Järvelä, S., Järvenoja, H. & Muukkonen, H. (2021). Motivation in inquiry learning environments. In Duncan, R.G., & Chinn, C.A. (Eds.). (2021). *International Handbook of Inquiry and Learning* (1st ed.). Routledge. https://doi.org/10.4324/9781315685779

Motivation in Collaborative Inquiry Environments

Sanna Järvelä, Hanna Järvenoja, and Hanni Muukkonen

Abstract

This chapter will focus on motivational effects on inquiry learning and their contribution to the learning outcomes. Two main themes are discussed: How does inquiry learning challenge or support students' motivation to learn? If both pathways, challenging and supporting, occur, what settings and supports create a learning environment for motivating inquiries? Theoretical grounding is based on a perspective of motivation as a social phenomenon and the recent empirical findings on how inquiry-based learning environments challenge or support motivation. The chapter also discusses regulation of motivation and its role in overcoming socioemotional challenges in inquiry learning settings. Finally, suggestions for designing and supporting motivation in inquiry learning are provided and future trends and developments are discussed.

Introduction

Inquiry learning at school has been a success. Inquiry activities provide a valuable context for learners to learn how to reason and to learn concepts in different domains. The results indicate that inquiry learning tasks and environments also foster productive task-related interaction and enhance student motivation in general (Blumenfeld et al., 1991; Rogat, Linnenbrink-Garcia, & DiDonato, 2013). This chapter will focus on motivational effects on inquiry learning and their contribution to the learning outcomes.

Inquiry-based instructional approaches propose techniques for active learning pedagogy that requires learners to observe, generate questions, discover gaps in their knowledge base, and study resources in order to overcome these gaps (O'Donnell & Hmelo-Silver, 2013). Learners are given meaningful tasks, such as problems or cases presented in a realistic context. Such instruction demands that the students take responsibility for their learning processes (Mäkitalo-

Siegl & Fischer, 2013). Students need to plan learning activities and monitor and evaluate their progress regularly, and these activities are closely related to strategic learning skills (Hadwin, Oshige, Gress, & Winne, 2010; Järvelä et al., 2014). In sum, inquiry learning creates an optimal context for learners' task engagement, but motivational involvement is also a prerequisite, as individuals' motivational characteristics, such as interest, influence forethought and goal setting (Zimmerman, 1989).

Researchers have extensively investigated implementations of inquiry learning in diverse contexts and have documented its cognitive and strategic consequences. In this chapter, we complement these discussions of cognitive aspects of inquiry learning by focusing on the motivational prerequisites and consequences of inquiry learning. We consider inquiry learning not only as a method for disciplinary learning but also as a potential and timely context for training 21st-century learning skills, such as collaborative problem-solving (Griffin, McGaw, & Care, 2012). Challenging learning tasks and situations are opportunities for students to train their motivation (e.g., interest) and regulation of learning during engagement in collaborative inquiries. Accordingly, in this chapter, we will discuss two main themes: (a) *How does inquiry learning challenge or support students' motivation to learn?* and (b) *If both pathways, challenging and supporting, occur, what settings and supports create a learning environment for motivating inquiries?* We build our understanding not based specifically on any "traditional theoretical paradigm" but instead on a perspective of motivation as a social phenomenon (Järvelä, Volet, & Järvenoja, 2010; Järvenoja, Järvelä, & Malmberg, 2016). We also draw on our experience working with collaborative inquiries and computer-supported collaborative learning studies.

We start with discussing empirical findings on how inquiry-based learning environments challenge or support motivation. Then we turn to a conceptual discussion and review several relevant motivational constructs explaining motivation in learning contexts; we conclude by introducing motivation as a contextual, situated, and process-oriented construct. We continue discussing regulation of motivation and its role in overcoming socioemotional challenges in inquiry learning settings. Finally, we provide suggestions for designing and supporting motivation in inquiry learning and discuss future trends and developments.

What We Know about How Inquiry-Based Learning Environments Challenge or Support Student Motivation

Conditions and consequences of inquiry learning have been studied from various perspectives. Earlier studies showed positive but also some mixed results when studying the cognitive effects of inquiry-based learning approaches (De Simone, 2009; Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006; Gijbels, Dochy, Van den Bossche, & Segers, 2005; Kirschner, Sweller, & Clark, 2006). It is crucial to note that there are also variances in the quality of the learning processes among different students; some students have major difficulties in engaging in research-like inquiry working procedures, and their learning processes are more regressive than progressive (Krajcik et al., 1998). We claim that, like other learning approaches emphasizing learners' own agentic roles, advanced cognitive learning skills do not guarantee the adaptive and agentic learning process alone. Collaborative learning skills, motivation, and, particularly, regulation of motivation are crucial for the inquiry-based learning process to be successful. These are relatively demanding competences, and it has been suggested that they do not develop without specific engagement in educational practices that involve engagement in complex

problem-solving and collaboration around messy problems (e.g., Barrie, 2012; Broussard, La Lopa, & Ross-Davies 2007).

Participation in inquiry strongly emphasizes *cognitive reconstructing* by changing the cognitive division of labor between teacher and student. When a student takes responsibility for higher cognitive activities, it enables him or her to go to a deeper level in the learning process. This shift from teacher-centeredness to student activity presupposes strong self-regulative efforts from students and, at the same time, offers more space for individual activities. This kind of meaningful and close relationship with learning tasks also may help students increase their interest and motivation (Järvelä & Renniger, 2014). However, the responsibility for setting up one's own learning goals and monitoring one's own learning activities can be quite demanding for some students, and, furthermore, collaborative interaction with other learners may be difficult to initiate (Rogat & Linnenbrink-Garcia, 2011). Motivational consequences of inquiry learning are therefore multifaceted, including factors that may increase motivation and engagement for learning but also factors potentially challenging motivation that can result in a decrease in commitment to inquiry and collaboration.

It is well established that there exist *motivational and socioemotional challenges* to effective group functioning during inquiry. In an ideal case, collaborative inquiry learning aims to bring a new culture of teaching and learning into the classroom, where students in groups engage in self-regulated learning activities supported by the teacher. Research shows that a process of collaborative inquiry is demanding in terms of social interaction and that groups often do not succeed (Kuhn, 2015). This is because effective and efficient collaboration entails much more than simply sharing ideas or working together. It involves building new knowledge together while adapting to different challenges with all of one's human mental capacities (Kirschner,

Sweller, Kirschner, & Zambriano, 2018). It also involves showing tolerance, expressing and understanding different viewpoints, and coping with uncertainty (Muukkonen & Lakkala, 2009). Therefore, the core of collaborative inquiry involves a complex interaction of cognition, motivation, and emotions (Järvelä, Hadwin, Malmberg, & Miller, 2017). In addition, successful collaboration hinges on social, non-task-related affective interactions, such as feelings of group cohesiveness, team orientation, mutual trust, and sense of community (Fransen, Kirschner, & Erkens, 2011; Fransen, Weinberger, & Kirschner, 2013).

To promote these positive types of interactions, researchers have investigated a variety of instructional factors. One important factor appears to be the use of *complex and realistic tasks.* Muukkonen and Lakkala (2009) and Muukkonen, Lakkala, Kaistinen, and Nyman (2010) investigated the effects of this factor in a study of inquiry in a higher education context. A qualitative analysis of students' experiences examined how students cope with a knowledge-creation challenge based on developing a project for a customer (Muukkonen et al., 2010). Student teams were asked to create ideas and plans on future possibilities and challenges in digital services for a broadcasting company. The outcome of each team's work was a report and a presentation to the customer. Based on team interviews halfway through the course, the students described high interest but were confused with the open-ended assignment and expressed a heightened need for both a teacher-provided structure to inquiry and an awareness of ways to monitor and adjust inquiry efforts in the groups. At the end of the course, their self-reflections revealed a change to more positive appraisals of the assignment. It was evident from students' feedback that the authentic nature of the knowledge creation challenge as well as the presence of the customer in the process and their expectations for the outcomes provided a motivational driver to overcome the challenges in collaboration.

Muukkonen and colleagues (2010) suggested that as students tackled the challenge of knowledge creation, they engaged in two parallel processes—project work and inquiry—which might be best supported with different types of scaffolding. The first type is facilitating project work by pragmatic scaffolding and supporting the management of the practical and social aspects of collaboration—for instance, by providing timelines or templates for project management. The second type is facilitating the inquiry process by models and practices for epistemic advancement. This could be supported, for instance, by templates structuring the expected outcomes or questions helping to identify key concepts and their connections. Within the knowledge creation approach to learning, both of these processes are related to advancing *shared objects of inquiry* (Muukkonen & Lakkala, 2009). Shared objects of inquiry can be understood as both the general motivation (objective) for the inquiry (what are we aiming for?) and the more tangible outcomes (e.g., reports, presentations, plans, and designs) that are elaborated during the collaborative inquiry process (Paavola & Hakkarainen, 2005). *Open-endedness and the need to invest collective efforts* in the elaboration of shared goals and co-construction of tangible objects (e.g., presentation and design) have been emphasized as providing motivation for collaborative working (Damsa, 2014; Knorr-Cetina, 2001; Paavola & Hakkarainen, 2005). However, due to their collective construction, objects emerge that are only partially shared and sometimes fragmented (Damsa, 2014); this contributes to the experience of confusion and an accentuated need for negotiating the motivation and regulation of inquiry efforts. For instance, to alleviate confusion in open-ended processes, there is a need to engage the group in iterative negotiation of the goals of collaboration and the means of contributing to the development of the shared object (Muukkonen et al., 2010).

How successful groups deal with this and how less successful groups could be facilitated with timely prompts continue to be relevant research questions. From the pedagogical design point of view, providing a highly complex and realistic task needs to be adjusted every time to the knowledge and competence level of the participants while maintaining a projection that exceeds students' prior levels in order for learning and efforts in regulation of motivation to occur.

Motivation in Learning Contexts—Conceptual Discussion

Traditionally, in conceptual discussion, motivation is considered as a psychological phenomenon that is made up of individuals' former experiences and interests, beliefs, and appraisals of learning (success). This complex mental construction has an impact on individuals' ability and willingness to engage in learning activities. In consequence, motivation cannot be considered as a single variable affecting learning; it is a multifaceted phenomenon formed and maintained as a part of the learning process in interaction with a social context (Järvelä et al., 2010). For example, during a collaborative inquiry learning task, students' situational interest in the topic can emerge if collaboration with other group members is stimulating and captivating, which can boost self-efficacy through new discoveries gained in encouraging socioemotional interaction. This can result in increased motivation to commit to the group's joint goals and can gradually support students in developing greater personal interest in the topic as well as greater feelings of competence and deeper engagement in inquiry as such.

Several motivational constructs have been used when discussing motivation in learning in general. Motivation is a broad term that encompasses both engagement and interest, as well as other topics, such as perceptions or beliefs about achievement; capability and competence; and goals, values, and choice. These factors are influenced by a person's consideration of the possibility, utility, importance, and benefit of participating and belonging (Minnaert, Boekaerts,

& de Brabander, 2007). Motivation also involves considering the choices people make without external influence and the conditions supporting the individual's experience of autonomy, competence, and relatedness (Ryan & Deci, 2000). We briefly overview several important constructs below.

Achievement goal theory provides a framework for understanding how students interpret and respond to various learning tasks and events. It posits two main explanations of students' achievement (Dweck & Leggett, 1988). These explanations are based on the way learners orient themselves toward learning, which are viewed as a strong indicator of engagement. Mastery goals refer to goals aimed at developing understanding, while performance goals reflect a focus on demonstrating one's ability or competence, often compared to others. These two primary goals have been further elaborated based on whether the student adopts an approach or avoidance focus (see Elliot, 1999). Achievement goals can explain and predict the students' behavior, affect, and strategic approaches (Linnenbrink-Garcia & Patall, 2016). Prior research generally suggests, for example, that mastery goals are beneficial for strategic regulation of learning and engagement, whereas performance goals, though useful in performance-oriented instructional settings, are considered as less adaptive in terms of adaptive learning processes and the use of regulation strategies (Payne, Youngcourt, & Beaubien, 2007; Volet, & Mansfield, 2006). Learning environments shape students' *goals.* Students' tendency to adopt mastery performance approaches can be both hindered or facilitated by the type of task, providing students' choices or reducing control, recognition, grouping, and evaluation (Maehr & Midgley, 1996). Although there is strong evidence of the influence of achievement goals on individual learning, not much is known about their influence on collaborative learning and inquiries. Mercier's (2017) study, however, showed that achievement goals influence interaction behaviors when students are

engaged in collaborative activities. In her study, 45 pairs of students engaged in a building task. Groups with learning goals showed more knowledge convergence than groups with performance goals. They also engaged in qualitatively more advanced strategies, such as reflection and explaining.

Another, complementary, body of research has addressed *social goals*. Social and well-being goals expand achievement goal theory with a sociocognitive perspective that reflects the social dimension that is typically present in real-life learning situations (Patrick, Ryan, & Kaplan, 2007). There is substantial evidence that students' goals to engage in learning activities are not only directed at the task or their own performance but also reflect the social learning context. Furthermore, real-life learning situations are not isolated from the surrounding world but can encompass multiple motivational goals, all related to academic achievement (Boekaerts, de Koning, & Vedder, 2006). This is highlighted in the range of social goals identified in the literature—for example, social approval goals, social responsibility goals, social interaction goals, social relationship goals, social status goals, contextual goals, or prosocial goals (Urdan & Maehr, 1995). In summary, inquiry learning contexts provide various ways to facilitate students' social goals and thus engagement in inquiries.

While achievement goal theory approaches motivation to learn from the desired and prioritized outcome and value perspective, *self-efficacy beliefs* are ability-related judgments that a person makes of his or her capabilities to learn and perform, develop skills, and master knowledge in relation to a certain learning task or domain. Self-efficacy is found to shape engagement and to affect how much effort a person is willing to invest in regulating his or her own learning and persistence in the face of difficulties (Schunk & DiBenedetto, 2009). Inquiry learning can offer

opportunities for strengthening efficacy, as found by Jansen, Scherer, and Schroeders (2015) regarding perceived science self-efficacy.

Interest as a motivation concept describes meaningful participation with particular content: people's psychological state during engagement, as well as the likelihood that they will continue to reengage that content over time (Renninger & Hidi, 2016). Interest is a cognitive and affective motivational variable that develops through four phases, beginning with a triggering of interest that may or may not be sustained and extending through to a more well-developed individual interest. Interest as a concept has been useful to explain student motivation and engagement in science inquiries. This is mainly because inquiry learning supports learners' abilities to make connections to real disciplinary skills and content as well as to work with the language and tasks of the science content; inquiry learning thus develops learners' abilities to work through its challenges and thereby extend their current understandings (Renninger & Riley, 2015).

Motivation as a Contextual, Situated, and Process-Oriented Construct

The role of motivation in fostering learning and achievement has been widely acknowledged (Linnenbrink-Garcia & Pekrun, 2011). Motivation is not a static trait, however; instead, it develops in interaction with individual beliefs, contexts, learning situations, and social interactions. All of the motivational constructs presented above are involved in the ongoing, dynamic interplay between a person and the environment, as is emphasized in the sociocognitive theory of learning. In the next section, we will introduce *motivation as a contextual, situated,* and *process-oriented construct* (Järvelä et al., 2010; Järvenoja, Järvelä, & Malmberg, 2015). Our understanding of motivation is based on the assumption that, in a social learning context such as in collaborative inquiry, individual group members represent interdependent self-regulating agents who together constitute a social entity. The learners actively create affordances and

constraints for motivation and engagement in the situation and during the activity. In the context of collaborative inquiries, participants bring along their motivational beliefs, tendencies, and goals, and these play a mediating role in their actual engagement in the group activity. As revealed in research on collaborative learning, each group generates its own social dynamics, and it is through members' interactions that engagement, as enacted motivation, is afforded or constrained (Järvenoja & Järvelä, 2009).

We also argue that, in collaborative inquiry, both social and individual processes of motivation occur concurrently and represent distinct systemic levels (Volet, Vauras, & Salonen, 2009). The social construction conceptualization of motivation provides a useful theoretical perspective to examine motivation as an enacted, dynamic, and social process (in inquiry learning). On an individual level, inquiry learning "motivates," "hooks," or "triggers" motivation or interest. On this level, motivation is a characteristic of individuals that is "*socially influenced*" by the context (e.g., situated interest in hands-on science inquiry activities). This level is the level that has been discussed as a main argument for designing motivating learning environments, but collaborative inquiry also provides students with socially constructed motivation (Nolen & Ward, 2008). On a social level, motivation is "*socially constructed*" in interactions between group members as they together engage in collaborative inquiry (e.g., through building up a joint engagement and goal commitment in disciplinary interactions). When considering motivation in collaborative inquiries, the social construction perspective to motivation is relevant, as it builds upon the idea that motivation emerges through interactions in social situations and that actual engagement represents enacted motivation (Järvelä & Järvenoja, 2009; Järvelä & Volet, 2004).

Regulation of Motivation and Emotions in Challenging and Open Learning Tasks

Grounding our analysis in a contextual and situated perspective on motivation, we review the role of motivation in a variety of learning environments. Many conventional studies on student motivation focus on students' perceptions but not on what they really do and how they act in the learning context to create, shape, maintain, or restore motivation (Järvelä et al., 2010; Järvenoja, Järvelä, &, Malmberg, 2016; Volet & Järvelä, 2001). A process-oriented perspective on studying motivation in social learning contexts instead investigates how motivation affects the groups' learning processes or inquiries in complex ways rather than just being a static motivational ground or condition for regulated learning. We discuss *regulation of motivation* as a part of the motivated and (self)-regulated learning process. This is particularly useful for inquiry learning settings that expect learners' interactions with a situated task and the associated social challenges.

Self-regulated learning theory explains the regulation processes in learning. Self-regulated learning refers to the process of an individual becoming a strategic learner by regulating his or her cognition, motivation, and behavior in order to optimize his or her learning (Schunk & Zimmerman, 1994). Motivation lies at the foundation of these regulatory processes and is critical to learning and achievement (Komarraju & Nadler, 2013). Research has defined different motivation and emotion regulation strategies that individuals use to purposefully influence their motivation (Gross & Thompson, 2007; Wolters, 2003). Motivation regulation strategies can, for example, aim to strengthen or redirect motivational goals through performance and mastery *self-talk* or make tasks more interesting through *interest enhancement strategies* (Wolters & Benzon, 2013). The studies on motivation and emotion regulation show that the regulation of motivation and emotions is composed of purposeful and appropriate activities through which individuals initiate, maintain, and supplement their willingness to complete a particular learning goal and

overcome situations that challenge motivation and commitment. By engaging in regulation of motivation and emotions, not only individual learners but also groups can actively adjust their motivation and channel the emotional atmosphere within the group to overcome challenges (Boekaerts & Pekrun, 2015; Järvelä, Järvenoja, Malmberg, Isohätälä, & Sobocinski, 2016). Group members' personal experiences, group dynamics, and task characteristics can produce situated cognitive challenges (e.g., challenges in task understanding), motivational challenges (e.g., task commitment problems), and emotional challenges (e.g., dominating interaction). These challenges pose risks to motivated inquiry and joint engagement within collaborative groups. Through regulation of emotion and motivation, these conditions are actively shaped and adapted to create a ground for balanced collaboration and metacognitive processes, which is critical in inquiry learning success. For example, if a group gets stuck within an inquiry learning task and feel frustrated or willing to give up, group members can boost each other's efficacy by encouraging each other to invest more effort and emphasizing small success moments. Overall, the ability to take an agentic role toward one's own motivation and to regulate feelings and engagement has been recognized as having a strong positive effect on students' development throughout their school years (Boekaerts, 2011; Zimmerman, 2011). When engaging in the regulation of emotions and motivation, the learner becomes aware of the motivation and emotions experienced and can strategically direct or control them to ensure engagement in learning (Boekaerts & Pekrun, 2015). Järvelä and her colleagues have been analyzing the socioemotional aspects of peer interaction and group learning and have illustrated how students' motivational accounts of their interactions reflect changes in engagement (Järvelä, Järvenoja, & Veermans, 2008; Järvelä, Veermans, & Leinonen, 2008). As an example, this was seen in students' goal-oriented discussions and thinking about various reasons for persisting in or

completing a task in a situation where the students discussed which topic to choose for a task to create a poster, as in these examples: *"Lets' take the topic 'metacognition'." That is also a good choice concerning the exam."* Students' intrinsic motivation or situational interest were enhanced while completing the activity, as shown in statements such as: *"This is a brilliant idea!" "I can describe my example…."* Similarly, Vauras et al.'s (2009) micro-genetic analyses revealed how individuals' cognitive, affective, and motivational behaviors during real-time activities were related to change processes in their social relationship patterns. Together, these studies have shown that motivation is a critical component shaping the successful learning process.

Motivation Regulation in Collaborative Inquiry Learning

The actual process of collaborative inquiry involves opportunities for appraisals which may cause socioemotional challenges (e.g., situations presuming tolerance of ambiguity or differences in students' interest), which have a significant impact on motivation. When individuals' characteristics, goals, and situational demands clash and create conflicts, motivation and engagement are challenged, forcing individuals to exercise control over their emotions, their motivation, and sometimes their social environment. For example, in their case study Järvenoja and Järvelä (2013) describe a collaborative learning episode in which emotional balance within the case group falls apart as a result of group members' different opinions and their questioning of one member's personal experiences from childhood. The clash between the group members conflicts with their ability to continue joint learning. The case study illustrates that group members recognized the change in the atmosphere, which led them to exercise emotional regulation at a personal level, but also in coordination with each other to restore the secure and supportive emotional atmosphere. Given the challenging nature of most group activities, this

type of regulation of both personal and joint motivation and emotions is needed for continued engagement and progress toward goal achievement (Järvenoja & Järvelä, 2005; Salonen, Vauras, & Efklides, 2005).

Process-oriented studies point out that such *motivational and socioemotional challenges* described in the above example act as triggers for motivation regulation and are typical in inquiry and collaborative learning tasks (Järvenoja et al., 2017; Näykki, Järvelä, Kirschner, & Järvenoja, 2014). These challenging situations are also triggers to activate motivation regulation. In the above example, the motivation to continue was endangered by the one group member who was heavily questioned by others. However, the challenging situation triggered the group's efforts to restore motivation and goal-oriented work. Students' interpretations of their interactions with peers have revealed, for example, how their goals are shaped through those interactions (Boekaerts & Minnaert, 2006) and how the actions of group members can have both positive and negative influences on individual motivation (Järvenoja & Järvelä, 2005; Volet & Mansfield, 2006). Similarly, self-efficacy beliefs can shape how people experience and the ways that an individual either on his or her own or in interaction with others is able to regulate these motivationally challenging situations. Again, going back to the previous example, without adaptive motivation and emotion regulation in the emotionally challenging situation, the questioned group member could have ended up giving up and questioning her self-efficacy. This could have further hampered the collaboration and motivation in the rest of the group. Motivation, however, is affected by the appraisals of the learning process and collaborative interactions in general.

To capture the social construction and enactment of motivation, researches must also consider the complementary cognitive angle, which explains the mediating role of individual member's

metacognitive reflections and interpretations. For example, in a study by Järvenoja, Näykki, Törmänen, and Järvelä (2018), emerging challenges and related emotion regulation were studied as teacher education students worked collaboratively across six different mathematics tasks. The analysis revealed that, in collaborative learning situations, a wide range of micro-level challenges emerge, covering challenges with motivational and emotional issues, such as anxiety, annoyance or frustration, and a lack of self-efficacy or interest, as well as different cognitive and socially and contextually oriented challenges, such as difficulties in understanding the task or content and differences in working and communication styles (see also Järvenoja, Volet, & Järvelä, 2012). All of these challenging situations are possible triggers not only for decreasing motivation but also for regulation to emerge.

Recent research has shown that, when individuals work collaboratively, at least three types of regulated learning come into play for shaping motivation in the collaborative inquiry learning situation (Hadwin, Järvelä, & Miller, 2017). First, each group member takes responsibility for regulating his or her learning (self-regulated learning); second, each group member supports peers in regulating their learning (co-regulated learning); and third, the group comes together to collectively regulate learning processes in a synchronized manner (shared regulation of learning). Shared regulation refers to group members' deliberate and strategic adaptation during phases of collaborative planning, task enactment, and reflection. It involves multiple individual perspectives and fine-tuning of cognitive and motivational and emotional conditions as needed. For example, a study by Järvelä, Järvenoja, Malmberg, Isohätälä, and Sobocinski (2016) showed that motivation plays a role in successful collaborative inquiry. They studied how self- and shared regulation in computer-supported collaborative learning took place and whether they were useful for the learning outcomes. In their study, 44 teacher education students worked with open

and challenging collaborative tasks, and temporal sequences of online chat discussions and log file traces were analyzed in online collaboration. The results showed that socially shared regulation of motivation is important in maintaining productive collaboration. When considering the contribution of socially shared regulation on collaborative learning outcomes, the correlation analyses showed that groups with higher learning outcomes tended to engage in socially shared planning and socially shared motivation, whereas the groups with low learning outcomes tended to engage more in self-regulated learning.

Designing and Supporting Motivation in Inquiry Learning: Principles, Tools, and Technologies

Even though there is an increasing interest in motivation in inquiry and collaborative learning groups, Belland, Kim, and Hannafin (2013) emphasized that, in the design of learning environments, in general, motivation has been ignored. Järvelä and Renniger (2014) claimed that the two main challenges to successful engagement in inquiry learning are as follows: (1) How do we enable those who are not yet engaged to develop their motivation for learning, and how can we help unmotivated learners become motivated to learn? and (2) How do we design in order to continue to support those who are already engaged so that they continue to deepen their interest and, as a result, their motivation to learn a particular disciplinary content? A third question could be added—how can a formal learning context create spaces to practice motivation regulation in action and generic or discipline-specific competences?

It is evident that students' motivation in various learning environments needs to be supported. We can classify motivation support into two levels: macro- and micro-levels of support for motivation. Macro-level support focuses on disciplinary practices, and micro-level support

targets specific learning processes. We will describe both levels of motivation support as follows.

Macro-level support for students' interest, task engagement, and deepening of disciplinary work has been provided in many motivation intervention studies that provide principles for planning tasks and models for day's or week's working or principles applied in curriculum or study periods. For example, Renniger, Ren, and Kern (2018) have designed an intervention especially contributing to the development of science interest, in which they have implemented macro-level support through conducting out-of-school science workshops among middle-school-age students. The intervention was designed to support workshop participants' abilities to make connections to disciplinary skills and content workshops, consolidate their developing understanding and abilities to work with science skills and content, identify what they do and do not yet understand in science, and realize that they can do science in terms of skills and content knowledge. In practice, the intervention includes a brief writing assignment that is integrated into science activities. Overall, the study's findings showed that a motivation-based intervention was successful in supporting students' interest development and learning of disciplinary content. Macro-level supports have also been investigated in higher education in a project designed to enhance competence and motivation through inquiries simulating knowledge work. Taking place in collaboration, knowledge work can be defined as co-developing knowledge objects (e.g., project plans, prototypes, articles) by a community's collective efforts and resources (Muukkonen et al., 2019). Studies on the development of knowledge work competence have examined the interplay of pedagogical design, assignment characteristics, engagement, and motivation as well as the learning of collaboration competence measured by the Collaborative Knowledge Practices (CKP) questionnaire (Muukkonen, Lakkala, Toom, & Ilomäki, 2017).

When students in veterinary education had a peer-teaching activity included as an assignment in addition to collaboration during a dissection exercise task to learn the anatomical entities, they learned statistically significantly more about collaboration in order to advance a shared outcome and about the integration of individual and collective efforts (Laakkonen & Muukkonen, 2018). Preparation for a presentation of complex anatomy given to peers was experienced as promoting an increased need for socially shared planning, and it supported the motivation for in-depth inquiry to gain a full understanding of the complex subject. Another study using the CKP (Muukkonen et al., 2017) generated evidence on how the intensity of activities and the type of assignments affected the competence learning reported by students. Structured intense collaboration was related to higher ratings on learning about the iterative nature of development efforts and feedback practices. The courses had assignments that simulated multiple aspects of authentic professional tasks. Students related the authenticity to higher motivation to engage in the inquiry as a prolonged effort. These studies point out that the types of activities involved in inquiry learning courses correspond well with student self-assessment in learning the targeted collaboration competence, and these can be examined apart from the discipline-specific content.

Micro-level support is targeted toward groups' and group members' learning processes. When trying to understand social learning contexts, such as collaborative inquiry learning, educators must consider an extremely complex set of variables—cognitive, social, emotional, motivational, and contextual variables interacting with each other in a systemic and dynamic manner (Thompson & Fine, 1999); all of these contribute to students' motivational interpretations in a situation (Järvenoja et al., 2016). Based on our understanding of motivation as a social and situated phenomenon, we have targeted regulation of motivation as a way for micro-level support for motivation during collaborative inquiries (Järvenoja, Järvelä, & Malmberg, 2018). Regulating

and controlling motivation, emotion, and task enactment during a learning process is the quintessential skill in collaborative inquiry because working together means co-constructing shared task representations, shared goals, and shared strategies (Järvelä & Hadwin, 2013). It also means regulating learning through shared metacognitive monitoring and control of motivation, cognition, and behavior (Hadwin et al., 2017).

In order to simplify design principles for motivational support in a complex intertwined process of cognition, motivation, and emotion in a learning process, we have used the concepts of *awareness*, *recognition*, and *regulation* as main principles in our tool development for supporting motivation. Awareness refers to student's meta-level acknowledgment that "something is wrong" and needs to be regulated (i.e., inquiry progress is endangered), recognition to an ability to accurately identify sources and reason for that (e.g., what causes a motivational problem), and regulation is to act, adapt, control behavior according to the recognized need (i.e., we need to adjust our joint goals as all group members are not committed to the current one). They are the main components of developing motivation in a learning task and continuing the motivated learning process during the challenging learning task progress. Next we introduce technological tools for supporting the individual and collaborative motivation implemented in our studies.

Individual-Level Motivational Support in Collaborative Inquiry Task

In a study by Järvenoja et al. (2018), we involved primary school students in a long-term inquiry learning project as a part of a biology curriculum during which they studied a science topic dealing with the vital conditions for life. The project included classroom lessons with the teacher, experimental field trips, collaborative group work, and individual work in the gStudy learning environment (Winne, Hadwin, Nesbit, Kumar, & Beaudoin, 2005). The study's pedagogical design emphasized both self-regulated learning and science inquiry skills; the students were

encouraged to take responsibility for planning and directing their own learning, for example, by focusing their work according to their own interests and deciding how much time and effort they would invest in various subtopics of vital conditions for life—namely water, air, nutrition, heat, light, family, and human rights.

Because the science learning project inherently required high engagement and persistence from students as well as the ability to coordinate their learning, different types of motivation support were provided. At a *macro level*, the classroom teacher structured the work during the school day as well as within the lesson. That is, the teacher controlled the time both teachers and students spent with the project and with the different functions within the project, such as when there were teacher-led lessons, experimental field trips, or students individually working. The students themselves planned the flow of their independent working. The teacher provided hands-on support when it was requested, but the students were encouraged to perform independent inquiry and self-regulated learning. In addition to the teacher's support, *micro-level* support was also provided within the gStudy environment. The cognitive tools of the provided gStudy learning environment were complemented by the emotion awareness tool (EmAtool, Figure 9.1). The EmAtool (Järvenoja, Malmberg, Järvelä, Näykki, & Kontturi, 2018) was designed to support the students' motivation through increasing awareness of their situational motivation during inquiry learning. The students began every gStudy working session by spending a couple of minutes to evaluate their current emotional state and motivational goals for that particular inquiry learning session. This conscious consideration of these two components was supposed to increase students' awareness of their micro-level, situation-specific motivation so that the need for regulation could be recognized if the motivated learning was challenged, and further, the student

could plan on how to proceed with motivated learning and activate accurate motivation regulation.

<COMP: Place Figure 9.1 Here>

The EmAtool increases awareness of the user's current emotional state by asking the user to estimate the valence level (negative-positive) and then *recognize* the reason for this emotional state (i.e., what is the motivational, cognitive, and/or emotional source or reason for the current state). Then EmAtool prompts user to situate his or her current state with his or her motivational goals in that situation, which can help to adjust the goals and activate proper regulation strategies especially if the motivation is poor (Järvenoja et al., 2018).

Shared Motivation Support in Collaborative Group Task

Another tool that we developed—the socially shared regulated learning (S-REG) tool—extends our previous work on situated micro-level supports by providing targeted support for group work (for a review, see Järvelä et al., 2016; and for specific tool examples, see Järvenoja, Volet, & Järvelä, 2012; Järvenoja et al., 2018). Support is provided based on the challenges the groups have identified in their collaborative inquiry tasks. Similar to the EmAtool, S-REG elicits individual group member's awareness of motivational and emotional states but extends this to encompass group-level awareness and evaluations of the cognitive efficacy as well. After increasing the individual group member's awareness, the S-REG tool further prompts the groups to address the recognized challenges together. This change from individual- to group-level awareness, recognition, and, finally, regulation of the situation, takes place in a series of phases, as presented in Figure 9.2.

<COMP: Place Figure 9.2 Here>

Figure 9.2 demonstrates how group members first evaluate their individual beliefs of efficacy related to their cognitive (*I know what I am supposed to do*), motivational (*I am willing to work*), and emotional (*I feel fine*) abilities (Figure 9.2, Phase 1). One group member can, for example, evaluate his or her cognitive starting point to be low ("I have no idea how to start"), but his or her motivation and emotions to be high ("I am committed and eager to start working"), while another group member may offer an opposite evaluation of his or her approach to working on that day. In the next phases, S-REG indicates all the areas in which group members' evaluations clash or where they evaluate some challenges. The tool prompts the group members to recognize, through discussion, the "challenge areas" for the specific inquiry learning task and then consider how to regulate the situation to ensure the motivation for joint inquiry. The S-REG tool first initiates the discussion between the group members by providing a "traffic light" indicator to represent their joint motivational and emotional state (Figure 9.2, Phase 2). Next, the S-REG tool prompts the group members to discuss the traffic light. In this phase, group members can together recognize sources that can potentially create motivational challenges. For example, the group member doubting his or her ability to start working on a task has an opportunity to express this to other group members, or a group member having motivational problems can explain his or her standpoint. The discussion helps students become more aware and explicate the challenges the *group* encounters, and which may endanger the group members' joint motivation in order to continue the collaborative inquiry. After the discussion, the S-REG tool helps the group members recognize the reasons "behind" the challenges by providing a list of pre-stocked options from which to select (Figure 9.2, Phase 3). Finally, related to the groups' selected reason for a challenge in each of the three areas, the S-REG tool provides a regulation strategy that prompts the group to overcome their challenge (Figure 9.2, Phase 3). The use of the tool ends

with a request to discuss the prompt or other alternatives to regulate the challenge in question. Empirical studies have shown that collaborating groups use the tool purposefully (e.g., Järvenoja, Järvelä, & Malmberg, 2017). In particular, the students became aware not only their own but the groups' emotional and motivational states by using S-REG tool. The results showed that when S-REG tool was implemented, the reported lower levels of group motivation and emotions were associated with the occurrence of co-regulation in the beginning of the learning sessions. The results of the study suggested that the S-REG tool balanced collaboration by prompting the groups to regulate emotions and motivation right in the beginning of the motivationally and emotionally challenging learning sessions.

To conclude, motivation in inquiry learning functions in several layers, which is important to acknowledge when designing and supporting motivated inquiry. While macro-level support provides means for addressing motivation and engagement, micro-level support targets the motivational challenges encountered in a situation during the process. In addition, motivation also functions on individual and social layers, particularly in collaborative inquiry. When support for motivation is designed, neither layer should not be neglected. Together, well-designed micro- and macro-level support implemented with technological tools will provide means to support students' ongoing motivation in inquiry learning, addressing the challenges deriving from overall unmotivation as well as more situated motivational challenges that endanger engaged learning and inquiry.

Future Trends and Developments

Motivation is a driving force for individual students and contributes to engagement among group members in collaborative inquiry. Motivation regulation keeps students on track while they are progressing in their inquiries, because motivation deals with processes involved in both initiating

and sustaining behavior and engagement. As a construct, motivation is hard to operationalize in the practice of inquiry because its focus is on self-related beliefs that are cognitive, conscious, affective, and often under the control of the individual (Minnaert et al., 2007). More research is needed to understand how *inquiry learning challenges or supports student motivation to learn and especially what the settings, supports, and technologies are that make up the learning environment for motivating inquiries.* We suggest that theoretical approaches should extend well beyond the distinction between motivated and unmotivated and toward understanding motivation as a socially constructed and situated phenomena (Järvelä et al., 2010; Järvenoja et al., 2015), which can be supported by macro- and micro-level designs.

More research could focus on competence building in general and motivation support specifically with macro-level designs. Lakkala, Toom, Ilomäki, and Muukkonen's (2015) study examined how teachers redesigned their course according to pedagogical design principles supporting knowledge creation. They found that teachers took into account the benefit of the design principles as conceptual tools when redesigning their courses to integrate content learning with competence development objectives. Furthermore, teachers valued recommendations on how to model authentic professional practices in education and methods of scaffolding students' collaborative knowledge creation efforts, focusing on overcoming challenges to individual student's motivation and shared regulation of inquiry and motivation.

Integrating motivation scaffolds into technology in inquiry learning environments is promising (cf. Linn, McElhaney, Gerard, & Matuk, 2018). These scaffolds might include simple tools for prompting awareness of motivation in a collaborative inquiry situation, as we have introduced in this chapter (cf. Järvelä et al., 2014). Mobile tools implementing the experience sampling method can be used to trace fluctuations in motivation, challenge, and competence as well as emotions

(e.g., Litmanen et al., 2012). In the future, through visualizations of ongoing activities, these may help regulate efforts or initiate interventions needed for achieving socially shared regulation of motivation in inquiry. Furthermore, situated self-reports could be implemented during the process of inquiry, and more adaptive support could be provided in online environments, such as through dashboards derived from machine learning and educational data mining (Dindar et al., 2018).

In the practical design of inquiry learning sessions, students should be engaged in reflecting on and talking about their motivation. This is especially a signal to teachers and teacher educators so that teachers and students learning to be teachers would themselves have an understanding of motivation as a phenomena and its driving force for successful inquiry. On the one hand, inquiry learning provides opportunities for individual and collective success for reinforcing motivation, and on the other hand, there are experiences of failures and learning challenges that provide opportunities for training motivation regulation. These situations are valuable for learners to become aware of their strengths and weaknesses in learning situations and “to investigate” their own learning.

Figure 9.1 Emotion awareness tool.

Figure 9.2 Socially shared regulated learning (S-REG) tool.

References

Belland, B. R., Kim, C., & Hannafin, M. J. (2013). A framework for designing scaffolds that improve motivation and cognition. *Educational Psychologist*, *48*(4), 243–270. http://doi.org/10.1080/00461520.2013.838920

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3–4), 369–398. https://doi.org/10.1080/00461520.1991.9653139

Boekaerts, M. (2011). Emotions, emotion regulation, and self-regulation of learning. In B. J. Zimmerman & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 408–425). New York: Routledge.

Boekaerts, M., de Koning, E., & Vedder, P. (2006). Goal-directed behavior and contextual factors in the classroom: An innovative approach to the study of multiple goals. *Educational Psychologist, 41*(1), 33–51. https://doi.org/10.1207/s15326985ep4101_5

Boekaerts, M., & Minnaert, A. E. M. G. (2006). Affective and motivational outcomes of working in collaborative groups. *Educational Psychology*, *26*(2), 187–208. https://doi.org/10.1080/01443410500344217

Boekaerts, M., & Pekrun, R. (2015). Emotions and emotion regulation in academic settings. In L. Corno & E. Anderman (Eds.), *Handbook of educational psychology* (3rd ed., pp. 76–90). New York: Routledge.

Broussard, S. R., La Lopa, J. M., & Ross-Davis, A. (2007). Synergistic knowledge development in interdisciplinary teams. *Journal of Natural Resources and Life Sciences Education*, *36*(1), 129–133. Retrieved from http://www.human-dimensions.org/images/JNRLSE_2007.pdf

Care, E., Griffin, P., & McGaw, B. (2012). *Assessment and teaching of 21st century skills.* Springer.

Damşa, C. I. (2014). The multi-layered nature of small-group learning: Productive interactions in object-oriented collaboration. *International Journal of Computer-Supported Collaborative Learning*, *9*(3), 247–281. https://doi.org/10.1007/s11412-014-9193–8

Derry, S. J., Hmelo-Silver, C. E., Nagarajan, A., Chernobilsky, E., & Beitzel, B. D. (2006). Cognitive transfer revisited: Can we exploit new media to solve old problems on a large scale? *Journal of Educational Computing Research*, *35*(2), 145–162. https://doi.org/10.2190/0576-R724-T149-5432

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199. https://doi.org/10.3102/0013189X08331140

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, *95*(2), 256–273. US: American Psychological Association. https://doi.org/10.1037/0033-295X.95.2.256

Elliot, A. J. (1999). Approach and avoidance motivation and achievement goals. *Educational Psychologist*, *34*(3), 169–189. https://doi.org/10.1207/s15326985ep3403_3

Fransen, J., Kirschner, P. A., & Erkens, G. (2011). Mediating team effectiveness in the context of collaborative learning: The importance of team and task awareness. *Computers in Human Behavior*, *27*(3), 1103–1113. https://doi.org/10.1016/j.chb.2010.05.017

Fransen, J., Weinberger, A., & Kirschner, P. (2013). Team effectiveness and team development in CSCL. *Educational Psychologist*, *48*(4), 9–24. https://doi.org/10.1080/00461520.2012.747947

Gijbels, D., Dochy, F., Van den Bossche, P., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research*, *75*(1), 27–61. https://doi.org/10.3102/00346543075001027

Gross, J. J., & Thompson, R. A. (2007). Emotion regulation: Conceptual foundations. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 3–24). New York: Guilford Press.

Hadwin, A., Järvelä, S., & Miller, M. (2017). Self-regulation, co-regulation and shared regulation in collaborative learning environments. In D. Schunk & J. Greene (Eds.), *Handbook of self-regulation of learning and performance* (pp. 83–106). New York: Routledge.

Hadwin, A. F., Oshige, M., Gress, C., & Winne, P. (2010). Innovative ways for using gStudy to orchestrate and research social aspects of self-regulated learning. *Computers in Human Behavior*, *26*(5), 794–805. https://doi.org/10.1016/j.chb.2007.06.007

Jansen, M., Scherer, R., & Schroeders, U. (2015). Students' self-concept and self-efficacy in the sciences: Differential relations to antecedents and educational outcomes. *Contemporary Educational Psychology*, *41*, 13–24. https://doi.org/10.1016/j.cedpsych.2014.11.002

Järvelä, S., & Hadwin, A. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist*, *48*(1), 25–39. https://doi.org/10.1080/00461520.2012.74800

Järvelä, S., Hadwin, A. F., Malmberg, J., & Miller, M. (2017). Contemporary perspectives of regulated learning in collaboration. In F. Fischer, C. E. Hmelo-Silver, P. Reimann, & S. R. Goldman (Eds.), *Handbook of the learning sciences* (pp. 127–136). Taylor & Francis.

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

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

Järvelä, S., Kirschner, P. A., Panadero, E., Malmberg, J., Phielix, C., Jaspers, J., … Järvenoja, H. (2014). Enhancing socially shared regulation in collaborative learning groups: Designing for CSCL regulation tools. *Educational Technology Research and Development*, *63*(1), 125–142. https://doi.org/10.1007/s11423-014-9358-1

Järvelä, S., & Renninger, K. A. (2014). Designing for learning: Interest, motivation, and engagement. In D. Keith Sawyer (Ed.), *Cambridge handbook of the learning sciences* (2nd ed., pp. 668–685). New York: Cambridge University Press.

Järvelä, S., Veermans, M., & Leinonen, P. (2008). Investigating student engagement in computer-supported inquiry: A process-oriented analysis. *Social Psychology of Education*, *11*(3), 299–322. https://doi.org/10.1007/s11218-007-9047-6

Järvelä, S., & Volet, S. (2004). Motivation in real-life, dynamic, and interactive learning environments: Stretching constructs and methodologies. *European Psychologist*, *9*(4), 193–197. https://doi.org/10.1027/1016-9040.9.4.193

Järvelä, S., Volet, S., & Järvenoja, H. (2010). Research on motivation in collaborative learning: Moving beyond the cognitive-situative divide and combining individual and social processes. *Educational Psychologist*, *45*(1), 15–27. https://doi.org/10.1080/00461520903433539

Järvenoja, H., & Järvelä, S. (2005). How students describe the sources of their emotional and motivational experiences during the learning process: A qualitative approach. *Learning and Instruction, 15*(5), 465–480. http://dx.doi.org/10.1016/j.learninstruc.2005.07.012

Järvenoja, H., Järvelä, S., & Malmberg, J. (2015). Understanding regulated learning in situative and contextual frameworks. *Educational Psychologist*, *50*(3), 204–219. https://doi.org/10.1080/00461520.2015.1075400

Järvenoja, H., Järvelä, S., & Malmberg, J. (2017). Supporting groups' emotion and motivation regulation during collaborative learning. *Learning and Instruction.* Advance online publication. https://doi.org/10.1016/j.learninstruc.2017.11.004

Järvenoja, H., Malmberg, J., Järvelä, S., Näykki, P., & Kontturi, H. (2019). Investigating students' situation-specific emotional state and motivational goals during a learning project

within one primary school classroom. *Learning: Research and Practice, 5*(1), 4–23. https://doi.org/10.1080/23735082.2018.1554821

Järvenoja, H., Volet, S., & Järvelä, S. (2012). Regulation of emotions in socially challenging learning situations: An instrument to measure the adaptive and social nature of the regulation process. *Educational Psychology, 33*(*1), 1–28.* https://doi.org/10.1080/01443410.2012.742334

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Kirschner, P. A., Sweller, J., Kirschner, F., & Zambrano R., J. (2018). From cognitive load theory to collaborative cognitive load theory. *International Journal of Computer-Supported Collaborative Learning, 13*(2), 213–233. https://doi.org/10.1007/s11412-018-9277-y

Knorr-Cetina, K. (2001). Objectual practice. In T. R. Schatzki, K. Knorr-Cetina, & E. von Savigny (Eds.), *The practice turn in contemporary theory* (pp. 175–188). London: Routledge.

Komarraju, M., & Nadler, D. (2013). Self-efficacy and academic achievement: Why do implicit beliefs, goals, and effort regulation matter? *Learning and Individual Differences, 25,* 67–72. https://doi.org/10.1016/j.lindif.2013.01.005

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., Fredricks, J., & Soloway, E. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *Journal of the Learning Sciences, 7*(3–4), 313–350. https://doi.org/10.1080/10508406.1998.9672057

Kuhn, D. (2015). Thinking together and alone. *Educational Researcher*, *44*(1), 46–53. http://doi.org/10.3102/0013189X15569530

Lakkala, M., Toom, A., Ilomäki, L., & Muukkonen, H. (2015). Re-designing university courses to support collaborative knowledge creation practices. *Australasian Journal of Educational Technology*, *31*(5), 521–536.

Linnenbrink-Garcia, L., & Pekrun, R. (2011). Students' emotions and academic engagement: Introduction to the special issue. *Contemporary Educational Psychology*, *36*(1), 1–3. https://doi.org/10.1016/j.cedpsych.2010.11.004

Linnenbrink-Garcia, L., Patall, E. A. (2016). Motivation. In E. Anderman & L. Corno (Eds.), *Handbook of educational psychology* (3rd ed., pp. 91–103). New York: Taylor & Francis.

Litmanen, T., Lonka, K., Inkinen, M. Lipponen, L., & Hakkarainen, K.(2012). Capturing teacher students' emotional experiences in context: Does inquiry-based learning make a difference? *Instructional Science, 40*(6), 1083–1101. https://doi.org/10.1007/s11251-011-9203-4

Maehr, M. L., & Midgley, C. (1996). *Transforming school cultures*. Boulder, CO: Westview Press.

Mäkitalo-Siegl, K., & Fischer, F. (2013). Help seeking in computer-supported collaborative inquiry-learning environments. In S. A. Karabenick & M. Puustinen (Eds.), *Advances in help-seeking research and applications: The role of emerging technologies* (pp. 99–120). Charlotte, NC: IAP Information Age Publishing.

Mercier, E. M. (2017). The influence of achievement goals on collaborative interactions and knowledge convergence. *Learning and Instruction, 50,* 31–43. https://doi.org/10.1016/j.learninstruc.2016.11.006

Minnaert, A., Boekaerts, M., & de Brabander, C. (2007). Autonomy, competence, and social relatedness in task interest within project-based education. *Psychological Reports, 101*(2), 574–586. https://doi.org/10.2466/pr0.101.2.574–586

Muukkonen, H., & Lakkala, M. (2009). Exploring metaskills of knowledge-creating inquiry in higher education. *International Journal of Computer Supported Collaborative Learning*, *4*(2), 187–211.

Muukkonen, H., Lakkala, M., Kaistinen, J., & Nyman, G. (2010). Knowledge creating inquiry in a distributed project management course. *Research and Practice in Technology-Enhanced Learning*, *5*(2), 73–96. Retrieved from http://www.worldscinet.com/rptel/05/preserved-docs/0502/S1793206810000827.pdf

Muukkonen, H., Lakkala, M., Lahti-Nuuttila, P., Ilomäki, L., Karlgren, K., & Toom, A. (2019). Assessing the development of collaborative knowledge work competence: Scales for higher education course contexts. *Scandinavian Journal of Educational Research*. Retrieved from 10.1080/00313831.2019.1647284

Muukkonen, H., Lakkala, M., Toom, A., & Ilomäki, L. (2017). Assessment of competences in knowledge work and object-bound collaboration during higher education courses. In E.

Kyndt, V. Donche, K. Trigwell, & S. Lindblom-Ylänne (Eds.), *Higher education transitions: Theory and research* (pp. 288–305). London: Routledge.

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

Nolen, S. B., & Ward, C. J. (2008). Sociocultural and situative approaches to studying motivation. In M. Maehr, S. Karabenick, & T. Urdan (Eds.), *Advances in motivation and achievement: Social psychological perspectives on motivation and achievement* (pp. 425–460). London: Emerald.

O'Donnell, A. M., & Hmelo-Silver, C. E. (2013). What is collaborative learning: An overview. In C. E. Hmelo-Silver, Chinn, C., Chan, C., & O'Donnell, A. M. (Eds.), *The international handbook of collaborative learning* (pp. 1–16). Abingdon: Routledge.

Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor – An emergent epistemological approach to learning. *Science & Education, 14*, 535–557. https://doi.org/10.1007/s11191-004-5157-0

Patrick, H., Ryan, A. M., & Kaplan, A. (2007). Early adolescents' perceptions of the classroom social environment, motivational beliefs, and engagement. *Journal of Educational Psychology*, *99*(1), 83–98. https://doi.org/10.1037/0022–0663.99.1.83

Payne, S. C., Youngcourt, S. S., & Beaubien, J. M. (2007). A meta-analytic examination of the goal orientation nomological net. *Journal of Applied Psychology, 92*(1), 128–150. https://doi.org/10.1037/0021-9010.92.1.128

Renninger, K., & Hidi, S. (2016). *The power of interest for motivation and engagement*. New York: Routledge.

Renniger, K. A., Ren, Y., & Kern, H. M. (2018). Motivation, engagement, and interest. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.), *International handbook of the learning sciences* (pp. 116–126). London: Routledge. https://doi.org/10.4324/9781315617572-12

Renninger, K. A., & Riley, R. R. (2015). The ICAN Intervention: Supporting learners to make connections to science content during science inquiry. *Science Scope, 29*(4), 49–53. https://doi.org/10.2505/4/ss15_039_04_49

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

Rogat, T. K., Linnenbrink-García, L., & DiDonato, N. (2013). Motivation in collaborative groups. In C. E. Hmelo-Silver, C. A. Chinn, C. Chan, & A. M. O'Donnell (Eds.), *International handbook of collaborative learning* (pp. 250–267). London: Routledge.

Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *The American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Salonen, P., Vauras, M., & Efklides, A. (2005). Social interaction: What can it tell us about metacognition and coregulation in learning? *European Psychologist, 10*(3), 199–208. https://doi.org/10.1027/1016-9040.10.3.199

Schunk, D. H., & DiBenedetto, M. K. (2009). Self-efficacy theory in education. In K. R. Wentzel,, & D. B. Miele (Eds.), *Handbook of motivation at school, 2* (pp. 34–54). New York: Routledge.

Schunk, D. H., & Zimmerman, B. J. (Eds.) (1994). *Self-regulation of learning and performance: Issues and educational applications*. Hillsdale, NJ: Lawrence Erlbaum.

Thompson, L., & Fine, G. A. (1999). Socially shared cognition, affect, and behavior: A review and integration. *Personality and Social Psychology Review, 3*(4), 278–302. https://doi.org/10.1207/s15327957pspr0304_1

Urdan, T. C., & Maehr, M. L. (1995). Beyond a two-goal theory of motivation and achievement: A case for social goals. *Review of Educational Research, 65*(3), 213–243. https://doi.org/10.3102/00346543065003213

Vauras, M., Salonen, P., Lehtinen, E., & Kinnunen, R. (2009). Motivation in school from contextual and longitudinal perspectives. In M. Wosnitza, S. A. Karabenick, A. Efklides, & P. Nenninger (Eds.), *Contemporary motivation research: From global to local perspectives* (pp. 1–23). Göttingen: Hogrefe.

Volet, S., & Järvelä, S. (Eds.). (2001). *Motivation in learning contexts: Theoretical advances and methodological implications.* London: Pergamon.

Volet, S., & Mansfield, C. (2006). Group work at university: Significance of personal goals in the regulation strategies of students with positive and negative appraisals. *Higher Education Research & Development*, *25*(4), 341–356. https://doi.org/10.1080/07294360600947301

Volet, S., Vauras, M., & Salonen, P. (2009). Self- and social regulation in learning contexts: An integrative perspective. *Educational Psychologist*, *44*(4), 215–226. https://doi.org/10.1080/00461520903213584

Winne, P. H., Hadwin, A. F., Nesbit, J. C., Kumar, V., & Beaudoin, L. (2005). gStudy: A toolkit for developing computer-supported tutorials and researching learning strategies and instruction (version 2.0) [computer program]. Simon Fraser University, Burnaby, BC.

Wolters, C. A. (2003). Understanding procrastination from a self-regulated learning perspective. *Journal of Educational Psychology*, *95*(1), 179–187. https://doi.org/10.1037/0022-0663.95.1.179

Wolters, C. A., & Benzon, M. B. (2013). Assessing and predicting college students' use of strategies for the self-regulation of motivation. *The Journal of Experimental Education*, *81*(2), 199–221, https://doi.org/10.1080/00220973.2012.699901

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

Zimmerman, B. J. (2011). Motivational sources and outcomes of self-regulated learning and performance. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Handbook of self-regulation of learning and performance* (pp. 49–64). New York: Routledge.