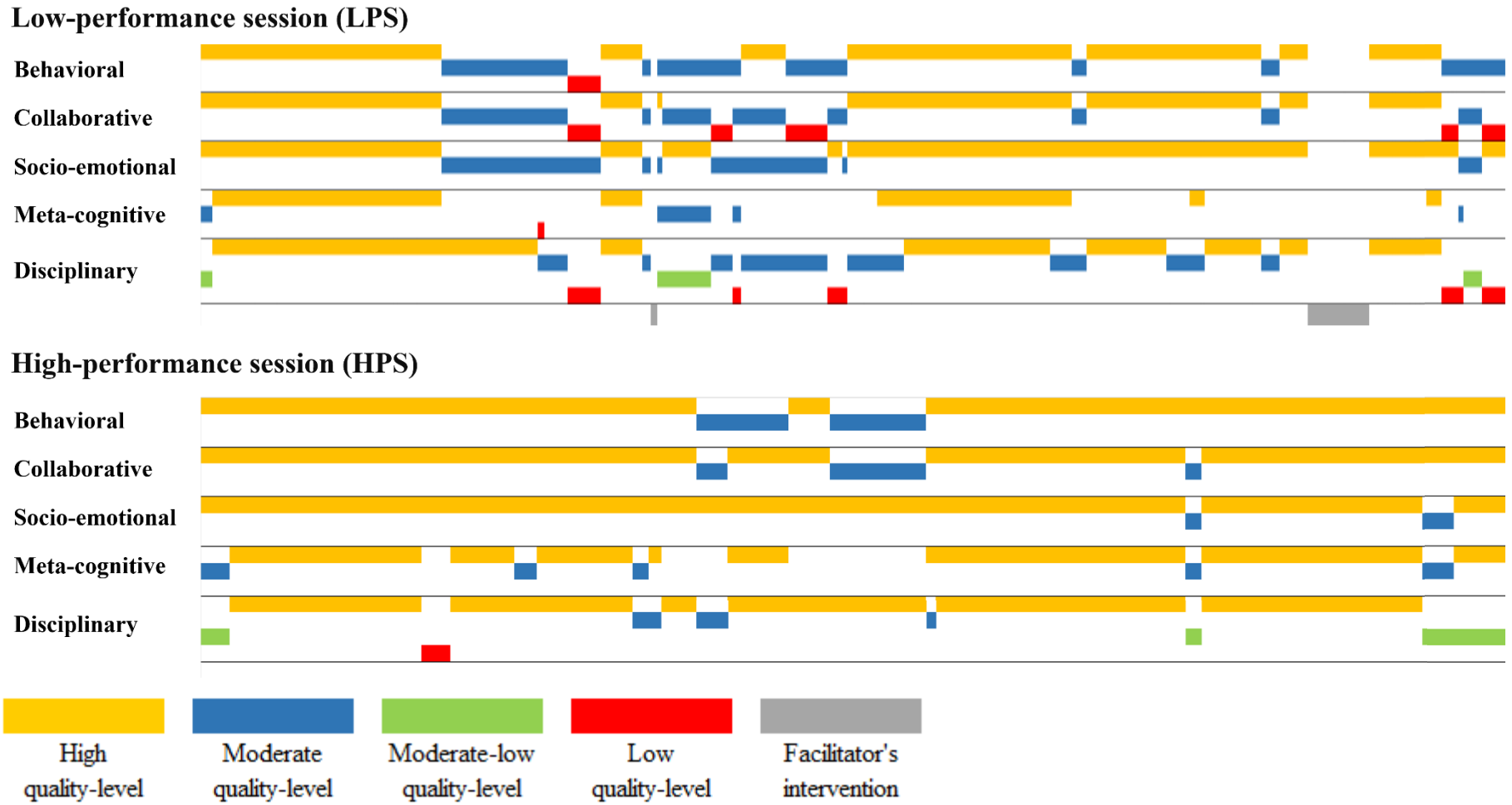

Figure 7. Levels of engagement quality per dimension in selected segments of High Performance Session and Low Performance Session

In regard of the behavioral dimension, the group sustained in both segments the high- and moderate-quality levels most of the time. In the HPS the group sustained the high-level of quality for almost all the segment. But in two moments at the middle of the exercise the quality-level dropped to moderate, when the members wrote down their responses in their individual booklets. On the other hand, in the segment corresponding to the LPS, the lack of a common group understanding about the problem to solve (e.g. member A asking if they are not repeating what was done previously), undermined the behavior of members B and A who had an oscillatory participation. Likewise, in five moments of the session, the collaborative engagement had a low quality when the group struggled to overcome a challenge, creating uncomfortable silences where group members got easily distracted. Due to the same reasons, the quality levels in the collaborative dimension presented similar variations.

Despite the challenges faced by the group, in both sessions they sustained a positive and safe atmosphere, with moderate- to high-quality levels of socio-emotional engagement. Thus, in the LPS the group mostly disagree about the need to keep diving into the exercise and not jump to the next. However, when asked, reasons to keep exploring were presented, and the members who were not totally engaged in the discussion, were still respectful with the process of their peers. On the other hand, in the HPS some disagreements occurred when the solving process was not clear for all group members. Even though the moment triggered some expressions of frustration, both parties were able to defend their points in a respectful and polite way.

Regarding the metacognitive dimension, the focus of metacognitive activity (see Figure 5) was similar in both performances, with reflections about content predominating over task-completion. On the other hand, they differ in the consistency of metacognitive activity. This is, while in the HPS the metacognitive engagement varied in different moments from high- to moderate-quality, in the LPS the metacognitive events emerged and concluded, with only one variation of quality at the beginning of the segment. In the HPS, the contrasting approaches about the best way to solve the exercise triggered group metacognitive activity when members where reviewing their progress. But also, when the exercise was completed, the group reflected about the best way to use the tool with children, considering their own experience in solving it. On the other hand, in the LPS, there are not opposing positions but the whole group tries to match the solution reached solving the problem in paper, with the one using the cakes. Thus, the meta-cognitive events are triggered when the group reflects about how to use the fraction cakes or when remembering about how to operate the divisions with fractions.

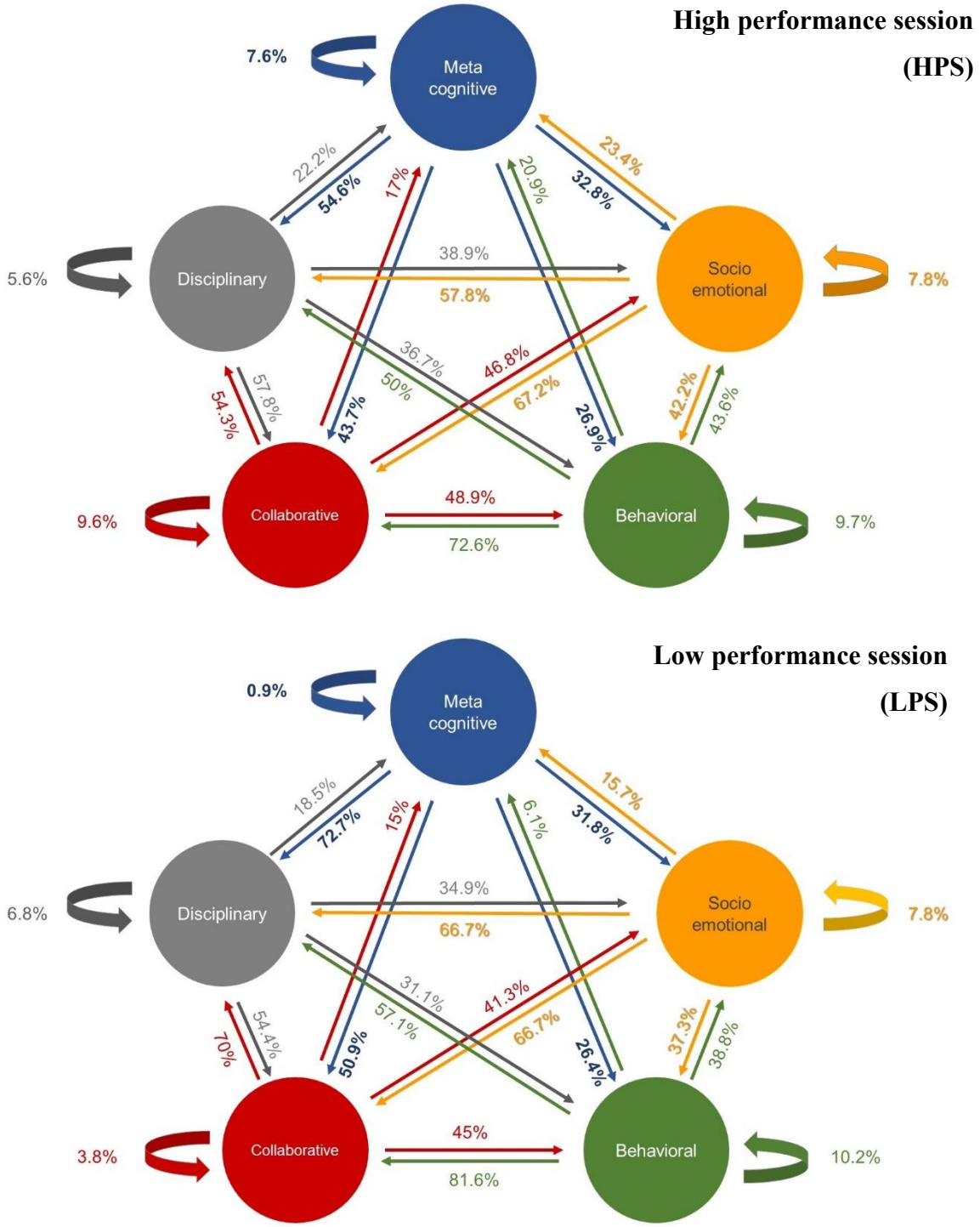

Figure 8. Co-occurrence of variations in the quality-level of engagement between dimensions in High Performance Session and Low Performance Session

The challenges the group faced in each section also shaped somehow their level of disciplinary engagement. So, the different approaches to solve the problem in the HPS led to a sustained debate with active participation of all members, during and after task completion. On the opposite, in the LPS the lack of understanding about the representation of fractions and its operationalization impede the group to have a clear understanding of the problem, as well as limited their individual contributions due to the different levels of knowledge about the topic.

5.4.4. Interplay between dimensions

Despite both segments were the most extensive and with the largest number of HQEs per session, the evolution of the different levels of quality of engagement were determined by the circumstances the group faced in each context. A similarity between segments was the high levels of sustained quality for socio-emotional engagement, as in the behavioral and collaborative dimensions. But in the latest case, with higher differences between sessions.

Also, when observing the evolution of all dimensions (Figure 7), were found many points where the quality-level of different dimensions varied simultaneously. Following this, the LPS showed a strong pattern of similar variation in the quality level of behavioral, collaborative, and, in lesser extent, socio-emotional dimensions. A similar pattern was also found in the HPS. Moreover, in this session were also discovered several points were the variation of quality level in the disciplinary dimension coincide with either a variation in the quality level of metacognitive engagement, or the beginning or end of an event of metacognitive activity.

Based on these findings, a co-occurrence analysis was run for both full sessions, focusing on the points were one dimension changed its level of quality together with others (see Figure 8). In both cases was found a strong co-occurrence of variations in the quality level of behavioral engagement joint with collaborative engagement (81.6% in the LPS, 72.6% in the HPS), collaborative engagement joint with disciplinary engagement (70% in the LPS, and 54.3% in the HPS), and socio-emotional engagement joint with collaborative engagement (66.7% in LPS, 67.2% in HPS) and disciplinary engagement (66.7% in LPS, 57.8% in HPS).

On the other hand, the weakest relationships regarding the co-occurrence of variations of quality-level are all related to metacognitive engagement. Thus, in the HPS, from all the variations in the level of quality for the collaborative dimension only 17% co-occurred with a similar change in the metacognitive dimension. The results are similar for the behavioral (20.9%), disciplinary (22.2%), and socio-emotional (23.47%) dimensions.

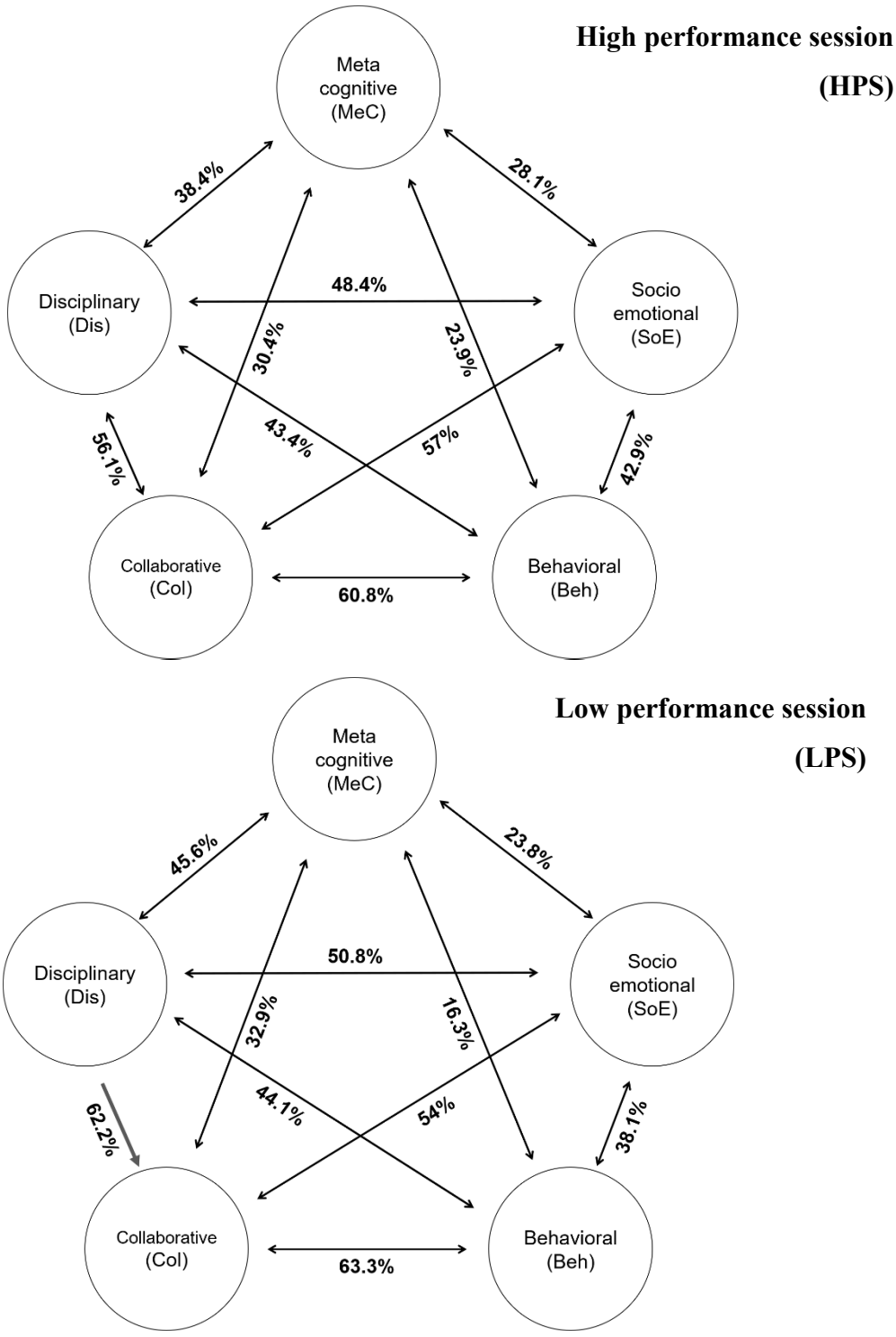

Figure 9. Average of co-occurrence of variations in the quality-level of engagement between dimensions in High Performance Session and Low Performance Session

In the LPS, these differences become more acute. Thus, only 18.5% of all variations in the quality-level of disciplinary engagement were simultaneous to a similar variation in the meta-cognitive dimension. Even weaker levels of co-occurrence are presented in the socio-emotional (15.7%), collaborative (15%) and behavioral (6.1%) dimensions.

Averaging the co-occurrence of variations between two dimensions (see Figure 9), all the pairs with the highest values in both performances include the collaborative dimension of engagement. Its strongest connections are with the behavioral (63.3% in LPS, 60.8% in HPS), disciplinary (62.2% in LPS, 56.1% in HPS), and socio-emotional (54% in LPS, 57% in HPS) dimensions. On the other hand, the weakest pairs include both the metacognitive dimension. These are metacognitive-behavioral (16.3% in LPS, 23.9% in HPS) and metacognitive-socioemotional (23.8% in LPS, 28.1% in HPS) sets.

Based on the level of co-occurrence between dimensions, these results suggest that most of the dimensions tend to vary with the disciplinary and collaborative dimensions whereas they do it the less with the metacognitive dimension. On the other hand, in both sessions the socio-emotional and behavioral dimensions slightly protrude over the others regarding the level of co-occurrence of quality-level variation with the other categories of engagement. The discussion and implications of these results are explored in the following section.

6. DISCUSSION

Considering engagement as a meta-construct encompassing different dimensions (Fredricks et al., 2004) and an evolving process (Järvelä et al., 2016; Kumpulainen, 2014), the present study aimed to explore teacher education students' collaborative engagement during mathematical tasks. For this, I compared two performances of a group of teacher students within a Mathematics education course. Following previous research linking high levels of engagement with learning outcomes and student achievement (Sinatra et al., 2015; Appleton et al., 2008; Fredricks et al., 2004), the two performances correspond to the higher and lower group academic performance, this is the sessions were the group obtained the highest and lowest scores for their collective performance.

Addressing the higher complexity of measuring engagement in collaborative learning processes (Boekaerts, 2016; Järvelä et al., 2016) was used the taxonomy of engagement and rubric developed by Rogat et al. (2019a). The rubric considered five categories (behavioral, collaborative, socio-emotional, meta-cognitive and disciplinary engagement), with three or four levels of quality each.

Like previous studies on productive disciplinary engagement taking the group as a unit of analysis (Rogat et al., 2019b; Sinha et al., 2015), in the present study were also found different levels of variation for each dimension of engagement during group interaction. This provides more evidence to support the complexity of engagement as a multidimensional construct (Fredricks et al., 2004; Reschly & Christenson, 2006; Furlong & Christenson, 2008; Appleton et al., 2008; Reeve & Mei Tseng, 2011; Pekrun & Linnenbrink-Garcia, 2012; Reeve, 2013; Sinha et al., 2015; Rogat et al., 2019a, 2019b), with different dimensions varying and influencing each other during group interaction.

When analyzing the performance of the group during the more challenging tasks for each performance (high-performance and low-performance), and later exploring the joint variation in the level of quality between dimensions for the whole session, the results suggest a relationship between the behavioral and collaborative dimensions that was sustained in both sessions. This is partially aligned with the findings by Rogat et al. (2019b), who compared the results for two groups of students. They establish a poor relationship between the level of quality for the social (coordinated and responsive interaction of the group) and emotional (respectful and cohesive climate) categories of engagement, with the disciplinary category (contributions to intellectual progress involving integrated conceptual and disciplinary activity).

On the other hand, the similar quality and the high percentage of simultaneous variation in the quality levels of the metacognitive and disciplinary dimensions found in the high-performance session (HPS) suggest a potential relationship between these two dimensions. This is partially aligned with the findings by Sinha et al. (2015), who concluded that behavioral engagement (on-task behavior) and social engagement (respectful and responsive interactions among group members) fostered high quality cognitive engagement (use of cognitive strategies such as planning, monitoring, and evaluation), which then facilitated consequential engagement (use of domain-specific content and disciplinary practices as tools to solve problems). However, metacognitive engagement had also the lower rate of variation with the other dimensions. Further studies will need to explore this potential association.

In regard of the quality-level of engagement for the different dimensions, it was expected that comparing both sessions, in the HPS, the learning outcomes of the group will be related also with higher levels of engagement (Greene, 2015; Appleton, Christenson & Furlong, 2008; Furlong & Christenson, 2008; Greene et al., 2004; Fredricks, Blumenfeld, & Paris, 2004). This was confirmed for all five categories, with the highest values in the behavioral, socio-emotional and disciplinary dimensions. Likewise, although the lower group learning outcome in the low-performance session (LPS), the group still sustained most of the time a high quality-level of socio-emotional and disciplinary engagement. However, the time spent in the moderate level of quality for most of the categories was noticeably longer than in the HPS.

Among the similarities between both sessions, the socio-emotional category had the highest percentage of high-quality of engagement compared to the other dimensions. This is explained by the positive interactions the group sustained in both sessions, based on the group members ability to regulate their emotions (Boekaerts, 2011; Linnenbrink-Garcia & Pekrun, 2011). More often in the HPS, the group generated considerate and responsive interactions, not undermining the group cohesion but raising the quality of the group discussion (Engle & Conant, 2002; Webb, Ing, Nemer, & Kersting, 2006). This also provides support to prior research indicating that positive interactions are connected to higher-quality group performances (Bakhtiar et al., 2017; Näykki et al., 2014; Järvenoja & Järvelä, 2013).

Since the present study considered both, the group as a unit of analysis as well as individual level analysis, it can be concluded that the individual variations in the level of engagement was visible for contributing to the overall group engagement (Gross & Thompson, 2007). Thus, for example, two members (A and C) showed clear signs of disengagement in the LPS. However, their individual reactions to this affected the group in different ways.

Member A developed a clear disengagement in her behavior, focusing on external factors to the group interaction, maybe in an attempt to cope with her emotions (Boekaerts, 2011). She remained quiet and rely on her group mates to complete the task, participating only sporadically in the group discussions. On the contrary, member C showed a high level of participation in both performances, so when her disengagement became obvious, it undermined group engagement in different facets, eventually leading to group off-task behavior (Van den Bossche et al., 2006).

In regard of the disciplinary engagement, one element promoting high-quality levels of engagement in the high-performance session was disagreement within the group. This led some members to explain and defend their points of view, which in turn brought the discussion to a high-quality level of cognitive and disciplinary engagement (Hatano & Inagaki, 1991). This disagreement forced group members to clarify their explanations, supporting their claims with evidence rather than providing mere descriptions (King, 1997, 2007), which led to clarification and enhancement of learning (Vygotsky, 1978; Webb, 1989; King, 2007).

On the contrary, this did not occur in the low-performance session, where the lack of robust understanding about the procedures needed to complete the task impede the conceptual engagement of the group (Gresalfi et al., 2009). Even though some group members had a clearer understanding of the topic, and explained it to the other members, this was insufficient to set a solid common ground (Iiskala, Vauras, Lehtinen, & Salonen, 2011). Thus, the members who struggled the most with the content reduced their level of participation throughout the lesson, impeding digressions to engage into knowledge construction (Hmelo-Silver & Barrows, 2008; Scardamalia, 2002), reducing the quality-level of disciplinary engagement. Moreover, evidencing the task exceeded the resources available for the overall group to overcome it (Vygotsky, 1978; Engle & Conant, 2002).

In regard of the metacognitive dimension, the main differences between sessions rely on the higher rate of absence of metacognitive activity for the LPS, and the higher quality-level of engagement in the HPS. This is aligned with the findings of previous studies about the advantages of groups monitoring their performance (Goos, Galbraith, & Renshaw, 2002; Hurme, Palonen, & Järvelä, 2006) and the relation between more active knowledge co-construction activity and task-related monitoring (Khosa & Volet, 2014; Näykki, Järvenoja, Järvelä, & Kirschner, 2017; Vuopala, Näykki, Isohätälä, & Järvelä, 2019). In the HPS, the higher level of metacognition responded to the shared level of proficiency by all group members, which in turn allow them to carry out the same actions, working together in pursuit of a common goal (Dillenbourg, 1999). Since the task demanded from them only to know the four

basic mathematic operations, their effort was directed towards the exploration of the manipulatives as a pedagogical tool for children. On the other hand, since in the LPS, the group members had an uneven level of proficiency, it hindered the transactive interactions impeding a critical engagement of each other ideas, which in turn reduced the changes of monitoring activity among peers (Goos et al., 2002; Mäkitalo-Siegl, 2008).

Metacognitive experiences are individual subjective experiences (cognitive or affective) that monitor and inform a person about an aspect of the cognitive process related to the current task (Flavell, 1979). Previous research has shown that in collaborative settings, individual metacognitive experiences may impact also on other members (Efklides, 2006), potentially triggering metacognitive regulatory mechanisms (Efklides, 2006, Flavell, 1979; Iiskala, Vauras, Lehtinen, & Salonen, 2011). In the case of this study, this was the case of member A, who in both sessions demonstrated a low-level understanding related to mathematics. However, the main difference between sessions relies in the lack of support from her team members in the low-performance session. Since they were also struggling with their low understanding of the topic, in this case it was not possible to compensate the asymmetry of knowledge, hindering the range of action of member A (Dillenbourg, 1999).

Furthermore, the absence of group regulatory mechanisms to cope with this situation may be explained by problems in the meta level of communication and the level of task difficulty. About the former, Branco, Pessina, Flores, and Salomao (2004) highlight the main role that metacommunication plays in group interactions. According to the authors, a group permanently co-construct a frame for their communication when group members give meaning to the actions of the others. Embedded within their cultures and context, this includes verbal and non-verbal signs. So, it becomes relevant for collaborative interactions the ability to comprehend the other's interpretative background (Iskala et al., 2011).

Also, another element that shed light on the higher absence and lower quality of metacognitive engagement in the LPS is task difficulty. Previous studies have shown how a high level of task difficulty can hinder the presence of metacognitive activity (Efklides, Papadaki, Papantoniou & Kiosseoglou, 1998; Prins, Veenman & Elshout, 2006). In their study, Prins et al. (2006) found that advanced learners activated their metacognitive skills during complex tasks, when they were still working within the boundaries of their knowledge. However, this did not occur in very difficult or easy tasks.

On the other hand, the script had an impact on the level of group engagement (Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen, & Häkkinen, 2017), in regard of the level of guidance provided and the possibilities to increase awareness about group performance. About the for-

mer, the level of guidance provided by the script was a key-factor to explain the variation in the quality-level of engagement of the group. In the HPS, the progression in complexity and difficulty of tasks along the session helped the group to explore progressively the challenges of the manipulatives to teach basic mathematical operations. On the other hand, the slighter open questions for the group tasks in the LPS, demanded more cognitive resources from the group when it was already facing a problem due to the uneven level of proficiency (Dillenbourg, 1999).

For learning to successfully occur, the task should address the students' capabilities and resources (Vygotsky, 1978; Engle & Conant, 2002). In that sense, a low level of guidance during instruction can be ineffective (Kirschner, Sweller & Clark, 2006), leading to a negative emotional display (Pekrun & Linnenbrink-Garcia, 2012). So, the lower level of guidance provided during the LPS, could have been compensated with the intervention of the facilitator to support student's knowledge building (Hmelo-Silver & Barrows, 2008).

On the other hand, even though the scripted questions to promote group monitoring and regulation remained the same between sessions, the group used them differently (Vuopala et al., 2019), leading to different influence in the level of engagement. Previous research has proven that collaborative learning does not occur spontaneously (Määttä, Järvenoja & Järvelä, 2012; Barron, 2003; Kumpulainen & Wray, 2002; Dillenbourg, 1999), due to the lack of group awareness about when or how to regulate their learning or collaboration (Malmberg, Järvelä, & Järvenoja, 2017; Näykki et al., 2017). In the HPS, the script led many times to high-quality engagement events, where the group was able to reflect about their performance, gaining new insights about the content. Furthermore, in different passages of the HPS the script prompted to group members to share their emotions. This, in turned, increased the group awareness, helping them to maintain regulation (Järvenoja & Järvelä, 2013; Näykki et al., 2017, 2014), as well as preventing socio-emotional conflicts (De Dreu & Weingart, 2003; Jehn & Mannix, 2001).

However, there are important differences between sessions in regard of using the script. Thus, when completing the script questions in the HPS the group reached four times the highest quality of engagement, reflecting in deep about content understanding, after being focus on task completion. This is aligned with previous research (Wang, Kollar, & Stegmann, 2017) which has proven that scripts can be useful to foster regulation processes in groups, allowing the learners to focus on the cognitive activities without diverting their attention into planning or monitoring the collaborative interaction. On the other hand, in the LPS the group did not respond the questions thoroughly, even skipping the last set of questions. This result is

aligned to the conclusions reached by Hämäläinen and Häkkinen (2010), who found that scripts can be used differently for distinct groups, therefore not assuring high-level group collaboration. In this way, this provides further support to the claim to understand how students use scripts to better support their learning (Vuopala, et al., 2019).

7. CONCLUSION

The present study aimed to compare the evolution of the different facets of engagement in two different performances of a group, with the highest and lowest academic achievements, as well as studying the features that characterize and promote high quality engagement events.

First, in the high-performance session the group sustained the highest quality level of engagement more steadily, while in the low-performance session it was the moderate quality level. Likewise, in both sessions, the dimensions with highest level of quality are the behavioral, socio-emotional and disciplinary dimensions. In both cases the amount of time spend at the highest level of quality in the metacognitive dimension was lower compared to the other categories. However, the amount of metacognitive activity in the high-performance session was higher.

The interplay of dimensions suggests a co-relationship between the behavioral and collaborative dimensions, which however does not affect the disciplinary dimension (Rogat et al., 2019b). Also, in the high-performance session was found a potential relationship between the metacognitive and disciplinary dimensions (Goos et al. 2002; Hurme et al., 2006; Näykki et al., 2017).

Second, the studied elements that promote high quality engagement were group composition, pre-task knowledge and the use of the collaborative script. The diversity of approaches of the group members, promoted a diversity of points of view to resolve the disagreements, bringing the discussion to a high-quality level of cognitive and disciplinary engagement (Hatano & Inagaki, 1991). However, in the low-performance session, this was hindered due to important differences in pre-task knowledge among group members as well as higher level of task difficulty (Efklides et al., 1998; Prins et al., 2006). This limited the participation of members in disadvantage (Dillenbourg, 1999), due to a lack of regulatory mechanisms (Malmberg et al., 2017; Näykki te al., 2017; Hardwin & Oshige, 2011) and an uneven meta level of communication (Branco et al., 2004).

Also, in both sessions there were differences in regard of the script use. In the high-performance session, the script proved useful to led the group to high-quality engagement events by increasing group awareness (Järvenoja & Järvelä, 2013; Järvenoja, Näykki, & Törmänen, 2019; Näykki et al., 2017, 2014), while in the low-performance session did this not happen (Hämäläinen & Häkkinen, 2010).

7.1. Implications

As far as the studies about engagement have progressed, the conceptualization of the phenomena unveiled its complexity of different dimensions. Thus, the present study provides support to the claim of engagement as a meta construct with different components (Sinha et al., 2015; Rogat et al., 2019a, 2019b). This not only provides a better understanding and more solid grounds for future research, but also for best design of collaborative scripts, including not only behavioral and cognitive aspects, but also socio-emotional, disciplinary, and meta cognitive.

Likewise, the theoretical integration of the concepts of frameworks of Self-Regulated Learning and Productive Disciplinary Engagement (PDE) (Engle & Conant, 2002) in the rubric used for the present study (Rogat et al., 2019a) suggest the need to provide support to develop individual and group regulatory skills in order to increase the quality of individual and group engagement respectively. Similarly, following the principles postulated by the PDE, engagement is related to the agency, accountability, resources, and tasks provided to students.

To provide students with such resources, teachers must be aware of the cognitive, emotional, and meta-cognitive competencies, as well as the collaborative skills of their students. This would help them to design better learning scenarios as well as better scripts. Moreover, considering that students reproduce teacher discourses (Webb, Nemer, & Ing, 2006), teachers should also incarnate the expected attitudes and beliefs they expect of their students.

7.2. Limitations and future research

Following previous studies on collaborative engagement (Sinha et al., 2015), the case method study approach used in this study aimed to provide a richer understanding of the group phenomena. However, this methodological option became a limitation due to the reduced amount of the sample size. Studies encompassing different groups, tasks and fields will provide a richer characterization of the trends of engagement during different collaborative learning activities.

Another limitation of this study is related to its focus. Since only the two ends of the group learning outcomes were considered for analysis, future research including a wider set of groups, will provide a broader perspective of the interplay of dimensions, and how these are related to the learning outcomes. Likewise, another potential line of inquiry relates to analyz-

ing the dynamics of the different facets of engagement across several classes, or courses (Fredricks et al., 2004; Helme & Clarke, 2001, Sinha et al., 2015).

Finally, the repercussions of some group members in the overall group engagement suggest future multilevel studies crossing information from the individual and group level, and its potential repercussion on other spheres of engagement (Lawson & Lawson, 2013). Also, considering the international environment where the data was collected, and the results of previous studies regarding the influence of culture in collaborative learning activities (Popov, Noroozi, Barrett, Biemans, Teasley, Slof, & Mulder, 2014; Chen, Hsu & Caropreso, 2006; Reeder, Macfadyen, Chase, & Roche, 2004), future studies of engagement could include culture as variable to examine.

8. EVALUATION

During this thesis, I have studied the evolution of the quality of Productive Disciplinary Engagement in a group of first year teacher students. I have done that using the rubric developed by Rogat et al. (2019a), to analyze the video material collected in the PREP21 project (Preparing teacher students for the 21st century learning practices).

In the following section, I am going to discuss about the validity and reliability of the study, the process used to review and synthetize previous researches, as well as the processes followed for the collection, access and use of the video material. The latest following the ethical guidelines established by the Finnish National Board on Research Integrity (2009), as well as previous studies.

8.1. Validity and Reliability

Considering the qualitative nature of this study, it pursues examining phenomena in context-specific settings. Therefore, my ability and effort as a researcher play a key role to assure the credibility of a study as such (Golafshani, 2003).

In that sense, and according to Morse, Barrett, Mayan, Olson, and Spiers (2002), a researcher needs to use verification strategies (e.g. active analytic stance, methodological coherence, and responsiveness) during the whole study. These principles help to adapt the direction of the study and analysis, ensuring reliability and validity of the research project (Morse et al., 2002). In the iterative process of developing this research, the analysis of the videos, and the elaboration of the theoretical background were quite useful to keep aligned the study, and narrow the research questions considering the evidence at hand to provide answer to them.

However, two aspects could be considered for future studies to increase the trustworthiness of the research: triangulation of data and intercoder reliability. The former is about collecting data from different sources, to later use them to confirm or complement each other (Teddlie & Tashikori, 2003). In that sense, since the data set used to develop this study was collected in advance, it was not possible to either make notes during the data collection process or arrange post-recording interviews with the participants, to confirm our assumptions. On the other hand, since the participants were coming from different cultures and background, to add an intercoder reliability value would have also reduced the likelihood of potential bias. Even though it was not possible due to time constraints and lack of resources, I highlight it for future studies.

8.2. Ethical Issues

As any intellectual work that demands collecting information from different sources, for the elaboration of the present study were used different referencing techniques to avoid misappropriation and plagiarism, therefore ensuring acknowledgement of the authorship, and originality of the study.

The video material was collected by a renowned research group, following ethical guidelines as voluntary involvement of the participants, respect to their dignity and autonomy, without causing them any harm or putting them at risk (Finnish National Board on Research Integrity, 2009). Even though video data is not anonymous itself (Derry et al., 2012), confidentiality can still be protected. In this case, since I did not collect the data, I could only review the video material of the English-speaking groups, without further access to their personal information. Similarly, I used the same protocols, not sharing or storing the material in any cloud service or public space. Also, the name of the participants and number of groups were not mentioned.

In regard of the methods and process followed to develop the present study, they have been described thoroughly in the empirical part. During the process of data analysis, the decisions taken have been justified from both, methodological and ethical perspectives. Similarly, the results have been reported according to the findings.

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