Regulating Self, Others' and Group Motivation in Online Collaboration

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We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

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Abstract

Collaboration is a sought-after competency in the 21st-century knowledge economy in which the value of collective ideas and innovations are emphasized. Educational institutions have a role to play in preparing graduates to work well in collaborative teams. However, collaborating with peers is often received with mixed feelings. Students raise concerns about group members' motivation and engagement, in anticipation of unsatisfactory social and learning outcomes. Facing motivation challenges in collaboration is a common occurrence, but limited research examines how students working in groups manage motivation challenges in that context.

The purpose of this multi-paper dissertation was to examine undergraduate students' regulatory responses to motivation challenges during online collaborations. Three empirical studies comprising this dissertation examined: the interrelated process involved in groups' regulation of the socio-emotional aspect of collaboration (Bakhtiar, Webster, & Hadwin), the tactics and strategies students enacted in response to salient motivation challenges (Bakhtiar, Hadwin, & Järvenoja, 2019), and the dynamic interplay between individual- and group-level regulation during motivationally challenging situations (Bakhtiar & Hadwin, 2019). The first study was a comparative case analysis between two groups with contrasting socio-emotional climates. Groups' self-report and observational data (collected before, during, and after a 90-minute collaboration) were examined in relation to the COPES-model of regulation to identify the similarities and differences between groups' prevailing conditions, operations, products, evaluations, and standards in regulation. In Study 2, group members' perceptions of motivation challenges that emerged during planning, early, and towards the end of a semester-long collaborative project were explored. Students' open descriptions of strategies adopted in response to their salient motivation challenges were qualitatively coded. Study 3 was another comparative

case analysis between two groups, who experienced high levels of motivation challenges during collaboration but achieved contrasting group perceptions of team learning productivity. The groups' use of self-, co-, and socially shared-regulation of motivation in three collaborative sessions were examined and contextualized using group members' self-reports and log data.

Findings across the three studies were discussed in terms of their contributions to the COPES scripts of regulating motivation in collaboration, to develop a catalogue of individual and social strategies for regulating motivation, and to identify adaptive forms of motivation regulation in collaboration. Overall, groups that experienced a more positive outcome regarding motivation regulation had group members who (a) were more prepared going into the task, (b) engaged in proactive forms of regulation, (c) more metacognitively attuned to individuals' and groups' diverse needs and challenges, (d) used diverse types of strategies, and (e) regulated each other in a positive and encouraging way. Future directions are discussed in terms of examining the metacognitive information students base on when regulating motivation individually, for others, and as a team, as well as designing tools and instructions to support motivation in collaboration.

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List of Original Manuscripts

This dissertation is based on the following manuscripts referred in the text by author and year:

1. Bakhtiar, A.,* Webster, E., & Hadwin, A.F. (2018). Regulation and socio-emotional interactions in a positive and negative group climate. *Metacognition and Learning*, 1-34.
2. Bakhtiar, A.,* Hadwin, A.F., & Järvenoja, H. (2019). Strategies for regulating salient motivation challenges in online collaboration. *Manuscript Submitted.*
3. Bakhtiar, A.,* & Hadwin, A.F. (2019). Dynamic interplay between regulatory modes of regulation during motivationally challenging episodes in collaboration. *Manuscript Submitted.*

Corresponding author (*) responsible for theoretical grounding, study design, and data analysis and interpretations.

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Chapter 1: Theoretical Framework

In the era of globally distributed knowledge and expertise, there is growing pressure for universities to prepare graduates to work well on collaborative teams in face-to-face and virtual settings (Chen, Donahue, & Klimoski, 2004; Volet, 2001). Ontario Public Services (2016) describe collaboration as the competency to (a) work with and learn from others, (b) contribute to the learning of others, and (c) develop collective intelligence through co-construction of ideas and perspectives. The benefits of collaborative learning for students are well documented; they include enhancing critical thinking, higher-order cognitive proficiencies, and motivation to learn through productive social interactions (Blumenfeld, Kempler, & Krajcik, 2006; Chen, Wang, Kirschner, & Tsai, 2018; Cook, 1991; Dolmans & Schmidt, 2000; Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009; Nokes-Malach, Richey, & Gadgil, 2015). On the other hand, research indicates that university students often express an aversion towards working in teams (e.g. Cavanagh, 2011; Hammond, Bithell, Jones, & Bidgood, 2010; Solomon & Globerson, 1989). This attitude could be due to collaboration being socially and motivationally demanding; it requires learners to coordinate efforts, negotiate understanding and perceptions, and maintain a productive socio-emotional climate. Even so, teachers tend to assume that when learners are placed into groups, provided with some tools, and asked to collaborate on a problem, motivation to engage will arise naturally (see Belland, Kim, & Hannafin, 2013; Dillenbourg, Järvelä, & Kirschner, 2009). Research findings challenge this notion.

Research indicates that motivation challenges prevail in group work. Collaborating students raise issues about uneven workload or social loafing, distrust towards peers, and frustration over differences in opinions, goals, and priorities (Crook, 2000; Finlay & Faulkner, 2005; Kelly & Fetherston, 2008; McCorkle, Reardon, Alexander, King, Harris, & Iyer, 1999;

Plaff & Huddleston, 2003; Rogat, Linnenbrink-Garcia, & DiDonato, 2013; Walker, 2001). Experiencing motivation challenges can interrupt students' cognitive processing of the learning materials and may lead to superficial learning and lower task performance (Barron, 2003; Blumenfeld et al., 2006; Grunschel, Schwinger, Steinmayr, & Fries, 2016). However, limited research examines students' responses to motivational challenges during collaboration and whether students are equipped with the regulatory skills needed for addressing challenges independently.

Self-regulated learning theorists posit that successful learners take responsibility in their own learning by engaging in deliberate and strategic planning, enacting, monitoring, and adaptation of several aspects of their learning including motivation (Boekaerts, 1996; Pintrich, 2002; Winne & Hadwin, 1998; Zimmerman, 2008). The complex individual-social interaction in collaboration requires multiple forms of regulation to be at work. Hadwin, Järvelä, and Miller (2011, 2018) suggest that to collaborate productively, learners must (a) regulate their own motivation (self-regulation), (b) temporarily support the motivation regulation of others (co-regulation), and (c) regulate the collective motivation of the team (socially shared regulation). As novice collaborators, university students are still developing the skills to regulate across the different forms of regulation. Students may need to be scaffolded and supported to develop regulatory competencies.

Moreover, technology is ubiquitous in 21st-century collaboration. Groups are beginning to leverage various online tools, including video or audio conferencing, synchronous and asynchronous online interactions, online workspace, and document or resource sharing (Curtis & Lawson, 2001; Dillenbourg & Fisher, 2007; Miller & Hadwin, 2015). Online technologies are essential for non-co-located groups, such as a collaboration between distance learners.

Researchers are also beginning to scaffold productive collaborative processes using technological tools when guiding students' collaboration (Dillenbourg & Fischer, 2007; Hadwin, Oshige, Gress, & Winne, 2010; Miller & Hadwin, 2015). Collaborative learning occurring in a technologically-scaffolded environment is referred to as computer-supported collaborative learning (CSCL; Dillenbourg & Fischer, 2007; Puntambekar, Erkens, & Hmelo-Silver, 2011). Within the environment, students interact with technological tools and communicate synchronously and asynchronously with team members. In general, CSCL environments provide numerous possibilities in terms of data collection, given that students' activities and communications are easily tracked and logged by the computer system (Dillenbourg & Fisher, 2007; Winne, Hadwin, & Gress, 2010).

Together, the purpose of this multi-paper dissertation was to examine individuals' and groups' regulatory responses to motivation challenges during online collaborations, conducted within a CSCL environment. This aim was achieved by examining the interrelated processes that unfolded during students' regulation (Study 1), the types of tactics and strategies demonstrated (Study 2), and the dynamic use of self-, co-, and shared-regulation in motivationally challenging situations (Study 3). This dissertation is presented in two parts. Part 1 provides an overview of the guiding theoretical framework and methodological approaches, and concludes with a discussion of the main findings, limitations, and implications for theory, research, and practice. In Part 2, the three empirical studies are presented in a manuscript format as appendices.

What is Collaborative Learning?

The term collaborative learning and cooperative learning are often used interchangeably, as the conceptual distinction between the two terms is usually not drawn. Recent work highlights the need for clarifying the difference between the two terms because collaboration may be viewed

as a more sophisticated form of social learning than cooperation (Baker, 2015; Ingram & Hathorn, 2004). Johnson and Johnson (1987) regard cooperative learning as involving students working in small groups where students contribute their knowledge and skills to achieve a group goal. On the other hand, Dillenbourg (1999) defines collaborative learning as "a situation in which two or more people attempt to learn something together" (p.1). The word *together* emphasizes a joint effort by group members who seek to encode, interpret, and recall information collectively rather than alongside one another (Barron, 2003; Järvelä & Häkkinen, 2002; Moreland, Argote, & Krishnan, 1996). Collaboration is "a coordinated synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of the problem" (Roschelle & Teasley, 1995, p. 70). Researchers argue that cooperation and collaboration can be distinguished on the dimension of mutuality, with cooperation being lower on joint activities than collaboration (Baker, 2015; Damon & Phelps, 1989; Ingram & Hathorn, 2004). Ingram and Hathorn add that collaboration is not about combining multiple learners' pieces of individual work; the product of true collaboration must represent a synthesis of ideas between all group members who actively interact with one another.

The number of group members required for a collaborative unit was also contested (see Hadwin et al., 2018). Dillenbourg's (1999) definition implies that two individuals suffice to be considered a collaborating group. However, Moreland (2010) suggests dyads cannot be construed as groups because dyads dissolve quicker, experience a different set of emotional connections, and do not necessarily share the same group dynamics and group processes as theorized in small group research. Theories relating to how a group functions (e.g., group cohesion or groupthink) cannot be accurately described in the dynamic between two individuals learning together. I concur with Moreland in discounting dyads as a collaborative unit. In this dissertation,

collaborative learning is defined as a situation in which three or more individuals coordinate effort, expertise, and activities to co-construct shared knowledge products and solutions, ideally, beyond what any member could accomplish alone.

Self and Social Regulation of Learning Model

Research on the regulation of learning examines learners' goal-directed and strategic actions in managing their cognition, behaviour, motivation, and emotions. Inherent in that work is the philosophical assumption that individuals are agentic beings who make their own choices and impose those choices on the tasks and situations (Bandura, 1997). Early models of regulated learning are grounded in the socio-cognitive perspective of learning. The models emphasize individual learners' regulatory processes *as influenced* by their internal metacognitive thoughts and beliefs, self-observed behavioural patterns, and external or environmental factors (see Zimmerman, 1989). In contrast, proponents of the socio-cultural perspective of learning emphasize a more dynamic interplay between the (a) internal metacognitive thoughts and behaviours and (b) external contexts, influences, metacognition, and behaviours (Hadwin & Oshige, 2011). In other words, the interactions between individuals and the social context are reciprocal; an individual's position is not exclusive to the receiving end of external forces. Social perspectives of learning give rise to social forms of regulation, namely co-regulation and socially-shared regulation (McCaslin, 2009; Hadwin et al., 2011). Hadwin and colleagues (Hadwin et al., 2011, 2018; Järvelä & Hadwin, 2013) theorize regulation of cognition, behaviour, motivation, and emotions exists in social forms regulation and most notably when multiple individuals come together to work on a single problem or task. Thus, during collaboration, learners may make use of the three forms or modes of regulation: self-regulation, socially shared regulation, and co-regulation.

Self-regulation of learning (SRL) refers to an individual learner's deliberate and strategic engagement in metacognitive planning, task enactment, reflection, and adaptation in learning tasks (Hadwin et al., 2018; Winne & Hadwin, 1998; Zimmerman, 2008). During that process, an individual exercises metacognitive control to fine-tune regulatory actions or reactions to take control of their cognition, behaviour, motivation, and emotions. In contrast, *socially shared regulation* (SSRL) refers to groups' strategic engagement in negotiated planning, task enactment, reflection, and adaptation in a shared learning task, during which groups jointly take control of their cognitive, behavioural, motivational, and emotional conditions or states. Shared regulation emerges through a series of transactive exchanges among group members where group members negotiate their ideas, thoughts, and perceptions. Shared regulation cannot be reduced to aggregated individual processes; instead, the regulating agents operate as one social entity targeting regulation of the group versus the individual (Hadwin et al., 2018; Volet, Vauras, & Salonen, 2009).

Co-regulation refers to affordances and constraints, stimulating appropriation of strategic planning, enactment, reflection, and adaptation. Co-regulation functions as the dynamic metacognitive processes through which self- and shared-regulation of cognition, behaviour, motivation, and emotions are transitionally and flexibly guided or compensated. Co-regulation is not limited to a "more-able" individual guiding a "less-able" individual. Instead, co-regulation can be activated by a single individual, multiple individuals, tools, or the physical task aimed to temporarily support individuals or the group. Some examples of co-regulation that support productive regulation include a group of peers helping an individual to correct his or her understanding of the task purpose, or a mobile application reminding the group of the task deadline. Co-regulation may also thwart productive regulation, such as when a group provides

inaccurate task information to a member who originally had a better understanding of the task, or overly frequent mobile reminders that disturb members' attention on the task. With the addition of co-regulation in Hadwin et al.'s (2011, 2018) model, the person-in-context perspective is foregrounded, highlighting the dynamic interactions between individuals and the social context. This perspective does not view individuals as having diminished agency over their actions but acknowledges that interactions in the social sphere shape and influence individuals' agency, beliefs, regulatory processes, and products.

Figure 1 illustrates the mediating role co-regulation plays (Bakhtiar & Hadwin, forthcoming). While co-regulation supports or thwarts self-regulation and socially shared regulation, activities that occur during self- and shared-regulation may also generate cues which potentially shape and reshape co-regulation. For example, a self-regulating learner may prompt co-regulation by requesting help, and the learner's responses (upon being co-regulated) may continue to shape future co-regulation demonstrated by others. Similarly, a group's shared regulation may signal the need for co-regulation, such as when the group's attempt at completing the task is judged by some members as lacking substance.

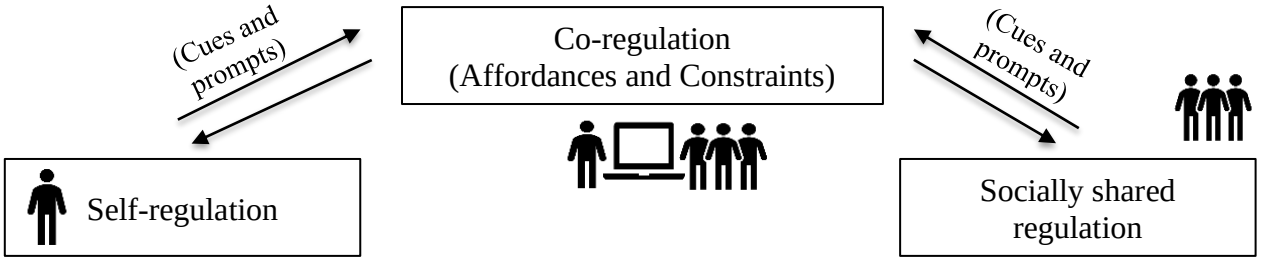

Figure 1. The dynamic interaction of self- and socially shared-regulation as temporarily mediated by co-regulation. Both self and groups can provide cues for and prompt co-regulation to occur.

The boundaries between co-regulation and socially shared regulation can sometimes be unclear. Take this scenario as an example:

> *A: I think we should backtrack. Everyone seemed off-track and starting to put low-quality work.*
> *B: Backtrack to the first draft?*
> *A: Right.*
> *C: Couldn't we just scrap what we have altogether and start a new topic? Let's search for a more exciting topic.*
> *A: Yeah… that may work, too.*
> *C: OK. Let's do that!*
> *B: OK.*

The first line in this scenario is a co-regulatory prompt. Person A posed a piece of metacognitive information about the task not progressing well. The conversations that followed belong to an episode of socially shared-regulation because individuals were negotiating a shared plan. The negotiation was, however, shallow because Person A was quick to abandon her initial idea and the group adopted Person C's idea. If group members were to directly follow Person A's instruction to backtrack without engaging in any negotiations, this alternative scenario could be considered an episode of co-regulation. Hadwin et al. (2018) described that, because co-regulation is activated when necessary by and for whom it is appropriate, the collective uptake of a co-regulatory prompt may blur the boundaries between co- and shared-regulation and influence how these two regulation modes are coded in conversations.

Hadwin et al.'s (2011, 2018) model of regulation implies that, regulating motivation in collaboration involves individual learners not only regulating their own motivation, but also playing a role in recognizing and temporarily guiding or supporting the motivation of team members and the collective group, and the group jointly taking control of the team's collective motivation. The focus on motivation is distinct from regulation targeting the cognitive or task content group members activated on their own, for others, or together as a team. Cognitive or task

content regulation involve strategic planning, monitoring, and adapting geared towards taking control of the cognitive aspect of the task, including regulation of memory, learning, problem solving, understanding, task comprehension, and awareness of task features (Järvelä et al., 2016). Regardless of the differences in the target of regulation, Hadwin et al.'s model is an extension of Winne and Hadwin (1998) self-regulated learning model which outlines the macro and micro processes of regulation. In collaborative contexts, those processes are evident in each mode of regulation (self-, co-, and shared) and they dynamically interact across the different modes. Together, Hadwin et al.'s model and the foundational macro and micro-processes outlined in Winne and Hadwin SRL model are frameworks used for conceptualizing motivation regulation in this dissertation.

Winne and Hadwin model of self-regulated learning. At a macro-level, Winne and Hadwin (1998) describe SRL as unfolding over four loosely sequenced and recursively linked feedback loops. In Phase 1 (Task Perceptions), learners construct an internal representation of a learning task. Based on this task perception, learners generate goals and plans for meeting the task demands in Phase 2 (Goal Setting). In Phase 3 (Task Enactment), task enactment ensues drawing on a range of strategies and tactics. Finally, in Phase 4 (Large-scale adaptation), learners adapt task understanding, goals and plans, and strategies and tactics within and across tasks. Large-scale adaptations are forward-reaching and may include changing individual beliefs and attitudes for more successful learning in the future. The last phase is optional if no adaptation is needed. Originally introduced in Winne (1997), the micro-level mechanism guiding transitions across all phases is the COPES (conditions, operations, products, evaluations, and standards) cognitive architecture, which is catalyzed by metacognitive monitoring and evaluating. The COPES architecture recognizes motivation as being relevant in all regulatory phases and as having dual

roles: (a) as a *condition* that influences regulatory actions (e.g., a high level of motivation influencing task choices), and (b) a *product* of regulatory actions (e.g., experiencing an increased level of motivation after successfully working on a task).

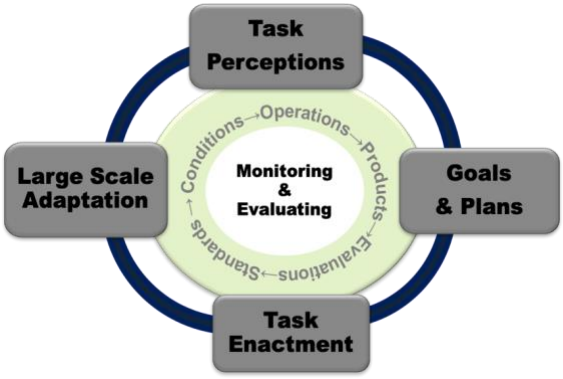

Figure 2: Winne and Hadwin (1998) model of self-regulation. Regulation as unfolding over four loosely sequenced macro phases (greyed boxes) and fueled by metacognitive COPES processes.

Per the COPES model, internal and external *conditions* provide context for engagement in each regulatory phase. Internal conditions comprise factors internal to the learner, such as domain knowledge, epistemic beliefs, motivation, emotions, and personal histories. In contrast, external conditions refer to factors that are external to the learner, such as tasks features and available technological tools. When considering groups as a social system, conditions can be divided into (a) self, (b) group, and (c) task and context conditions (Miller, 2015; Hadwin et al., 2018). *Self conditions* (my perspectives about me) include personal characteristics, beliefs, and histories individuals bring to the task. In contrast, group conditions emerge when group members interact with one another and create new experiences together. *Group conditions* (my perspective about us) are individual group members' knowledge and beliefs about the group's collective characteristics and abilities, and shared norms and histories. The individual perspective of the group conditions is emphasized to acknowledge that group conditions do not imply that everyone

in the group holds the same conditions. How each group member interprets and stores information about "group condition" may differ. In other words, group conditions are interpreted and stored in the minds of individuals. The more similar group members' interpretation of their shared experiences, the more there are shared group conditions. When the interpretations differ amongst group members, then the group conditions are not shared. Lastly, *task and context* conditions (my perspectives about the situation) include "affordances and constraints created by others and the larger social context, task context, and physical context" (Miller, 2015, p. 11), such as the presence of specific individuals (e.g. instructors) or tools for support. In collaboration, all three conditions dynamically intertwine, producing complex systems of interactions and contexts for regulation.

The letter O in COPES refers to cognitive *operations* learners use to process and manipulate information. Winne (1985) proposed a heuristic set describing primitive cognitive operations, which include searching, monitoring, assembling, rehearsing, and translating (SMART). Motivational processing is argued to use the same set of primitive cognitive operations, where the processing is applied to motivation-related information as opposed to cognitive-based information related to a learning domain (Winne & Marx, 1989). Operating on motivation-related information signifies that motivation is the object of regulation. The coupling of two or more SMART operations creates a "script" of a learner's regulation. For example, an individual (1) searches for information about his or her prior experiences and achievements related to the task at hand. The individual then (2) assembles pieces of those historical experiences to gain an understanding of what the information means in terms of his or her competency and current task motivation. At the group level, group members concurrently operate their own cognitive machinery and may model or suggest operation(s) a group member can adopt

during group interactions. For example, a group member may suggest for other members to think about and articulate their concerns while the group together tries to construct their next plan. The results of operations create *products* in each regulation phase, and products can manifest in cognition, behaviour, motivation, emotions, as well as observed physical outcomes. Finally, learners construct judgment or *evaluations* of the products by comparing them to specified or perceived *standards*.

To piece all COPES elements together, consider an example of a regulatory event which involves Anna, who was faced with a novel collaborative task. Anna considered her internal and external conditions and made a judgment (evaluation) about her lack of experience with the task. She then looked at the available class handouts (conditions) and searched for relevant information and assembled that information (operations) to help her get a sense on how to move forward. Her renewed sense of knowing (product) was evaluated against how much information she considered enough to begin the task (standard).

Also consider an example of a group who perceived that they had planned well in the past (shared group condition) and proactively decided to engage in planning and negotiate a shared understanding of the current task. The group did this by collectively gathering information and articulating one another's thoughts about the task demands (operations). The product of that regulation was a shared or negotiated goal, which later served as a standard for evaluating whether the group has progressed well in the task. Within this shared regulation, group members' evaluation of their product(s) may be similar or different and may influence the group's future iterations of shared regulation. Overall, the COPES model of regulation acknowledges that I, We, and You experiences in collaboration stretch across self-, co-, and shared-regulation rather than

being contained within them. For example, any change in my motivation would influence the COPES profile of my own, my group members, and the group.

Table 1. *COPES of Self- and Shared-Regulation of Motivation*

	Self-regulation of motivation	**Shared regulation of motivation**
Conditions	Internal **Self:** *My motivation, goals, values, beliefs, domain knowledge, dispositions, and histories.* External **Group:** *My interpretation of the group's collective motivation, goals, values, beliefs, knowledge, and histories.* **Task and context:** *Other group members' personal motivation, goals, values, beliefs, characteristics, knowledge, and personal histories; instructor's support and directions; available tools and resources; environmental distractions.*	Internal **Group:** *Our shared understanding of our experiences, motivation, goals, values, and beliefs; established group norms and dynamics; shared task knowledge and histories.* External **Task and context:** *Other group members' personal motivation, goals, values, beliefs, characteristics, knowledge, and histories; instructor's support and directions; available tools and resources; environmental distractions.*
Operations	My cognitive operations.	Group members' own cognitive operations working alongside and influencing one another.
Products	My orchestrated strategies; My motivation and its cognitive, behavioural, and affective manifestations.	Our orchestrated strategies; Our motivation and its cognitive, behavioural, and affective manifestations.
Evaluations	My judgment about my motivation and its related outcomes and consequences.	Our shared or negotiated judgment about our motivation and its related outcomes and consequences[1].
Standards	My accepted levels of motivation and engagement.	Our group accepted levels of motivation and engagement.

Note: Co-regulation transitionally and temporarily supports or thwarts self- and shared-regulation, and so is not represented in the table.

[1] This would be a shared judgment when group members discussed their evaluations of the shared products and arrived at the same conclusion. Groups do not necessarily engage in such discussion, which means that it is possible for group members to have dissimilar evaluations of the products and remain at that evaluations.

Why COPES? The COPES-based perspective of regulation (Hadwin et al., 2018; Winne, 1997; Winne & Hadwin, 1998) is used as a theoretical foundation of this dissertation for three reasons. First, the model provides a detailed account of how regulation unfolds as a situated and social phenomenon, allowing researchers to examine the dynamic interaction between individuals and context. Second, the COPES scripts can be examined at different grain size levels, within and across tasks or episodes of regulation. Third, the model recognizes motivation as conditions and products of regulation (Winne & Hadwin, 2008) as well as information that learners may target when regulating (Winne & Marx, 1989). Together, this allows researchers to identify when and where motivation is involved and how it is regulated. However, within the model, motivation is broadly discussed; what constitutes "motivational" information is yet to be specified. Below, informed by extensive theories on motivation, I present my conceptualization of motivation and later situate the construct within the COPES-based perspective of regulation.

Motivation and Its Sources

A wealth of motivational theories offers different perspectives about motivation and its related processes. Broadly, motivation to learn is defined as the willingness to engage in learning processes and tasks (Stipek, 1996). Beyond the dichotomy of willing and not willing, researchers associated certain types of qualities as markers of motivation. Motivation can have a trait quality such as by describing a student as generally *oriented* towards challenging tasks, and it can also have a state quality such as observed in learners' episodic task engagement, beliefs, and emotions (Graham & Weiner, 1996; Pintrich & Schunk, 2002; Winne & Marx, 1989). Motivation involves complex psychological processes where an individual's subjective beliefs and perceptions influence their choices, effort, and persistence (Eccles & Wigfield, 2002; Stipek, 1996). Drawing

from multiple theories, four psychological processes influencing motivation can be highlighted: (a) goals—What do I want to achieve?, (b) values—Why is this important to me?, (c) competency beliefs—Can I do this?, and (d) affect—How do I feel about this? (Anderman & Wolters, 2006; Boekaerts, 1996, 2002; Eccles & Wigfield, 2002; Keller, 2008; Linnenbrink-Garcia & Patall, 2016; Murphy & Alexander, 2000; Pekrun, Goetz, Titz, & Perry, 2002). In COPES perspectives, these four sources are information on which learners cognitively operate.

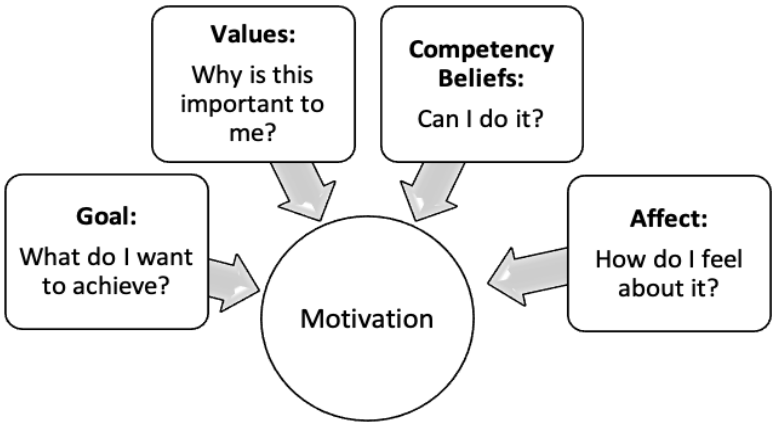

Figure 3. Four broad psychological processes that influence motivation.

Goals. Motivated learners can be assumed to be pursuing some types of goals. Research on goals has long focused on two goal orientations: mastery- or performance-oriented goals (e.g., Ames, 1992). Mastery goals concern extending knowledge and gaining competence, whereas performance goals concern receiving favourable judgments about one's seeming or actual competence. From a regulated learning perspective, goal orientations are dominant beliefs that inform specific choices students pursue in the learning task (e.g., Wolters, Shirley, & Pintrich, 1996). For example, in collaborative tasks, mastery-oriented group members (a) are more likely to persist when faced with challenging tasks (Mullins, Deiglmayr, & Spada 2013), and (b) engage in more complex information processing when solving the task (Sins, Van Joolingen, Savelsberg,

& van Hout-Wolters, 2008). In contrast, performance-oriented group members tend to (a) opt for short-cuts, (b) proceed through the collaborative learning task as fast as possible, (c) use trial-and-error tactics for solving questions, and (d) engage in self-handicapping when perceiving their ability as insufficient to bring success to the team (Mullins et al., 2013).

Learners' goals in collaboration often extend beyond academic pursuits (Hijzen, Boekaerts, & Vedder, 2007; Wosnitza & Volet, 2009). Learners can pursue social goals, such as intending to assist others and contributing to the development of a positive group atmosphere. Wosnitza and Volet (2009) extend the conceptualization of goal orientation to account for the social nature of collaboration: individuals in teams may pursue performance, mastery, and/or well-being-oriented goals that are either directed to benefit oneself, others, or the group. The researchers found that self-directed goals were common when the collaborative assignment contributed to individuals' grade in the course. However, in an open-ended collaboration where grades were not at stake, socially-directed goals were found to be important in predicting performance (see also Tempelaar, Wosnitza, Volet, Rienties, Giesbers, & Gijselaers, 2013).

A self-regulated learning perspective emphasizes the dynamic properties of goals that are manipulated as a response to a specific learning situation (i.e., goal setting-focused rather than goal orientation-focused). Kruglanski, Shah, Fishbach, Friedman, Chun, and Sleeth-Keppler (2002) describe these dynamic properties in their theory of goal systems. Goals exist in a hierarchical network where goals may be connected to their corresponding means and alternative goals. The likelihood of choosing a goal depends on the contextual factors that trigger the activation of specific goals and means. A goal that is strongly connected to one specific mean is more likely pursued over a goal that activated several loose means. When regulating during any learning episode, individuals weigh these possible goal pathways, selecting a goal perceived to

yield the best return in that moment. Fitzsimons, Finkel, and van Dellen (2015) extended the theory by arguing that goal systems can be shared among two or more interdependent individuals. For instance, when one member adopts to carry out specific approaches to complete the task, this person's goal may influence the goals other members adopt. Conflicting goals can often be a serious challenge in a collaborative task (Järvelä & Järvenoja, 2011).

Values. Values refer to "incentives or reasons for doing the activity" (Eccles & Wigfield, 2002, p. 110). Individuals' perceptions of task value may change as learners dynamically interact with the task at hand. Eccles and Wigfield (2002) distinguished four types of values individuals draw from when making choices: (a) *intrinsic*—the mere enjoyment and pleasure an individual gets when performing the task; (b) *utility*—perceived benefit for immediate or future goals; (c) *attainment or self-worth*—personal importance for successfully attaining the goal; and (d) *cost*—the salient negative cost for pursuing the goal, such as anxiety or time.

Under the self-determination theory of motivation, Deci and Ryan (1985) categorized values as either intrinsic (pursuing a task because of the inherent satisfaction that engaging in the activity provides) or extrinsic (pursuing a task because of specific external outcomes such as praise or grade). Extrinsic value is further theorized to exist on a continuum that differs in the degree of autonomy or control. From the least autonomous form, individuals carry out an activity because (a) of external pressure that makes them feel obligated or ashamed if the activity is not carried out (introjected), (b) individuals identify with the societal/external values placed on the activity and perceive those values to be important (identified), or (c) that the external values related to the activity have been fully integrated into the individual's sense of identity (integrated).

Research indicates that having intrinsic values towards learning is associated with adaptive outcomes, such as better learning adjustments and higher quality of cognitive engagement (e.g., Eccles & Wigfield, 2002; Otis, Grouzet, & Pelletier, 2005; Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009). Otis et al. (2005) found that students with a stable extrinsic value towards learning demonstrated maladaptive outcomes in the form of poor academic success and school dropout. However, during specific learning activities, students often need to regulate external incentives or values, sometimes, at the service of completing the task. In some cases, students purposely think of an external incentive to get them started, particularly when the task is perceived to be mundane (Wolters, 1998, 2003).

One of a limited number of studies examining intrinsic and extrinsic motivation in collaborative learning demonstrates different patterns of participation between intrinsically and extrinsically motivated collaborators (Rienties et al., 2009). Through a social network analysis of group members' patterns of interactions, highly intrinsic group members were seen to be central in the social network, had more ties to other group members, and contributed more towards the task- or knowledge-related discourse. In contrast, highly extrinsic group members showed no association to a particular position in the social network and were less active in non-task or social-related discourse. This finding demonstrates how group members' intrinsic and extrinsic values towards learning can influence the social dynamics during collaboration.

Competency beliefs. Research that examined students' internal question about whether they can do a task developed a range of theories, including self-efficacy, self-attribution, and self-worth (Broussard & Garrison, 2004). These theories were influenced by the socio-cognitive perspective of learning. A key concept within that perspective is the notion of agency, which views individuals as self-organizing beings with the ability to exert influence over their own

functioning and course of events (Bandura, 1997). In Bandura's work on the agency concept (e.g., Bandura, 2001, 2006), three relevant types of agency can be highlighted: (a) personal—a person's direct performance to achieve desired outcomes, (b) proxy—relying on others to act on one's behalf to obtain desired outcomes, and (c) collective—the joint and coordinated effort in obtaining desired group outcomes (Bandura, 2001). These agency beliefs in the context of research are often examined as efficacy beliefs, demonstrating the extent to which learners believe in their or others' agentic role in influencing specific learning outcomes.

Self-efficacy is defined as an individual's belief that he or she can perform a task or achieve a specific goal successfully (Bandura, 1997). Extensive research on the construct suggests that students' self-efficacy can significantly influence their academic performance, and highly efficacious students tend to show a higher level of task persistence and effort (e.g., Schunk, 1991; Pajares & Miller, 1994). Several factors can influence one' self-efficacy: (a) mastery experience—previous attainment in related tasks, (b) vicarious experience—witnessing other people's experience with related tasks, (c) verbal persuasion—receiving evaluative feedback and encouragement from external others, and (d) emotional and physiological state—psychological and physiological reactions towards the task (Bandalos, Yates, & Thorndike-Christ, 1995; Bandura, 1997). Although mastery experience was found be the most influential factor (Usher & Pajares, 2006), Bandura suggests that it depends on how greatly an individual depends on a specific influence over others. In collaboration, for instance, a group member's self-efficacy may be more dependent on teammates' verbal feedback compared to the group's previous accomplishments.

Collective efficacy refers to a group's shared belief regarding their team's capability to perform a task and is positively correlated with measures of group performance (Bandura, 1997;

Karau & Williams, 1993; Wang & Lin, 2007). Individual members' self-efficacy has been shown to significantly predict their team's collective efficacy (Wang & Lin, 2007). However, there seems to be a missing link between self and collective efficacy, particularly the metacognitive processes that lead individuals to feel efficacious in their team's ability. Bandura (2001) introduced the concept of proxy agency or proxy efficacy, which reflects one's belief in others' ability in helping to bring about desired outcomes. Proxy efficacy is not widely researched, but it is possible that the link between self- and collective efficacy is mediated by proxy efficacy. My colleagues and I found that higher proxy efficacy was associated with lower levels of task participation in the first round of an online collaboration (Bakhtiar, Milford, & Hadwin, in prep). This link was, however, not observed in the second round of collaboration as group members gained awareness of the online tool's availability to track their contributions. Individuals were more likely to loaf when they strongly believed that other group members could do the task (high proxy efficacy) and when it was unknown to them that their participation was being recorded. Overall, findings suggest that the psychological processes between believing in *others'* capability and believing in *my* capability may be different, and their effects need to be separated in research.

Affect. Emotional reactions toward a task or experienced affective states can either facilitate or withdraw engagement in a task (Ainley, Hidi, & Berndorff, 2002; Ayoko, Konrad, & Boyle, 2012; Linnenbrink-Garcia, Rogat & Koskey, 2011; Pekrun et al., 2002). Miele and Scholer's (2018) model of meta-motivational regulation recognizes emotions as bottom-up indicators of a need to regulate motivation. Despite its role, affect has not been well fused in motivation research and theories (Meyer & Turner, 2006).

Pekrun et al. (2002) suggest students' emotional reactions in academic settings are connected to either the learning activities or outcomes. One type of emotion that has been

extensively researched in relation to students' learning activities is interest. Interest reflects a sense of enjoyment combined with several physiological and expressive reactions including increased attention, concentration, and vocal speed (Ainley, 2006; Hidi & Ainley, 2008; Silvia, 2008). Interest promotes learning exploration and influences learners' task choices, persistence, and cognitive engagement (Silvia, 2008). While interest may be viewed as a stable individual characteristic, situationally, interest can also be instigated and supported by contextual factors such as by introducing novel task features (Hidi & Ainley, 2008). Research found that students may deliberately use learning strategies to seek interesting aspects of a task to increase their motivation towards the task (Sansone, Weir, Harpster, & Morgan, 1992; Wolters, 2003).

Examples of emotions related to learning outcomes may include anger or frustration when the experienced outcomes are unexpected or not meeting the students' expectations (e.g., Capdeferro & Romero, 2012). Attribution theorists demonstrate that learners have the tendency to explain unexpected outcomes as having caused by uncontrollable factors, such as teacher's unfairness or not having the disposition to be good at the task (Mezulis, Abramson, Hyde, & Hankin, 2004; Weiner, 2000). Such attributions can lower task motivation and engagement as individuals are less likely to take personal responsibility in changing their outcomes or course of actions (Weiner, 2000).

An important source of affective experience in collaboration is the group's socio-emotional interactions or how group members interact at a more personal level (Ayoko et al., 2012; Järvenoja & Järvelä, 2013, Linnenbrink-Garcia et al., 2011; Näykki, Järvelä, Kirschner & Järvenoja, 2014). The affective experience can be derived from personality differences and the social dynamics between group members (Blumenfeld et al., 2006; Järvenoja & Järvelä, 2009; Van den Bossche, Gijselaers, Segers, & Kirschner, 2006; Volet & Mansfield, 2006). A highly

negative socio-emotional experience may overwhelm some group members, leading them to withdraw from the group work altogether (e.g., Näykki et al., 2014). In some respects, intense socioemotional conflicts affecting group members' motivation to collaborate must be regulated for the task to progress productively.

Summary. In sum, motivation is a multidimensional construct referring to both stable characteristics and a process whereby a level of willingness is continuously constructed and reconstructed to maintain engagement in a task. As offered in various theories, an individual's motivation is influenced by their goals (What do I want to achieve?), perceptions of task values (Why is this important to me?), competency beliefs (Can I do it?), and affective reactions towards the task (How do I feel about it?). Incorporating these four sources in the conceptualization of motivation allows researchers to consider both the cognitive and affective dimensions of motivation. Today, motivation researchers are beginning to emphasize the theoretical interdependence of motivation, emotions, and cognition as process-based approaches in the study of motivation increases (Boekaerts & Corno, 2005; Järvelä, 2001; Keller, 2008; Linnenbrink-Garcia & Pattall, 2016; Schoor & Bannert, 2011).

Behavioural, Cognitive, and Affective Manifestation of Motivation

Motivation as a product (and later condition) of regulation may manifest in learners' cognitive, behavioural, and affective engagement (Martin, 2007; Miele & Scholer, 2018; Sinatra, Heddy, & Lombardi, 2015). Table 2 below outlines three types of manifestations of motivation (a) behavioural—individuals' behaviour in the task, (b) cognitive—individuals' thoughts and beliefs about themselves and the task, and (c) affective—individuals' emotional reactions and experiences in the task. Placing the specific manifestations into categories, however, can create a "boxology" problem because one item may not necessarily fit into one exclusive label. For

instance, effort and initiative seemed to portray a behavioural-like action but may also involve strategic planning that is cognitively driven. This categorization issue has been discussed in the engagement literature, in which researchers conceptualize engagement as involving cognitive, behavioural, and emotional aspects (Sinatra et al., 2015).

Nonetheless, such categorization can be useful for understanding learners' strategic actions at a finer-grain, especially when those actions are studied under the SRL framework where small- and large-scale adaptations are emphasized (e.g., Boekaerts, Pintrich, & Zeidner, 2000; Winne & Hadwin, 2008). Importantly, because regulation is activated based on perceptions, knowing the behavioural, cognitive, and affective cues that learners pick up on about theirs, others' or the group's motivation may help researchers to further contextualize the basis of the learners' regulation (see also Martin, 2008). Motivation regulation is not merely about the motivation itself, but it is about learners' perceptions of and responses to the behavioural, cognitive, and/or affective cues related to their motivation.

Table 2. *Behavioural, Cognitive, and Affective Manifestations of Motivation*

	Behavioural	**Cognitive**	**Affective**
Definition	Individuals' behaviour and actions in the task	Individuals' thoughts and beliefs about themselves and the task	Individuals' emotional reactions and experiences in the task
Examples of Indicators	● Persistence ● Verbal expressions ● Task choices ● Body languages ● Efforts exerted	● Efficacy beliefs ● Goals ● Outcome expectations ● Attributions ● Utility beliefs	● Interest ● Emotions (anxiety, sadness, fatigue, bored, anger) ● Flow

Motivation as Situated Within the COPES Model

Theories of motivation and regulation of learning, together, informed this dissertation research. Figure 4 illustrates how motivation is situated in Winne (1997) COPES-based model of

regulation to depict the process of regulating motivation in collaborative contexts. Explanations of specific components in the figure follows.

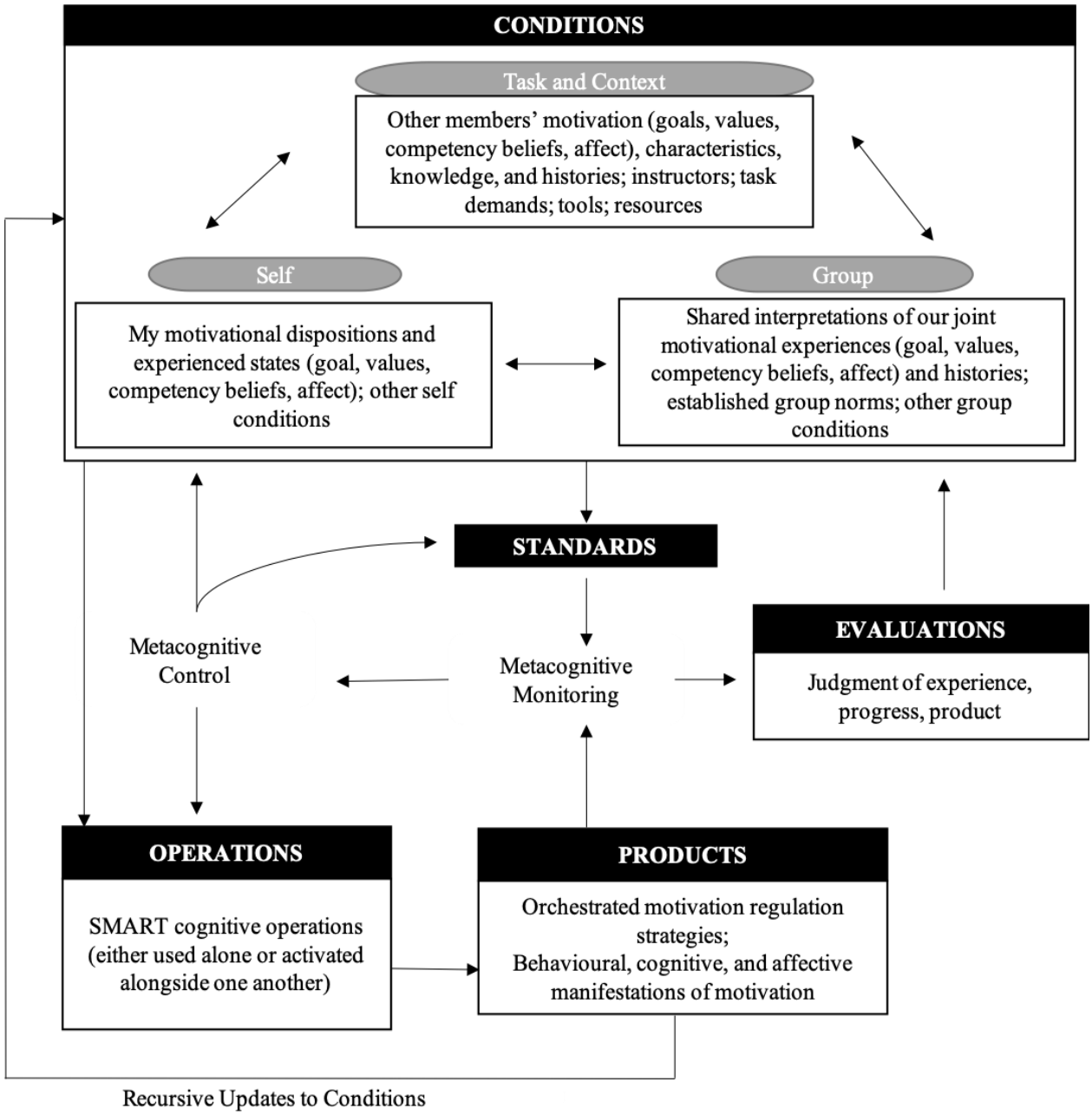

Figure 4. COPES processes of motivation regulation in collaboration.

From a regulated learning perspective, regulation is activated in response to anticipated and experienced challenges (Butler & Winne, 1995; Hadwin et al., 2018). Perceptions of

challenges are conditions that trigger regulatory actions. Challenges can be realized in two ways: (a) students may be directly told about the discrepancies between current conditions and desired standards (co-regulation), or (b) through *self*-initiated metacognitive monitoring of conditions and evaluating something was unsatisfactory. The conditions that are metacognitively monitored can be internal or external to the initiator of the regulatory process. In a system of collaborative activities, three types of conditions (i.e., self, group, and task and context conditions) interact to create a complex context for motivation regulation. When individuals self-regulate, their *self* conditions are internal, and the *group* and *task and context* conditions are external to the individuals. When a group engages in a shared regulation, conditions multiple group members hold in common are the group's internal conditions. A group's external conditions include the task and context conditions, such as availability of instructor help. Specific to motivation regulation, conditions that activate regulation are motivational conditions that disrupt the learners' willingness to engage in the task. In that regard, motivation regulation can be defined as purposeful and strategic actions to either initiate, sustain, or supplement motivation needed to complete, replace, or disengage from a task (Järvenoja et al., 2018; Miele & Scholer, 2018; Winne & Hadwin, 2008; Wolters, 2003).

When learners judge the monitored discrepancies as warranting further actions, a set of strategic actions may be activated. At this juncture, learners cognitively operate on various motivational information individually, with the help of others, or together in a team. The products of those operations can be observed in the orchestrated tactics and strategies applied to regulate motivation. Research has documented several types of strategies learners used to regulate motivation, including:

i. *Self-consequating*—rewarding efforts for completing a goal

ii. *Environmental restructuring*—(re)arranging the environment to increase the likelihood of task execution
iii. *Mastery and performance goal self-talk*—emphasizing reasons to pursue a goal
iv. I*nterest enhancement*—increasing situational interest and task value
v. *Self-handicapping*—avoiding responsibility by manufacturing obstructions to make failures look inevitable
vi. *Efficacy management*—maintaining favourable perceptions of competence and
vii. *Emotion regulation*—attaining emotional states that are conducive for effort expenditure and task engagement.

However, research on the types of strategies used by teams is limited. Järvelä, Järvenoja, and Veermans (2008) revised the descriptions of five individual strategies to reflect group socially shared enactment of strategies. The strategies included: (a) social reinforcing, (b) task/environmental structuring, (c) socially shared goal-oriented talk, (d) interest enhancement, (d) handicapping of group functioning, and (e) efficacy management (see also Järvelä & Järvenoja, 2011). Through coding of two groups' video data, the researchers found that groups used *social reinforcement* strategy most frequently compared to the other types. Social reinforcement strategy was defined as "students' identification and administration of reinforcements influencing their motivation and their joint behaviors," (p. 127). Viewing strategies as embedded within the COPES perspective emphasizes the need to contextualize strategies as addressing specific situational demands, rather than treating strategies as merely a set of actions learners performed.

Products of operations can also include a renewed sense of motivation manifested behaviourally (e.g., adapted engagement), cognitively (e.g., adapted self-efficacy), and affectively (e.g., enjoyment). If the strategy was not effective, learners' motivational conditions might not change. Learners evaluate the products of their regulation to know whether they have achieved the goals and standards they hold. Evaluation is performed against a series of goals and standards (e.g., a goal I have about my progress and a standard I hold about the amount of work others

should put) to determine whether there is a need to regulate further. If there is a perceived need, the cycle continues until the process is terminated by the learners.

The application of the COPES model in motivation regulation research is limited because the model has been portrayed as a cognitive information processing model of SRL (e.g., Greene & Azevedo, 2007), leading to an inaccurate observation that the model discounts motivation. However, it is well understood across many motivation theories that perceptions play a role in determining one's motivation. Motivation is an interpretation of situations and psychological reactions that involves questioning one's goal (What do I want to achieve?), values perceived about a task or an activity (Why is this important to me?), competency beliefs (Can I do this?), and affect (How do I feel about this?). These interpretations are cognitive and metacognitive questions which are modelled in Winne's (1997) COPES architecture (see also Linnenbrink & Pintrich, 2002). The COPES model is the only regulated learning model that has been extended to consider other social forms of regulation (see Hadwin et al., 2018). This dissertation research contributed to the lack of research that uses the COPES model in the context of collaborative learning, by empirically examining groups' and individual members' regulatory actions and responses to motivation challenges in accordance to the COPES script.

Chapter 2: Methodological Considerations

Researching motivation regulation in collaboration requires researchers to move beyond traditional approaches focusing on individual outcomes. New measures and analytical methods are needed to examine regulation as social, involving group members' dynamic negotiations of motivational goals and standards. Several overlapping methodological challenges are relevant in this dissertation research: (a) operationalizing motivation as a multi-dimensional process, (b) capturing regulation as social and cyclical, (c) using and balancing multiple data sources, and (d) selecting an appropriate grain size level of regulation. This chapter concludes with a description of how computer-supported collaborative learning (CSCL) environment provides a suitable data collection platform and a solution for addressing the methodological challenges.

Challenge 1: Operationalizing Motivation as A Multi-Dimensional Process

Clear definition and operationalization of constructs, anchoring to a theoretical framework, is a fundamental step towards building a sound research design. Ill-defined constructs can result in obscure measures, data misinterpretations, and poor integration with theory. Operationalizing motivation in regulation research concerns two aspects: (a) dimensionality—treating motivation as multi-dimensional rather than one-dimensional construct, and (b) stability—treating motivation as a dynamic state rather than as a stable aptitude.

Measures of motivation are often criticized for arbitrarily including and excluding variables considered to be "motivational" (Bong, 1996). Some measures comprise items tapping into one motivation process only, due to the measures' grounding in a specific motivation theory. When the measures are used in studies, researchers often do not provide a clear rationale for reducing motivation to the chosen construct, other than selecting based on the popular conceptualization of motivation. However, several instruments have been developed to measure

motivation as a multi-dimensional construct informed by research on self-regulated learning (examples in Table 3). Across all instruments, motivation is operationally defined as encompassing some dimensions of goals, values, competency beliefs, and affect. The discrete constructs measuring those components differ slightly. For example, in terms of affect, LASSI measured anxiety only but OMQ measured the discrete types of emotions. One issue of multi-dimensional measures of motivation is that they can be lengthy. For instance, Schoor and Bannert's (2011) Current Motivation Scale included eight factors and a total of 51 items for which learners must respond in a given moment. The measures may need to be modified to capture students' momentary perceptions of motivation during learning. Nonetheless, the dimensions that each measure covers provide a useful reference for the types of motivational processes to examine in this dissertation research.

Table 3. *Comparisons of Individual Motivation Measures*

Scale	Dimension of Motivation	Stability	Context for Assessment
Current Motivation Scale[a]	Self-efficacy (for task and computers), Instrumentality beliefs, Attainment value, Interest, Intrinsic task value, Utility value, Anxiety	State	Measured before, during, and after learning
LASSI[b]	Motivation, Attitude, Anxiety	Trait	The survey is retrospective of learning behaviours across learning contexts.
MSLQ[c]	Value (intrinsic goal orientation, extrinsic goal orientation, task value), Expectancy (control beliefs, self-efficacy), Affective (test anxiety)	Trait	The survey is retrospective of learning behaviours in a specific course.
OMQ[d]	Before task: Emotions; Task Appraisals (perceived difficulty, success expectancy, self-efficacy, task attraction, perceived relevance); Learning Intentions; After task: Reported Effort; Emotions; Attribution.	State	Administered in two parts—upon reviewing the task requirements, and immediately after the learning task

Note: [a] Current Motivation Scale for motivation in computer-supported collaborative learning (Schoor & Bannert, 2011). [b] Learning and Study Strategies Inventory (Weinstein, Palmer, & Schulte, 1987). [c] Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia & McKeachie, 1993). [d] Online Motivation Questionnaire (Boekaerts, 2002).

In terms of stability, LASSI and MSLQ measure motivation as a stable aptitude that is either domain-specific (e.g., Psychology course) or domain-general (e.g., motivation in learning). The OMQ and Current Motivation Scale treat motivation as task-specific, where motivational states are contingent upon learners' appraisals of the task at hand. Learners' motivational appraisals prior to the task may either afford or constrain the group's motivational experiences during collaboration. However, as individuals move along and interact with the task, their motivation may fluctuate and may need to be regulated for the learners to remain in the task. To account for the fluctuation, the Current Motivation Scale was administered more than once during

collaboration (Schoor & Banner, 2010). This measure, however, does not inquire into learners' deliberate management or regulation of their motivation during the task but only individuals' current perceptions of motivation.

In this dissertation, motivation is viewed as multi-dimensional and includes individuals' perceptions of their goals, task values, competency beliefs, and affect. During the learning process, motivation manifests in learners' behaviours (effort or persistence), cognitive beliefs (efficacy, task goals, or values), as well as affective experiences (interest or negative emotions). Individuals' motivation dynamically interacts with contextual features, fluctuate as learners progress in the task, and can be influenced or regulated during the task.

Challenge 2: Capturing Regulation as Social and Cyclical

Groups are systems of individuals who dynamically regulate their cognition, motivation, emotion, and behaviour individually or together across time and tasks (Hadwin et al., 2018). In that process, learners' regulation develops and changes over time in response to unfolding events. Thus, researching regulation in collaboration requires methods that allow researchers to examine regulation as socially situated and cyclical events (Hadwin et al., 2018; Järvelä, Volet, & Järvenoja, 2010; Volet & Vauras, 2013). Traditional work on self-regulated learning (SRL) has relied on self-report measures, which asked students to aggregate their regulatory behaviours across many situations (e.g., Pintrich et al., 1993). These types of measures describe regulation as an aptitude rather than an event (Winne & Perry, 2000; Zimmerman, 2008). The primary focus of analysis for the aptitude-based measures of regulation has been to examine its correlation with broad learning outcomes (e.g., Wolters & Pintrich, 1998), consequently losing the dynamic cognitive, behavioural, and affective experiences during learning.

In collaboration research, self-report measures are often administered once at the end of the collaboration, and they include assessments of members' perceptions about their team effectiveness, learning behaviours, and subjective interpretation about team regulation (e.g., Fransen, Kirschner, & Erkens, 2011; Van den Bossche et al., 2006). Team Learning Beliefs and Behaviour Questionnaire, for example, included an evaluation of team interdependence and cohesion reported after the collaboration has ended (Van den Bossche et al., 2006). Similarly, Edmondson's (1999) Team Survey Questionnaire invited group members to evaluate group work satisfaction, quality of group performance, and viability to exist as a productive unit upon completion of the collaborative activities. These self-report measures quantify groups negotiated motivational outcomes by drawing from individual members' subjective perceptions of the group work. One limitation of this approach is that it does not capture students' evolving strategic actions when regulating motivation during collaboration.

Järvenoja and colleagues' (Järvenoja & Järvelä, 2009; Järvenoja, Volet, & Järvelä, 2013) self-report instrument called the Adaptive Instrument of Regulation of Emotion (AIRE) is an attempt to measure regulation of motivation and emotion as contextualized within a specific collaborative experience. By increasing the number of assessment points during students' collaboration and comparing the coherence of group members' responses to different components of the AIRE, Järvenoja and colleagues attempted to capture the cyclical and social nature of regulation. Laid out in four sections, items on the instrument examined individual member's (a) personal goals, (b) subjective experience of their groups' socio-emotional challenges during different points in the collaboration, (c) evaluation of the regulatory strategies used to address the challenges performed either individually, in a co-regulatory or socially shared fashion, and (d) reflection on the attainment of the individual's personal goals and how their group contributed

towards the goals. Each section in AIRE builds on the next section. For example, instead of asking students to describe strategies for all their reported challenges, the instrument elicited responses only on one or two challenges group members perceived to be the biggest for their team. Järvenoja and colleagues' method of capturing regulation as a response to a challenging event fits with the regulated learning framework adopted in this dissertation research. In particular, the researchers' method highlights the importance of simultaneously examining students' perceptions of situated motivational conditions or challenges and the strategic actions adopted in response to the challenges.

Self-report measures are powerful for gaining insights into participants' cognitions and subjective interpretation of their own or others' regulation. However, the variation in regulatory actions, beliefs, and feelings used within and across regulatory episodes are lost when respondents are asked to aggregate over experiences and episodes. Also, the nature of the interaction between individual and group motivation is more complex than what could be extracted by self-report alone. At the very least, researchers can administer shorter self-report measures at multiple times to capture the cyclical nature of regulation exercised within the social context. A recent movement in the field is to gather multiple data channels (objective and subjective), allowing the adaptive nature of regulation to be captured from multiple angles (Azevedo, 2014). However, this approach is not simple, which leads to the third challenge below.

Challenge 3: Using and Balancing Multiple Data Sources

In response to the need for methods that capture regulation as socially situated and cyclical, it is now commonplace for researchers to combine objective and subjective measures of regulation (Azevedo, 2014; Järvelä et al., 2016; Järvenoja et al., 2018; Reimann, Markauskaite, & Bannert, 2014). The different streams of data make triangulation possible, not only for providing

a comprehensive outlook of individual motivation in action but also the interrelation between individual and group regulatory processes (e.g., Järvelä et al., 2008; Järvelä, Järvenoja, Malmberg, & Hadwin, 2013). When using multiple data channels, the limitation of one measure can be complemented by the strength of another (Winne, Jamieson-Noel, & Muis, 2002).

There are two types of data channels utilized in regulation research (Azevedo, 2015). First, *objective* data traces gathered using technological tools (e.g., log data, eye movement tracker, facial recognition) can provide continuous and minute information about internal and external indicators of motivation, such as attention, effort expenditure, or experienced emotions. Second, *subjective* data collected using self-report surveys and interviews, where students' subjective interpretations and reflections about their actions, thoughts, and emotions during a learning episode or culminating learning episodes are examined. Some researchers are beginning to incorporate more objective measures, collecting highly concentrated data about learners' physiological responses (skin conductance, heart rate, and facial expression) during learning events (Azevedo, Taub, Mudrick, Farnsworth, & Martin, 2016; Malmberg, Järvelä, Holappa, Haataja, Huang, & Siipo, 2019). However, such objective data pose analysis, interpretation, and practical challenges. For instance, inferring "neutral" facial expressions (an expression that cannot be detected by standard face-recognition tools) as lacking motivation can be misleading, particularly when the individuals' perceptions about that experience are not inquired.

Although multi-modal data may have the potential to contribute toward a holistic view of motivation as a process, it is crucial for researchers who work with objective data to carefully contextualize observed momentary actions and reactions using learners' self-reported intent and beliefs regarding that specific moment (Azevedo, 2014; Cleary & Zimmerman, 2001). Regulation of learning emphasizes learners' metacognitive awareness and control of their experiences, rather

than the experiences themselves. Regulatory responses learners make are goal-driven and are based on their *own* perceptions and interpretations. Hence, understanding learners' regulation requires researchers to take subjective perceptions and self-set goals into account.

Challenge 4: Selecting a Grain Size Level

Technological advances have allowed researchers to extract regulation at a fine grain, capturing motivated actions at a small fraction of time (e.g., mouse click or eye gaze). However, researchers are still struggling to determine the best temporal scope needed for making meaningful inferences about students' regulation—an issue coined as the grain size problem (Azevedo, 2014; Volet & Vaurus, 2013; Winne & Perry, 2000). Winne and Perry (2000) describe SRL as having dual characteristics: an aptitude and an event. An aptitude is defined as a relatively enduring characteristic of a person's or the group's readiness to benefit from a situation. Aptitude is measured at a macro level, where learners' regulation is aggregated across more extended periods and contexts, such as within a course or a group project. The grain size issue pertains to the *event* property of SRL. Here, researchers must judge the scope of information to collect for examining the role and emergence of students' metacognitive processes during authentic regulatory events.

An event can be as small as a state where regulation does not occur to a state where regulation occurs (Winne & Perry, 2000). An example in collaboration is an occurrence of a challenge where a group member indicates frustrations with the lack of inactivity, suggesting the presence of a metacognitive judgment that was previously absent. Winne and colleagues (Winne & Hadwin, 1998; Winne & Perry, 2000) describe two levels of events. First, IF-THEN contingency, showing a condition that follows a reaction (e.g., a remark of frustrations leading a group member to seek support). Second, patterned contingency, showing a collection of IF-THEN

contingencies where an array of cognitive tactics or actions make up a cognitive strategy (e.g., figuring specific actions needed to develop a strong plan of attack). When sequences of events are repeated frequently, patterns of regulatory actions are identified (Zhou, Xu, Nesbit, & Winne, 2010). Researchers may utilize sequential pattern mining tools to extract meaningful patterns of regulatory actions (e.g., Malmberg, Järvelä, & Järvenoja, 2017) or may qualitatively examine learners' patterns of responses (Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen, & Häkkinen, 2017).

Patterns may be modeled at different granularity levels. Patterns can be modeled at a coarser level, depicting a sequence of higher-level actions from a sequence of fine-grained actions. For example, a collaborative group's patterns of motivation regulation can be depicted by modeling the group's use of macro-processes (i.e., monitoring, adapting, planning, and enacting) activated within longer time intervals. In contrast, patterns that are mined at a finer grain may involve group members' sequence of utterances about situation-specific motivation challenge and its resolution. Regardless of the grain size, it can be assumed that a sequence of events identified at a higher level is a sub-sequence of events at a lower level (Zhou et al., 2010). The selection of grain size is argued to be driven by the research questions under study (Rovers, Clarebout, Savelberg, de Bruin, & van Merriënboer, 2019; Winne & Perry, 2000). Questions that relate to a specific SRL behaviour may require a finer grain size, whereas, questions that relate to examining students' global level of regulation skills may require a coarser grain size.

Despite this rule of thumb, researchers are still grappling with the complex task of identifying "meaningful" patterns that are interpretable in a particular research context, simultaneously judging the degree to which irrelevant intervening events can be filtered out (Zhou et al., 2010). Two further methodological considerations are relevant when analyzing collaborative groups' patterns of motivation regulation: (a) selecting an appropriate duration or

time intervals for depicting sequences of regulatory events, and (b) using constraint(s) for limiting the search space of patterns of regulatory actions.

Winne (2014) argue that the temporal markers for depicting sequences of regulatory events can be set a priori, such as at 10-minute intervals, or can “naturally” occur, such as explicit statements about experiencing motivation challenges that go on and off during the task. A priori selection of a time interval can be subjective and there is limited research that elucidate the potential errors associated with using specific time intervals for studying regulation. Borrowing from a study measuring students’ task engagement using several time intervals, Zakzeski, Hijnoski & Wood (2017) found that shorter time intervals produced score estimates that are more highly correlated with continuous recording of the students’ task engagement, and that shorter intervals had less measurement error compared to longer intervals. The measurement error influenced the reporting accuracy for students with low but not high enagement. This finding suggests that some patterns of events may be lost for some groups of learners when longer time intervals are used. While the construct of regulation may be different from task engagement, Zakzeski et al.’s (2017) study demonstrates that more research is needed to examine the consequences of a priori selections of specific time intervals for depicting regulation. It may be a good practice for researchers to compare several time intervals when analyzing learners’ patterns of regulation before collapsing events into longer time intervals. Would interpretations differ should a different time interval is used? —the answer to this question may differ across constructs and research contexts, but worth considering during the data analysis phase.

In terms of using a constraint for limiting the search space of regulatory events, an increasingly popular approach is to focus on students’ challenging moments in the task (Järvelä, Volet, & Järvenoja, 2010). Encountering challenges is a recognized opportunity for students to

exercise regulation (Hadwin et al., 2018). Näykki, Järvelä, Kirschner, and Järvenoja (2014) conducted a study in which they focused on examining group members' regulatory actions during episodes of emotional challenges experienced by groups working on a 12-week long collaborative project. Using video recordings of collaborative work sessions, episodes and categories of challenges that each group experienced were identified. Findings obtained from analysing one case group's patterns of responses indicated that the group's intense socio-emotional conflicts tend to be addressed using an avoidance-focused regulation strategy. Challenging episodes offered a mechanisim for limiting the search space for pattern mining, while proving to be useful for contextualizing the target or goal of students' regulatory actions (Hadwin et al., 2011, 2018).

Another method to constrain the search space is to focus on analyzing group members' utterances about motivation and emotions (socio-emotion) and eliminate utterances about cognitive regulation or task content processing (e.g., Järvenoja et al., 2013). One concern with isolating these utterances is potentially viewing socio-emotional- and task-focused regulation as occurring in parallel rather than dynamically informing one another. However, even when both types of regulatory utterance are concurrently examined, such as in Janssen, Erkens, Kirschner, and Kanselaar's (2012) study, researchers may still draw separate conclusions about how each type of regulation influence groups' performance and less so demonstrate how the two types of regulation interact. Despite the concern, it can be argued that understanding the whole neccesites understanding the pieces of the whole. The aim to examine motivation regulation in depth may justify separating utterances about motivation from other types of utterances, as long as the limitation of such approach is acknowledged.

Computer-Supported Collaborative Learning (CSCL) as a Methodological Solution

In this dissertation, CSCL environments were leveraged as a platform to promote regulation within and across group members, while also serving as the primary data collection tool. Both instructional and research purposes were considered because one aim of the dissertation research is to contribute to the development of support tools for students and groups to regulate productively in collaboration. Moreover, Winne (2018) propounds that students need to be guided with heuristics for practicing regulation because students are still researching about and developing tactics to better approach their own learning. Three types of CSCL tools were used in varying degrees across the dissertation studies and included: (a) log files, (b) scripting tools, and (c) chat records.

Log files. Log files or trace data assess learners' regulatory actions during an activity performed in a computer-based environment (e.g., Järvelä, Malmberg, & Koivuniemi, 2016). As students are using a variety of computer tools and engaging with the materials in the learning environment, log files are generated and collected automatically (see Hadwin, Oshige, Gress, & Winne, 2010; Perry & Winne, 2013). Examples of log files include mouse-clicks and timestamps associated with document-viewing or document-editing activities. These traces become data sources for researchers to examine group members' solo work as interleaved within collaborative episodes, group members' collaborative activities, and background activities that might contribute to the variation in groups' regulatory actions.

Järvelä et al. (2013) illustrate the application of log-file analysis. The researchers collected group member' reports about experienced challenges and used strategies, and log files as students were working in a computer environment called *nStudy*. Group members' contributions to the collaborative chat discussions and planning activities across three collaborative tasks were traced

and quantified. Upon interpreting groups' open-ended responses regarding their strategy choices across tasks, groups were categorized into the following: (a) strong—demonstrating efficient use of shared regulatory strategies; (b) progressive—emerging towards more shared regulatory strategies; and (c) weak—demonstrating routine level strategies that do not address the challenges well. Of interest, trace data for a group with the progressive profile and a group with the weak profile showed similar amounts of activities across the tasks; each member was an active participant in the group's chat discussions and planning activities. However, a more detailed analysis of the trace data revealed one distinctive character between the two groups: the group with a weak profile had contributions concentrated at the individual level, whereas the group with a progressive profile had more instances of shared regulation.

Järvelä et al.'s (2013) findings highlight the potential for using trace data to examine the adaptive nature of regulation, as well as how individual regulation transfers into group regulation and vice versa. However, traces are limited by the tools that learners choose to interact within the environment; if there are no observable interactions, researchers cannot quite determine students' regulatory actions and decisions. Trace data are rich with triangulation possibilities (Perry & Winne, 2013) but can be complex and challenging to work with (Gress, Fior, Hadwin, & Winne, 2010). The technical elements of traces require some judgments on how to measure and interpret the activities students demonstrated in the technological environment. For example, determining whether frequently logging into the group's shared workspace can be interpreted as frequent monitoring or multiple failed attempts at engaging with the materials in the workspace. In other words, trace data cannot quite capture the intent behind an action.

The trace data used in this dissertation included (a) group members engagement with their solo planning activity in Study 1 (i.e., submission date of a pre-task summary sheet and course

topic selected for the summary sheet), and (b) group members' activity logs in the group's shared online documents in Study 3 (i.e., when the documents were viewed or edited, who viewed or edited the documents, and what information was added or edited). Altogether, the trace data used in the dissertation research indicated individual group members' participation level and self-regulatory actions, either demonstrated in preparation for the collaboration or during the collaboration.

Scripting tools. Another type of commonly-used CSCL tool is a scripting tool (Dillenbourg & Fisher, 2007; Miller & Hadwin, 2015). Research has explored two types of scripting: (a) macro-scripts, which explicitly structure and sequence collaborative interactions, and (b) micro-scripts, which prompt learners to monitor and reflect on specific aspects of their learning either before, during, or after the learning task. The key strength of scripting tools, particularly micro-scripts, is that they prompt individuals and groups to exercise metacognitive awareness of their learning, leading to more efficient and insightful regulatory strategies.

For instance, Malmberg, Järvelä, Järvenoja, and Panadero (2015) studied groups' metacognitive knowledge about their experienced challenges and corresponding strategies. The collaborative process was macro-scripted based on Winne and Hadwin (1998) SRL model involving four sequential phases: task interpretation, goal setting, strategy enactment, and adaptation. Thirty groups completed two micro-scripts (OurPlanner and OurEvaluator) in each of nine collaborative sessions. OurPlanner prompted groups to think about the task demand and how they can plan accordingly to avoid potential challenges. On the other hand, OurEvaluator prompted groups to reflect on their challenges and socially shared regulation (SSRL) strategies. Based on groups' OurEvaluator responses across all collaborative sessions, the researchers created a challenge-SSRL strategy matrix to illustrate groups' adaptations. Of interest, groups

whose SSRL strategy focused on addressing cognitive and motivational challenges performed better on the task, compared to groups who tended to concentrate on addressing external constraints. Findings also demonstrate that the better-performing groups adapted successfully from the very beginning of the collaboration towards the end.

In this dissertation studies, groups were macro-scripted through a series of collaborative phases that was theoretically grounded in Winne and Hadwin (1998) self-regulated learning model. The phases begin from individual planning, group planning, enacting, to individual reflection. Guiding students through these phases served a pedagogical aim, which was to demonstrate the key phases of productive collaboration and highlight the importance of individual and shared planning prior to collaboration.

Micro-scripts were introduced in each macro phase. Micro-scripts introduced at planning guided students to think about the task demands, their motivation and emotions going into the task, anticipated challenges, a plan for regulating challenges, and a plan for productively working on the task. Individual group members worked through the scripted planner on their own during individual planning and worked through a similar set of scripts as a team during group planning. The content of the planning scripts slightly differed across the dissertations studies to fit with the collaborative task in each study.

Micro-scripts during the enacting phase served as opportunities for students to monitor their collaborative process and to check in with other group members (Study 1, 2). In Study 1, scripts in the enacting phase were designed in the form of emotion sampling, where students were prompted to evaluate their current emotions and to think of a plan for regulating the emotions. In Study 2, students were prompted to think about the challenges they encountered early in the

collaboration, the most salient motivation challenge in that period, and strategy they used to address the salient challenge.

Finally, micro-scripts during the reflecting phase prompted students to reflect on the challenges they encountered and the regulatory actions they exercised in response to the challenges. Students were also asked to evaluate their overall group work experience, the team learning behaviour, and a plan for improving future collaborations. Overall, the micro-scripts in the dissertation studies were designed to collect group members' interpretations of their experiences and regulatory actions prior to, during, and after collaboration. While these micro-scripts functioned as data collection instruments, they were also designed to engage learners' metacognition and promote proactive strategic actions.

Chat records. Interactions between group members occurring as they learn and regulate provide a wealth of data that can be mined at multiple levels of granularity. Current methodological approaches include coding groups' conversations at multiple levels and analyzing instances and patterns of regulatory actions and responses. For example, Rogat and Linnenbrink-Garcia (2011) examined social regulation through four levels of coding: (a) regulatory processes—planning, monitoring, and behavioural engagement; (b) positive socio-emotional interactions—active listening and respect, working to include a group member or actively attempting to involve the whole group, and group cohesion; (c) negative socio-emotional interactions —discouraging participation of a group member's participation in the group math task, disrespecting others, and low group cohesion; and (d) degree of collaboration—working individually or with the group. The multi-layer coding aimed to elucidate the multi-faceted aspects of regulation and how its quality can be influenced by other contextual factors.

Recently, researchers have begun to explore ways to identify and represent emerging patterns of regulation situated within groups' discourse data. For example, Lajoie et al. (2015) presented student-facilitator regulatory interactions on a heat map showing how co-regulatory support leads to several metacognitive activities and to positive or negative socio-emotional interactions. Järvelä, Järvenoja, Malmberg, Isohätälä, and Sobocinski (2016) took a different approach by arranging their discourse data on a timeline across five collaborative sessions. Their analysis revealed a decreasing level of planning and increasing level of enacting during the student-led (but not teacher-led) collaborative task. Overall, the prospects of mining regulatory actions using chat data are plenty, but analysis of groups' patterns of interactions need to be contextualized by considering group members' goals, plans, and perceptions that underlie the actions. This is because, regulation is a goal-driven metacognitive process that is activated in response to situational demands perceived by the learners, and not merely a set of conversation patterns or learning activities.

Groups studied in this dissertation completed their assigned collaborative task using an online text-based chat tool. Instructionally, conversation histories in the chat tool provided feedback in terms of each group member's participation and a record of groups' negotiated ideas and plans. Groups' chat records were used in two ways: (a) as a point of triangulation to contextualize group members' responses on the micro-scripts, and (b) to examine the actual dynamic discourse that took place between members during collaboration or regulation episodes. In Study 1 and 3, chat records were coded at multiple waves, with each wave focusing on a distinct aspect of group conversations or regulatory actions. Coded data were visually represented using two methods in two separate studies: (a) charting the frequency of different modes of

regulation in time bins (Study 1), and (b) chronologically charting group members' regulatory actions on an utterance-by-utterance level in a scatterplot diagram (Study 3).

Summary. Upon consideration of the methodological challenges and the types of solutions CSCL environment offers, Table 4 summarizes the methodological aspects addressed in each study comprising this dissertation. The operationalization of motivation within each study varies slightly due to the differences in the methodological lens and research purpose. Study 1 and 3 heavily relied on qualitative coding of groups' chat records and were both a comparative cases analysis. Study 1's (Bakhtiar, Webster, & Hadwin, 2018) aim was to examine groups' COPES processes of regulating the socioemotional aspect in collaboration. Motivation in Study 1 was operationalized as a product (and condition) of groups' engagement in regulatory processes. As a product it manifests in groups' socioemotional behaviours and dialogues, as well as emotional reactions. Study 3's (Bakhtiar & Hadwin, 2019) aim was to examine groups' dynamic use of self-, co-, and shared-regulation during motivationally challenging events during three online collaborative sessions. In Study 3, motivation challenges were detected in groups' behavioural engagement, expressed cognitive beliefs about task competency, goals, and values, as well as expressed affective experiences during collaboration.

Study 2's (Bakhtiar, Hadwin, & Järvenoja, 2019) aim was to examine group members' interpretations of motivation challenges during collaboration and the strategies they adopted in response. Motivation in Study 2 was examined at two angles: (a) motivation as an aptitude in the form individuals' task appraisal prior to collaboration and (b) motivation as situated challenges anticipated and experienced during collaboration. It was predicted from research that students' motivational aptitudes would have some influence on anticipating or experiencing motivation challenges during collaboration (Schoor & Bannert, 2011). The measure of task appraisal

included individuals' judgment of the task value or utility, self-efficacy, interest, and overall attraction towards the task. The construction of the short task appraisal scale was loosely informed by the motivational dimensions covered in Boekaerts' (2002) OMQ Task Appraisal subscale. In contrast, motivation challenges were assessed by inquiring into individuals' perceptions of challenges related to (a) behavioural engagement, (b) cognitive beliefs about efficacy, task, value, and goals, and (c) emotional experiences. Overall, across studies, motivation was treated as a multi-dimensional construct manifesting in students' dynamic behavioural engagement, cognitive beliefs, and affective experiences.

As illustrated in the section above, the three types of CSCL tools (log files, scripting tools, and chat records) were not utilized in the same amount across studies. Instead, the specific tools used in each study were limited to the ones that capture the individual and group processes relevant in the study. In terms of grain size, the selection of the temporal scope in each study directly matched the aim of the specific study. Despite differences in grain size, all studies attempted to examine regulation as a cyclical process that either unfolded during the whole duration of a collaborative session (Study 1), evolved from one distinct phase of collaboration to another (Study 2), or evolved across three successive collaborative sessions (Study 3).

Table 4. *Methodological Aspects Addressed in Each Study*

	Bakhtiar, Webster, & Hadwin (2018)	**Bakhtiar, Hadwin, & Järvenoja (2019)**	**Bakhtiar & Hadwin (2019)**
Operationalization of motivation as multidimensional and dynamic	• Motivation is a product (and condition) of groups' engagement in regulatory processes. It manifests in groups' socio-emotional behaviours and dialogues, as well as emotional interactions.	• Motivation as an aptitude in the form of task appraisal about task value or utility, self-efficacy, task attraction, and interest prior to the task • Motivation as situated challenges assessed through gaining individuals' perceptions of challenges related to behavioural engagement, cognitive beliefs, and emotional experiences during collaboration	• Motivation as manifesting in group members' behavioural engagement, expressed cognitive beliefs about task competency, value, and goals, as well as expressed affective experiences during collaboration
CSCL tools capturing *individual* activities and interpretation of situations	• *Log files*— engagement with the solo planning activity (submission of a pre-task summary sheet relative to the task deadline, course topic selected for the summary sheet). • *Micro Scripts*—Individual planner, emotion sampling tool (assessing current emotion and regulation plan), and individual reflection tool (assessing group members' interpretation of the group's overall socio-emotional climate).	• *Micro Scripts*— Individual planner (assessing students' appraisal of their goal, task value, self-efficacy, and interest; anticipated challenges and strategy). Individual check-in and reflection tool (assessing experienced challenges, salient motivation challenge and strategy response).	• *Log files*—Activity logs within the group's online shared documents (when the documents were viewed or edited, who viewed or edited the documents, and what information was added to or edited in each document). • *Micro Scripts*—Individual planner (assessing pre-task motivation, anticipated main challenge and regulation plan) and individual reflection tool (assessing main motivation challenge experienced and strategy response, and team learning behaviour).

CSCL tools capturing *group* processes	• *Chat records*—Groups' text-based conversations during one online collaboration.	*None*. However, individual students' interpretations of their group's motivation challenges and strategy responses were used to reflect group experiences and regulatory processes.	*Chat records*—Groups' text-based conversations in three collaborative sessions.
Selected Grain Size for Capturing Regulation Cycles	A 90-minute collaborative session. *Why?* To examine how regulatory processes unfolded during the whole duration of a collaborative session.	Three time-points: motivation challenges and strategies reported at (a) planning, (b) check-in, and (c) the end of a collaborative project *Why?* To examine how changing contexts, from one distinct phase of collaboration to another, influences students' motivation regulation.	Identified episodes of motivation challenges in three online collaborative sessions *Why?* To examine group members' dynamic use of self-, co-, and shared regulation in response to situational motivation challenges that arose and subsided during three collaborative sessions.

Chapter 3: Research Purpose, Context, and Overview of Manuscripts

The purpose of this dissertation was to examine undergraduate students' motivation regulation in the context of computer-supported collaborative learning (CSCL) setting by examining its related processes, the types of strategies enacted, and the dynamic interactions between individual- and group-level regulation in the online environment. The dissertation aim was achieved in three studies that involved:

i. A comparative case analysis of two groups' processes of regulating the socio-emotional aspects (motivation and emotions) of collaboration during a time-limited task (Bakhtiar et al., 2018).
ii. An exploratory analysis of individual group members' perceptions of motivation challenges in three distinct phases of collaboration and open descriptions of strategies the students planned and recalled using in response to salient motivation challenges identified in those phases (Bakhtiar et al., 2019).
iii. A comparative case analysis of two groups' dynamic use of self-, co-, and shared-regulation during motivationally challenging situations that arose and subsided in three collaborative sessions (Bakhtiar & Hadwin, 2019).

The theoretical model guiding the design and analysis in all three studies was the extended COPES model that considered the dynamics between self and social regulation (Hadwin et al., 2018; Winne, 1997). Collectively, a mixed-method approach was used, where different data sources were qualitatively and quantitatively analyzed to produce a comprehensive understanding of the process of regulating motivation in collaboration.

Research Context and Ethics

All three studies in the dissertation were conducted as part of a larger project on students' adaptive regulation in 21st-century learning at the University of Victoria (ethics protocol number 08-07-308b, Appendix A). The project was conducted in the context of a first-year elective Educational Psychology course, *ED-D 101 Learning Strategies for University Success*, offered to students across different faculties, including Social Sciences, Humanities, Sciences, Business, Fine Arts, Engineering, and Education. Very few students were from the Faculty of Education and no students were majoring in Educational Psychology. A minority of students may have been co-enrolled or had previously taken an introduction to psychology course. The course was not a remedial education intended for students with learning difficulties. Instead, it was presented as a full credit course presenting theories, research, and practice in Educational Psychology. Students enrolled in the course had a broad range of entering grade performance average (GPA). On a nine-point scale, the mean entering GPA of participants in Study 1 was 5.68 (SD = 2.21), Study 2 was 6.42 (SD = 2.15), and Study 3 was 3.97 (SD = 2.04). The last study was conducted in the second semester of the academic year (Spring 2018), whereas the first two studies were conducted in the first semester of the academic year (Fall 2013 for Study 1 and Fall 2017 for Study 2).

Two weeks before the commencement of the course and during the first two weeks in the course, students were informed of the nature of the implied consent process related to the project. Students were informed that enrollment in the course assumes consent to be part of the research conducted within the context of course activities and assignments. Students were also informed of the project aims and requirements, and the ability and mechanism to opt-out of the research at any point during the course (the consent withdrawal form in Appendix B). Student consent was

withheld from instructors (who were also researchers in the project) until students' final grades were submitted. My involvement in the instructional team included: (a) lab instructor in Study 2, and (b) lead course instructor in Study 3.

The course comprised a lecture and small group seminar component, each conducted for 1.5 hours per week. A lecture introduced theories and research related to effective learning and motivation, and a lab primarily engaged students in the application of theories and research to their own learning practices. Course topics (e.g., test-taking and note-taking) were theoretically grounded in Winne and Hadwin's (1998) four-phase SRL model. Students were encouraged to confront any learning task or situation systematically by (a) constructing accurate task understanding, (b) setting specific task goals, (c) experimenting with strategies, and (d) reflecting on their approaches, and adapting their approaches when necessary. Lab activities and course assignments were hosted in an online learning management platform called Moodle. Zoho chat (Study 1) and Google suite applications (Study 2, 3) were also used in the corresponding studies when some functionalities were absent or insufficient in Moodle.

Apart from developing an understanding of the theory and research about learning and motivation from a self-regulated learning perspective, the course also aimed to help students develop collaborative learning skills. Hence, students were assigned to groups of three to five to collaborate on two or more tasks in a CSCL environment. In Study 1 and 2, groups were made heterogeneous with groups having a similar number of males and females, English-as-second language learners, and students with strong and weak prior knowledge of SRL. Prior knowledge was measured in the first week of the course involving students completing 20 multiple choice questions about several aspects of self-regulated learning. Informed by findings in Study 1, which revealed that individuals in the overall positive socio-emotional climate group were better

prepared than individuals in the overall negative socio-emotional climate group, Study 3 took on a different group assignment method. Specifically, students were assigned into groups based on their planning scores, bringing together equal numbers of students with high and low planning scores in each group.

In terms of the task design, in Study 1, groups were required to work on two 90-minute collaborative assignments offered at two different points in the semester. Each of the assignments involved a case analysis of a hypothetical student's learning practices. Groups were required to scrutinize the case based on course concepts about studying, learning, and motivation. However, for the purpose of Study 1, only the first assignment was examined in detail. In Study 2 and 3, groups were tasked to work on an infographic building project over eight to nine different work sessions distributed across the semester. An infographic is a visual representation of information and data related to a topic of choice. The infographic project required groups to translate and represent course concepts into a strategy guide for tackling one aspect of university learning (e.g., test preparation, note-taking, motivation).

The tasks introduced in the dissertation research were ideal for examining collaboration because they were ill-defined and required the knowledge and skills of multiple individuals (see Ingram & Hathorn, 2004). As a result, group members needed to regulate at a higher degree and had to engage in a coordinated effort to solve the problem together (see Järvelä et al., 2016). Hadwin et al. (2011) emphasize that "collaborative learning tasks should involve the construction of shared understanding through interaction with others, where the participants are committed to or engaged with shared goals and problem solving" (p. 77). The collaborative tasks in this dissertation fit with that description.

While learning about regulation can influence the decisions and actions shown by the participants in the dissertation studies, I argue that the research context was appropriate for examining regulation. Students were provided with the same amount of background knowledge about self-regulated learning, but their responses and actions still vary when placed in a task. In a way, students' knowledge about regulation was loosely controlled for, allowing us to examine how students exercise regulation based on that knowledge. The same instructional context also made it possible to examine how students develop their regulatory skills as students engage in a series of tasks during the course.

Winne (2014) discussed in his commentaries on research on students' patterns of SRL that, students are generally poorly equipped with a variation of tactics and strategies for regulating learning. As a result, the variation in students' regulatory actions becomes truncated and limits researchers' ability to observe any meaningful "patterns." A remedy suggested by Winne (2014) includes training students the different component of SRL (e.g., goal setting, weighing motivational conditions, selecting tactics and strategies, reflecting) which consequently prepares students "to be in a stronger position to express variances in exercising SRL" (p. 235). Hence, the context of this dissertation research provides a richer dataset for examining students' unfolding regulatory actions and decisions during authentic learning.

Overview of the Manuscripts

Table 5 provides a summary of the purpose and research design of each manuscript. An overview of each manuscript follows.

Table 5. *Overview of the Purpose and Research Design of Each Study*

Overall Aim	Examine undergraduate students' regulatory decisions and actions to motivation challenges in the context of computer-supported collaborative learning (CSCL) setting.		
Study	**Bakhtiar et al. (2018)**	**Bakhtiar et al. (2019)**	**Bakhtiar & Hadwin (2019)**
Purpose	Examine the COPES processes of regulating the socio-emotional aspects of collaboration in two groups with contrasting socio-emotional climates.	Examine the types of salient motivational challenges that emerged in three distinct phases in collaboration and the strategies students adopted in response.	Examine the dynamic interplay between self, co-, and shared-regulation during motivationally challenging episodes in collaboration
Methods	A comparative case analysis of two groups: a group with an overall positive socio-emotional climate and a group with an overall negative socio-emotional climate.	An exploratory analysis of individual group members' perceptions of motivation challenges and open descriptions of the strategies the individuals planned and recalled using in response to motivation challenges.	A comparative case analysis of two groups with high ratings of experienced motivation challenges but the groups had contrasting perceptions of overall team learning productivity.
The Collaborative Task	A 90-minute collaborative case analysis task that involved analyzing a one-page case scenario about a fictitious student's learning behaviours.	A semester-long collaborative infographic building project, which required groups to generate and present a strategy for tackling one aspect of university learning in the form of an infographic.	A semester-long collaborative infographic building project, which required groups to generate and present a strategy for tackling one aspect of university learning in the form of an infographic.
Group Assignment	Students were assigned into heterogenous groups based on prior knowledge, gender, and English-as-second-language status.	Students were assigned into heterogenous groups based on prior knowledge, gender, and English-as-second-language status.	Students were assigned into heterogenous groups based on their individual planning scores.
Online Platform	Moodle + Zoho chat	Moodle + GSuite applications	Moodle + GSuite applications

Study 1

Bakhtiar, A., Webster, E. & Hadwin, A.F. (2018). Regulation and socio-emotional interactions in a positive and a negative group climate. *Metacognition and Learning, (13)*1, 57-90.

Study 1 lays the theoretical groundwork for examining motivation regulation as a process using Winne's (Winne, 1997; Winne & Hadwin, 1998) COPES-based perspective of regulated learning, which was foundational in Hadwin et al.'s (2018) conceptualization of self-, co-, and shared regulation. The purpose of Study 1 was to examine the COPES processes of regulating the socio-emotional aspects of collaboration demonstrated by two groups with contrasting socio-emotional climates. The interplay between regulatory processes (planning, monitoring, enacting, adapting), regulatory modes (self-, co-, and shared-regulation), and socio-emotional interactions that influence groups' motivational and emotional states were qualitatively examined. The selection of two groups was based on individual group members' reflection at the end of their first collaborative task. The group with an overall perception of positive climate comprised four members who recalled a positive socio-emotional experience, whereas the group with an overall perception of negative climate comprised four members who recalled a negative socio-emotional experience.

Groups worked in a 90-minute long online collaborative task that involved analyzing a one-page scenario about a fictitious students' learning behaviours. As students worked online, two data channels were extracted: (a) regulatory actions and socio-emotional interactions observed in groups' text-based chat records, and (b) self-reported data about group members' affective beliefs and perceptions prior to, during, and after the collaboration. Chat data were inductively and deductively coded on three dimensions: regulatory processes, regulation modes,

and socio-emotional interactions. Other data sources included group members' preparation prior to the task and the groups' task performance. Three research questions guided the inquiry: (a) What sets of conditions did each group enter the collaborative task with? (b) How did the observed regulatory processes, regulatory modes, and socio-emotional interactions fluctuate and interact in each group? And (c) what were group members' perceptions of the collaborative experience in terms of their emotional reactions?

Guided by Braun and Clarke (2006) thematic analysis technique, key themes describing the regulatory and socio-emotional interaction differences between the overall positive climate and the overall negative climate groups were identified. The first theme described how incoming conditions set the foundation for creating a positive collaborative experience. Students in the overall positive climate group were better prepared in terms of prior knowledge on their assigned topic and took responsibility in submitting their individual planning activities on time. These students were also exposed to a highly scripted individual planning tool geared to help students identify the implicit and explicit task requirements. In contrast, students in the overall negative climate group were less prepared and were exposed to a loosely scripted individual planning tool with open-ended prompts for constructing an implicit and explicit understanding of the task. Students in the overall positive climate group also entered the task with predominantly negative emotions anticipating challenges the group might encounter and recognized the need to regulate those emotions as a team. On the other hand, students in the overall negative climate group entered the task predominantly feeling positive (despite being less prepared) and planned for an individual approach to regulate those emotions.

In the second theme, it was identified that the entering conditions seemed to influence the group's ability to regulate emotions during the initial phase of collaboration. Students' self-reports

collected at the mid-point of the task indicated productive regulation in the overall positive climate group but less productive regulation in the overall negative climate group. The emotions experienced during the early phase then became conditions influencing the groups' future regulatory engagement. In the third theme, it was observed that groups' evolving socio-emotional experiences and regulatory patterns seemed to contribute to groups' success in adapting as a team during challenging moments. Negative socio-emotional experience constrained the overall negative climate group's share adaptation in the face of a challenge.

Finally, observations of the groups' socio-emotional interactions throughout the collaboration demonstrated the role socially-directed motivational statements play in creating a positive climate, as well as the importance of minimizing negative interactions. Although both groups engaged in more positive than negative interactions, the frequency and proportion of negative interactions were higher in the overall negative climate group compared to the overall positive climate group. This finding demonstrates that, despite attempts to interact positively, the presence of persistent negative interactions in the overall negative climate group seemed to have detrimental effects on group members' socio-emotional states. This finding was corroborated by self-reports of negative emotions and lower satisfaction by the individuals in the group.

Study 1 contributed to the purpose of this dissertation by establishing the theoretical foundation upon which to examine the unfolding process of motivation regulation. The COPES-based model of regulation was established as a useful framework for examining the cyclical and situated nature of motivation regulation in collaborative contexts. Overall, findings demonstrate how group members' entering conditions set the stage for regulation that occurred early in the collaboration, and the motivational and emotional products of that regulation became important conditions in the following iterations of regulation.

Study 2

Bakhtiar, A., Hadwin, A.F., & Järvenoja, H. (2019). *Strategies for regulating salient motivation challenges in online collaboration*. Manuscript submitted.

Study 1 informed Study 2's research design in two ways. First, learners' regulatory actions fluctuate and may differ across distinct phases of collaboration as the demands in each phase may vary. Second, both individual group members' entering conditions and the group's social interactions may be sources of motivation challenges students encounter in collaboration. Students' regulatory strategies for tackling motivational challenges that emerge during different phases of collaboration were investigated in this second study. Specifically, the purpose was to examine the types of salient motivation challenges students anticipated and reported in three distinct phases of collaboration and the strategies students adopted in response to the identified challenges. Individual group members' entering condition in the form of motivational appraisal of the task was acknowledged to be a potential source of motivation challenges in collaboration. The research questions included: (a) Do group members' ratings of motivation challenges differ across phases of collaboration? (b) Do group members' task appraisals correlate with their intensity ratings of motivation challenges? (c) What were the main motivation challenges that triggered regulation? And (d) what types of strategies were planned and reported as a response to the main motivation challenges?

Participants were 139 students enrolled in an undergraduate elective course where they worked in groups of three to five to complete a semester-long infographic-building project. Students approached the project in nine sessions in different weeks in the course: (1) individual planning, (2) group planning, (3) collaborative session 1 with groups discussing a model of self-regulated learning, (4) individual check-in, (5) collaborative session 2 with groups discussing

research on effective learning, (6) collaborative session 3 with groups discussing research on effective strategies, (7) building the infographic together using Google Slides or Google Draw, (8) presenting the infographic to the class, and (9) individual reflection.

Data sources included individual group members' self-reports collected at individual planning, check-in, and reflection. At individual planning, self-reports included (a) task appraisal, involving appraisals of task value, task utility, interest, self-efficacy, and overall task attraction, (b) intensity ratings of anticipated motivation challenges, (c) main anticipated motivation challenge and (d) a strategy planned for regulating that main challenge. At individual check-in and reflection, individuals (a) rated the intensity of experienced motivation challenges, (b) identified the main motivation challenge encountered, and (c) described the strategy they used for regulating that main challenge.

The intensity ratings of motivation challenges were assessed using three items describing three types of motivation challenges. First, *behaviour-focused motivation challenges* included difficulties getting individuals to participate, staying on-task, and getting the task done. Second, *cognitive-focused motivation challenges* included lacking positive efficacy beliefs and a sense of purpose or goals for the task. Third, *emotion-focused motivation challenges* included difficulties in maintaining favourable feelings and emotions about the task, the group, and the situation. After rating the intensity of each challenge, individuals selected one main challenge they anticipated or experienced and later described their strategy response in open-ended text fields.

Group members' intensity ratings of motivation challenges across the collaboration phases and their correlations to task appraisal scores were examined. In addition, group members' open descriptions of strategies were qualitatively coded and then quantified to examine each strategy's prevalence in each phase of the collaboration. The interaction between

challenge and strategy were then explored using within-person transition probability maps, showing the main challenge students experienced in the early phase of collaboration, the corresponding strategy response, and the likelihood of that strategy leading students to reencounter the same main challenge in the later phase of collaboration.

Findings revealed that, throughout the collaboration, most students were concerned about behaviour-focused motivation challenges related to lacking task participation and getting the task done. The intensity of motivation challenges students anticipated and reported experiencing had low to no correlation with their task appraisal scores. This finding suggests that the experienced challenges were more likely to emerge from the complex interactions between group members and the task and context. Moreover, students' intensity ratings of motivation challenges indicated that levels of anticipated motivation challenges were higher than what the students reported experiencing during collaboration. Prompting metacognitive planning about anticipated motivation challenges may have helped students to proactively plan for and respond to those challenges when they arise. Alternatively, it was possible that the decline was observed because students overestimated the potential for motivation challenges to arise during group work (see Hadwin, Webster, Bakhtiar, & Caird, 2015).

From inductive and deductive coding of students' open descriptions of strategies, Pintrich's (1999) provisional taxonomy of volition control was utilized to organize the coded strategies. Strategies were categorized into: (a) *behaviour control*—strategies that relate to managing one's behavior and performance in the task, (b) *cognitive control*—strategies that relate to managing one's thoughts or motivational beliefs about the task and/or the team, (c) *emotion control*— strategies that relate to managing feelings about the task, situation, or team which may involve either inducing positive emotions or decreasing negative emotions, and (d)

environment control—strategies that relate to managing the task and environmental features. The target motivation construct(s) associated with each strategy category were further identified. Specifically, (a) behaviour control strategies were aimed to increase effort and persistence, (b) cognitive control strategies were aimed to influence efficacy beliefs, task value and utility, and goals, (c) emotion control strategies were aimed to influence interest, enjoyment, and positive emotions and (d) environment control strategies were aimed to reduce external distractions that hinder engagement in the task or re-direct attention to the task.

Overall, students demonstrated a differentiated use of strategies for addressing the salient motivation challenges they identified during three distinct phases of collaboration. Prior to the collaboration, most students planned a behaviour control strategy, which was to check in with group members frequently. Next, in the early phase of collaboration, a behaviour control strategy was again preferred and included providing social support to group members. Towards the end, most students switched to a cognitive control strategy that included reminding themselves or others of the goals they need to complete. The exploratory analysis using transition probability mapping demonstrated that behaviour control strategies (e.g., checking in) were less useful than cognitive control strategies (e.g., planning and setting task goals) in reducing the likelihood of reencountering challenges related to behavioural participation.

Study 2 contributed to the main aim of the dissertation by cataloguing the varied tactics and strategies learners reported using in response to salient motivation challenges in collaboration. This study is one of few studies that identify the specific motivation regulation strategies students use in the context of online collaborative learning.

Study 3

Bakhtiar, A. & Hadwin, A.F. (2019). ***Dynamic interplay between modes of regulation during motivationally challenging episodes in collaboration*****. Manuscript submitted.**

In Study 2, the types of motivation regulation strategies demonstrated in collaboration were limited to group members' self-reported strategies. To address this limitation, it was necessary to unpack the processes involved during co- and shared-regulation of motivation, and how all modes of regulation (self, co-, and shared) interact during episodes of motivation regulation. In line with Hadwin et al.'s (2018) model of regulation in collaboration, co-regulation has been argued to be an essential metacognitive process through which self- and shared-regulation are temporarily guided or compensated. However, very few studies examined how co-regulation is used in relation to self- and shared-regulation during collaboration.

Therefore, the purpose of Study 3 was to examine groups' dynamic use of self-, co-, and shared-regulation of motivation, with a specific focus on examining the role co-regulation played in stimulating self- and shared regulation during motivationally-challenging episodes in collaboration. Attempts at unpacking the dynamic interplay between regulatory modes involved finding a method that could visually represent the dynamic processes. Therefore, a visual diagram called the Chronologically-ordered Representation for Tool-Related Activity diagram (CORDTRA; Hmelo-Silver, Chernobilsky, & Jordan, 2008) was utilized as a technique for representing groups' dynamic processes. The CORDTRA diagram was chosen for two reasons. First, the diagram fostered a holistic visualization of fine-grain and multi-dimensional codes depicting individual members' regulatory actions during group conversations. Second, because the diagram involved arranging individual group members' activities in chronological order, the ebb and flow of group members' self-, co-, and shared-regulation throughout the collaboration

could be recognized. Both aims of Study 3 were achieved by conducting a comparative case analysis. Three research questions guided case comparisons: (a) What were the motivation challenges (conditions) that triggered regulation in each group? (b) How were self- and shared-regulation used in relation to co-regulation? And (c) what strategies were used during episodes of motivation regulation?

Two case groups were selected based on individual group members' reflection data about perceptions of their group's motivation challenges and overall team learning productivity. Perceptions of challenges were collected using three items that collected students' intensity ratings of behaviour-, cognitive-, and emotion-focused motivation challenges similar to Study 2. Group members' perceptions of their overall team learning productivity were measured using the Team Learning Behaviour Questionnaire (Van den Bossche et al., 2006). Groups' mean scores on each measure were calculated by aggregating the scores of the individuals within each group. The selection criteria of the case groups included that: (a) groups must have similar high mean score of motivation challenges, indicating that both groups had relatively equal opportunities to regulate motivation challenges, and (b) groups must have contrasting perceptions of their overall team learning productivity, suggesting that they had different results in terms of success in regulating the motivation challenges. Therefore, the study involved comparing one group with a high mean score of motivation challenges and a high mean score of overall team learning productivity (high productivity group) with one group with a high mean score of motivation challenges and a low mean score of overall team learning productivity (low productivity group).

Groups worked on an infographic-building collaborative project like the one introduced in Study 2. However, the collaboration process differed slightly and groups were formed using a different group-assignment procedure. Students completed the project in eight sessions instead of

nine, dropping the individual check-in conducted in Study 2. Groups were made heterogeneous based on their individuals' planning scores, bringing together equal numbers of students with both high and low planning scores.

An array of data sources informed the analysis. Self-report data were collected using scripting tools that asked individuals about (a) their pre-task motivation and planned strategy, (b) the intensity of motivation challenges experienced during collaboration, (c) the main motivation challenge experienced during collaboration and strategy response, and (d) their perceptions of the group's team learning behaviour or productivity. Observational data included (a) individuals' activity logs related to viewing and editing their group's shared online documents, and (b) the groups' text-based conversation records during three collaborative sessions. Group conversations were qualitatively coded on four dimensions: task- versus socio-emotional focused, types of motivation challenges, modes of regulation activated in response to the challenges, and types of motivation regulation strategies used. The first two dimensions were for gaining an understanding of the contexts that triggered motivation regulation. The last two dimensions, which described groups' regulatory actions, were visually represented in a CORDTRA diagram generated for each group. The diagram also showed the specific individuals involved in each regulatory action.

The analysis revealed that, although groups had similar mean ratings of motivation challenges, groups differed in the types of motivation challenges they experienced. Specifically, the high productivity group experienced challenges that predominantly emerged from self-conditions, such as personal motivational beliefs and interest in the task. In contrast, the low productivity group struggled with challenges mostly arising from group conditions, such as inter-individual conflicts and lacking communication between group members. Groups also differed in

terms of the match between the types of motivation challenges they experienced and the corresponding regulatory responses. The high productivity group addressed the self-condition challenges by actively self-regulating and supporting others' when the challenges were not their own. In comparison, the low productivity group rarely addressed their group-condition challenges as a team. Perhaps because active self-regulation across group members was not always evident, the low productivity group's co- and shared-regulation became limited. Two members in the low productivity group tended to rely on others to regulate for them, rather than proactively self-regulating and socially sharing the responsibility to regulate as a team.

Findings also demonstrate that co-regulation in the high productivity group was typically positive and proactive, whereas co-regulation in the low productivity group was typically directive and reactive to specific actions or inactions. In response to challenges, the high productivity group engaged in more diverse types of motivation regulation strategies that, not only intended to change how group members participate and think about the task goals, but also strategies aimed to improve group members' emotional experiences during the task. In contrast, the low productivity group demonstrated narrower use of strategies that focused mostly on controlling behaviour and the environmental features of the task.

Overall, Study 3 demonstrated that the CORDTRA diagram was suitable for representing groups' regulatory actions because the intertwined processes between individuals and the group can be simultaneously considered. Moreover, co-regulation may afford and thwart the emergence of self- and shared-regulation of motivation, and these processes interacted with the group's situational challenges and the regulatory skills or strategies group members possessed. Study 3 contributed to the dissertation's purpose by demonstrating (a) the dynamic interplay between self-, co-, and shared regulation when group members' orchestrated strategies for regulating

motivation challenges, and (b) ways in which groups' strategic actions can promote a more productive team learning.

Chapter 4: Discussion

The three studies comprising this dissertation contributed to the examination of students' regulatory responses to motivational challenges during online collaboration and addressed a few gaps in research on motivation regulation in collaboration. Main findings across the studies are organized into three broad contributions, including: (a) COPES scripts of regulating motivation in collaboration, (b) motivation regulation strategies at the individual and group level, and (c) adaptive and maladaptive patterns of motivation regulation in collaboration. Within each contribution, the theoretical, research, and practical implications are discussed.

Contribution 1: COPES Scripts of Regulating Motivation in Collaboration

In this dissertation, the COPES model of regulated learning (Hadwin et al., 2018; Winne, 1997; Winne & Hadwin, 1998) was used as the framework for examining the contextualized and situated nature of regulation. The model describes motivation and emotions as *conditions* that create contexts for regulation and as *products* of engaging in regulatory actions (Winne & Hadwin, 2008). In this dissertation, the COPES-typology was elaborated upon to account for the process of regulating motivation in collaboration. Specifically, the types of motivational conditions and cues students may draw from when regulating motivation were identified.

In Study 1 (Bakhtiar et al., 2018), the COPES architecture guided the analysis of groups' unfolding regulatory and socio-emotional processes. Several affect-related data were organized according to the COPES architecture to create a COPES profile of each group. Findings showed how students' socio-emotional interactions, regulatory modes, and basic regulatory processes interacted to create a chain of regulatory actions. However, during the process of mapping groups' COPES profiles, the most challenging element to locate in the data was the *operations*. Learners' execution of cognitive operations when regulating the socio-emotional aspect of

collaboration was not readily transparent because this metacognitive process was not directly examined. Given this difficulty, Study 1 (Bakhtiar et al., 2018) examined the "outward instantiation" of operations in the form of socio-emotional interactions, which refer to the interchanges or communications among team members that shape group members' perceptions of the motivation, emotions, and socio-emotional climate of the group. Similarly, in Study 2 (Bakhtiar et al., 2019), the specific types of motivation regulation strategies were considered as the composite operations learners used to manage motivation in collaboration.

Study 1 demonstrates that the COPES model can be applied to motivation and emotion regulation in collaborative contexts. The model, as it was implemented in Study 1, emphasized (a) the importance of examining the situational conditions and demands that triggered regulatory actions and (b) the cyclical nature of regulation evolving from one iteration to the next. Across the dissertation studies, two main findings regarding key motivational conditions and products can be highlighted. First, individual preparation and self-regulation are important conditions for productive motivation regulation in collaboration. Second, diverse types of motivational challenges emerge during collaboration which create contexts for regulation.

Individual preparation and self-regulation. Individual members bring varied sets of conditions to the collaborative task. Research indicates that individual conditions can influence group experiences and the group's ability to regulate as a team (Bakhtiar et al., 2018; Bakhtiar & Hadwin, 2019; Panadero, Kirschner, Järvelä, Malmberg, & Järvenoja, 2015). However, Study 2's findings indicate that individuals' pre-task motivation in the form of appraisals of task interest, attraction, utility, and self-efficacy, had low to no correlation with the intensity of the motivation challenges anticipated and experienced during collaboration. This finding may suggest that motivation challenges in collaboration emerge through interactions between group

members and the task, and are less dependent on individual motivational appraisals prior to the task. Having group members who appraise the task favourably does not guarantee that intense motivation challenges will be prevented.

Entering conditions that reflect group members' active self-regulation in preparation for collaboration seemed to have more influence on groups' motivation and productivity during collaboration. Study 1 demonstrated that entering conditions relating to individuals' preparation in terms of prior knowledge and planning, and anticipation of challenges played a role in setting the stage for a more productive regulation (Bakhtiar et al., 2018). These entering conditions may indicate that the individuals were actively self-regulating for the collaborative task and were more metacognitively attuned to the needs to engage in proactive forms of regulation. When regulation is active at the individual level, even before the collaboration begins, productive shared-regulation is likely to occur (Bakhtiar et al., 2018; Panadero et al., 2015).

Of interest, findings in Study 1 also revealed that individuals in the overall positive socio-emotional climate were provided with detailed scripts that guided students to identify the implicit and explicit task requirements during individual planning (see Miller & Hadwin, 2015). In contrast, individuals in the overall negative socio-emotional climate were provided with open-ended scripts that prompted students to construct an understanding of the implicit and explicit task requirements. It is possible that supporting individuals to develop a more solid metacognitive awareness of the task demands could significantly change the contexts (conditions) for regulation, and consequently influence the socio-emotional process experience at the group level. With a larger pool of participations, future research should explore the effect of supporting individual members' task preparation on groups' overall affective experience.

Emerging situational conditions or motivational challenges. Regulation is described as a process that is particularly activated when the situation demands or when challenges arise (Butler & Winne, 1995; Hadwin et al., 2011, 2018; Winne & Hadwin, 1998). The types of situational challenges that affect students' motivation and their ability to remain engaged in the group work are plenty (see Järvenoja & Järvelä, 2011; Järvelä et al., 2008; Rogat et al., 2013). Informed by the literature on group work and motivation challenges, Study 2 and 3 attempted to capture the multi-faceted sources of motivation by examining three broad types of motivation challenges: behaviour-, cognitive-, emotion-focused challenges.

First, behaviour-focused motivation challenges included difficulties with effort initiation, distribution, and maintenance. Dealing with unequal participation and group members who are often absent in the online meetings (i.e., social loafing issue) are examples of behaviour-focused motivation challenge (see Dirkx & Smith, 2004; McCorkle et al., 1999). Individual students may themselves experience difficulties maintaining behavioural engagement throughout the collaborative process, particularly when the project requires a high level of commitment. Second, cognitive-focused motivation challenges included difficulties with cognitive beliefs about task efficacy, value, purposes, and goals. For example, students can be described as experiencing cognitive-focused motivation challenge when they do not have a sense of what the group is working towards or when they worry about being perceived as lacking an ability (see Rogat & Linnenbrink-Garcia, 2019). Third, emotion-focused motivation challenges included difficulties in maintaining favourable emotions about the task, the group, and the situation (Bakhtiar et al., 2018; Järvenoja & Järvelä, 2009). Having domineering group members who are punitive of one's contribution may bring about negative emotions, and consequently reduces one's motivation to engage in group discussions and activities. Findings in Study 2 showed that

students rated behaviour-focused motivation challenge to be the most problematic or salient throughout collaboration. Two possibilities could explain this tendency. First, it was easier for students to detect deficiencies in group members' behavioural participation than to question their cognitive beliefs and emotions that hinder task engagement. Second, behaviour-focused challenges were truly difficult to regulate, and learners do not possess the skills to manage such challenges effectively.

Moving beyond self-report, in Study 3, groups' conversations during three collaborative sessions were examined for types of emerging motivation challenges. Coding of chat transcripts revealed that along with behaviour-, cognitive-, and emotion-focused motivation challenges, environment-focused motivation challenges also emerged during students' interactions with technological tools and attentional demands outside of the collaborative task. For instance, group members encountered difficulties navigating the online learning platform and these challenges interfered with the person's ability to engage in team discussions. Findings also indicate that challenges originating from group conditions, such as having conflicting opinions, goals, and priorities, can take a toll on groups' ability to learn productively as a team (Study 3). This source of challenge is less likely to be resolved if the team fail to socially share the responsibility to regulate as a team. In contrast, challenges relating to self conditions, such as personally viewing the task as uninteresting, seem to have less influence on the overall team learning productivity if individuals with those conditions are actively self-regulating and are positively co-regulated by others in the team.

Overall, findings indicate that students respond differently to diverse types of challenges or conditions that emerge in their collaboration. Students need more support to address behaviour-focused motivation challenges, particularly when these challenges are shared by the

group (group conditions). This set of findings highlights the need for future research to examine the types of situational challenges or motivational conditions prevalent throughout collaborative learning. By doing so, more targeted supports that address the actual motivation challenges may be offered.

Methods for capturing COPES processes. The coupling of COPES elements in learners' regulatory processes can be difficult to examine empirically; hence, requires contemporary methods and analysis. In two separate studies in this dissertation (Study 1 and Study 3), qualitative case analyses were conducted involving multiple types of data sources that speak to different elements of the COPES architecture. The unit of analysis of those qualitative studies was at the activity level, where individual and group regulatory processes dynamically interacted as learners are collaborating. In some ways, the studies attempted to map groups' regulatory patterns that together illuminate how members oscillate between self-, co-, and socially shared-regulation. Methods of analyses involved arranging groups' regulatory actions in chronological time bins showing the frequency of specific regulatory actions in bar graphs (Study 1) and in chronological scatterplot diagrams showing groups' regulation at the utterance level (Study 3). The scatterplot diagram or the Chronologically-ordered Representation for Tool-Related Activity (CORDTRA) diagram was particularly useful for capturing interactions between individuals as well as between regulatory activities (Study 3).

In Study 2, a more quantitative approach was explored to examine the within-person patterns of regulating salient motivational challenges individuals identified and the strategies they adopted in response. The approach was loosely guided by the Markov chain procedure for expressing the probabilities of transitioning from one event to another. In the Markov chain, an event can transition back to itself, creating a loop in the chain. Accordingly, the matrix that

represents a transition mathematically must parallel; the possible events showing on the rows and columns of the matrix must be the same (see Winne et al., 2002). Unlike the Markov chain, we were interested in capturing within-person transitions in which the possible events in a given point of time were not necessarily the same. Specifically, we wanted to examine students' strategic response to an identified salient motivation challenge and the outcome of activating that response in terms of reducing the likelihood of reencountering the challenge. Therefore, directed graphs were used to capture the chain of events.

The directed graphs demonstrated within-person probabilities of experiencing specific types of motivation challenge (conditions) in the early phase of collaboration, to the types of strategies individuals selected in response (outward instantiation of operations), and to the likelihood of that response leading individuals to reencounter the same type of challenge in the later phase of the collaboration (products). The transition maps revealed dominant patterns of strategic responses to several types of motivation challenges. Of interest, findings demonstrated behaviour-focused motivation challenge tended to be more persistent than the other types of motivation challenges. Students who addressed that challenge using cognitive control strategies, such as planning and goal setting, had lower likelihood of reencountering the challenge. Future research may utilize a similar probability mapping approach with more data capturing various COPES elements across multiple iterations of regulation. Subsequently, by recognizing students' maladaptive patterns of regulation, research may explore ways to disrupt those patterns by introducing guidance tools that support students to exercise more adaptive regulatory actions during collaboration.

Contribution 2: Motivation Regulation Strategies at the Individual and Group Level

Another contribution made in this dissertation is cataloguing strategies group members recalled using (Study 2) and were observed using (Study 3) to address a range of motivational challenges encountered during collaboration. The only catalogue of motivation regulation strategies to date is the one emerging from Wolters and colleagues' (Wolters, 1998, 2003; Wolters & Benzon, 2013; Wolters & Rosenthal, 2000) research focusing on solo academic studying and learning tasks. Specific to collaboration research, Järvelä and Järvenoja (2011) attempted to revise Wolters' (2003) descriptions of six types of strategies to reflect groups' socially shared use of the strategies. The researchers examined shared motivation regulation strategies through coding video data collected from four collaborating groups.

Based on qualitative coding of 139 students' open descriptions of strategies and of two groups' strategic actions observed during motivationally challenging situations, this dissertation extends the catalogue of motivation regulation strategies in two ways. First, strategies individuals and teams use to regulate motivation were categorized into four broad types: behaviour-, cognitive-, emotion-, and environment-control. This categorization reflects the multi-faceted ways for taking control of individuals' and the group's motivation in collaboration. Second, to capture all the relevant modes of regulation, examples of how each strategy can be enacted in the form of self-, co-, and socially shared regulation are described.

Cataloguing motivation regulation strategies in collaboration. From Study 2 and 3 combined, findings indicate that individuals and teams used a breadth of tactics and strategies to initiate, increase, and maintain their levels of motivation in the task (catalogued in Table 5). These strategies can be used alone (self-regulation), for others (co-regulation), and together as a team (socially shared regulation). Table 5 displays four categories of strategies. The first

category of strategies is behaviour control, which refers to students attempts at managing effort and persistence in the task. Group members may influence effort by asking for and providing support, merely spending more time and effort on the task, conducting check-ins to monitor how much effort has been demonstrated, and providing reward upon completing a specific job. In Study 2, most students adopted behaviour control strategies likely because these strategies were perceived as easier to enact and yield the quickest gains (Cooper & Corpus, 2009; Pintrich, Smith, Garcia, & McKeachie, 1993). However, findings from Study 2 indicate that most students who used this strategy early in collaboration were more likely to reencounter the same behaviour-focused motivation challenge in the later phase of their collaboration. Findings suggest that cognitive control strategies, such as planning and setting task goals, may be more effective in reducing the likelihood of reencountering the same motivation challenge during collaboration.

Second, cognitive control strategies involve manipulating cognitive beliefs about efficacy, task value, utility, and goals. One of the common strategies in this category is planning and setting task goals. This type of planning is not merely about assigning tasks to group members but involves building clarifications around the requirements, demands, and goals. When goals have been set, a strategy called promoting goal striving may be adopted; this is where students remind others or themselves of the goals they should be pursuing and to believe in their ability to attain the goals successfully. Wolters (2003) refers to this type of strategy as goal self-talks. Other cognitive control strategies include building positive perceptions of task utility and value, as well as processing relevant knowledge, information, and resources to improve one’s comprehension of the task problem(s).

The third category is emotion control strategies, involving attempts to manage positive and negative emotions that could restore one's interest and enjoyment in the task. To induce positive affect, students may choose to focus on or find aspects of the task or experience that are interesting or enjoyable. In contrast, to reduce negative affect, students may choose to express their feelings and concerns to group members, or actively regulate those emotions through reappraisals. Finally, environment control strategies include students' manipulation of the task and external features to bring one's attention and focus to the task. In doing this, students may choose to reduce their work distractions, and change meeting locations or time to suit group members' needs (see summary in Table 5).

Table 6. *Categories of Motivation Regulation Strategies and Examples of Each Strategy in the Form of Self-, Co-, and Socially Shared Regulation*

Strategy Category	**Target Motivation Construct**	**Examples**		
		Self-regulation	**Co-regulation**	**Socially shared regulation**
Behaviour control	Effort; Persistence			
Social Support: Facilitating others' participation by seeking and providing feedback, promoting openness, accommodating needs, and demonstrating tactics or strategies		I sought help from others in my group in order to get back on track	I supported others by providing feedback and guidance in terms of how to do the task	We tried to create a supportive network and helped each other out in times of difficulties
Task Persistence: Merely spending more time and effort on the task or requesting individuals to spend more time and effort		I merely focused on completing my own work	I requested others to participate more and complete the task as soon as they can	We focused on completing as much work as we can regardless of constraints
Check In: Checking in about the task, progress and/or product		I monitored my task progress and my responsibilities	I checked on my group members' progress with their assigned tasks	We monitored our group progress and product regularly as a team
Reward: Providing some type of reward for completing a task		I promised myself a reward (e.g., an hour of gaming) if I completed the assigned task	*I brought treats to the team meeting to boost group motivation*	*We promised ourselves to go to the ball game together after finishing the task*
Cognitive control	Efficacy beliefs; Task value; Perceived utility; Task goal			
Planning and setting task goals: Planning, setting and revising goals to improve the clarity of individual or group goals, and not merely assigning tasks		I went back to the instructions provided in the course syllabus and thought of a plan for addressing them	I reminded others of the task instructions and requirements, and suggested to reassess our priorities	We clarified our task purposes and goals, and realign differences in task understanding before moving forward
Promote Goal Striving: Reminding about what one needs to strive for; Reminding about one's competency and ability to be successful		I told myself "You can do this!" and strived to achieve my set goal		We kept reassuring ourselves that we are getting there

Utility and Value: Thinking about the benefits and value of engaging in the task		I thought about why it would be important to engage in the collaboration and how it would benefit me in the long run	*I helped explained to others in plain language how the task can help us with our learning and skills development*	*We discussed about the benefits and values of the task in terms of our learning and professional development*
Information Processing: Improving mastery and understanding of the task problem(s) by seeking relevant resources		I searched for relevant information about the topic in the textbook and readings	I brought the group's attention to relevant articles and encouraged them to read before meeting	We searched for relevant information about the topic in the textbook and readings together
Emotion control	Interest; Enjoyment			
Interest & Enjoyment: Focusing on something about the task/experience that interests oneself or that is fun and enjoyable; Inducing positive affect		I focused on the fun aspect of working together with a group of people from different programs	I encouraged others to take the lead in parts of the project that they had the most interest in	We focused on making the task enjoyable by exchanging jokes or sharing about things that excite us
Expressing Emotions: Expressing or communicating emotions; Expressing concerns and/or challenges		I expressed my concerns and feelings about unacceptable behaviours in the team	I encouraged others to voice their concerns and unproductive feelings	We shared our feelings regarding the difficulties we faced in the task
Emotion Regulation: Re-appraising the emotions by sorting out frustrations or becoming flexible with differences which may be the cause of the frustrations; Decreasing negative affect		I altered my negative feelings by being more accepting of differences and the possibility of receiving a lower grade	I helped others to focus on the positives when they freaked out or upset at each other	*We accepted that everyone had different capacity to express themselves and different styles of working*
Environment control	Attention			
Environmental Restructuring: Reducing work distractions; Finding a better workplace, condition, or time to work on the group project		I tried going to the library to get in the mode of working	I suggested to others to use Facebook as a tool for communications	We thought it would better to work outside of lab time and change the meeting location

Note: Italicized refers to a strategy that was not transparent in the dissertation studies and need to be further examined in future research

Italicized strategies in Table 5, such as administering group reward, were not transparent in group conversations; they may have been covertly used at some point during or after the collaboration. As a result, research examining motivation regulation may risk overlooking the prevalence of some strategies. Future research is needed to explore ways to effectively complement objective and subjective data to capture strategies students activate overtly and covertly during collaboration.

It is also worth noting that the strategies catalogued above do not include strategies known to be maladaptive, such avoiding tasks and responsibilities as well as handicapping group functioning by manufacturing obstructions to make performing the group task difficult (see Järvelä & Järvenoja, 2011; Wolters, 2003). These types of maladaptive strategies are far less likely to be self-reported, similar to how individuals are less likely to report that they engaged in social loafing (Karau & Williams, 1993). Although research on these maladaptive forms of strategies is needed, it is more pressing for research to examine strategies that are effective for taking control of motivation in collaboration to support productive learning in collaborative contexts. The catalogue of strategies presented in Table 5 can guide future research to construct a questionnaire related to students' use of motivation regulation strategies in collaboration. Further, research may examine how using specific strategies under specific modes of regulation (self, co, or shared) can influence group members' motivational experience and productivity.

Thus far, findings from Study 2 suggests that not all strategies are effective across all collaborative situations; students choose different strategies during planning, in the early phase, and towards the end of the collaboration. During planning, most students planned to check in regularly with group members to ensure that all members are contributing to and participating in the task. During the early phase collaboration, most students recalled being supportive of each

other to establish a productive motivational state. Towards the end of the collaboration, most students switched to a different strategy that involved reminding themselves and others of the goals they need to achieve. This set of findings highlights the need to consider the changing situational demands in the collaboration process when examining effective motivation regulation strategies for that context. Moreover, findings showing that most students adopted behaviour control strategies suggest that students' strategy repertoire for managing motivation in collaboration may be limited. Therefore, students may need support to practice and experiment with diverse types of strategies, preparing them to regulate more effectively in future collaborations.

Contribution 3: Adaptive and Maladaptive Motivation Regulation

By examining groups' regulatory skills in iteratively addressing situated motivation challenges, the dissertation studies point to several features of adaptive motivation regulation. In the studies, adaptive regulation has been conceptualized as patterns of responses that contributed to the amelioration of motivation challenges during collaboration or that positively contributed to the team motivation and learning. In contrast, maladaptive regulation has been conceptualized as patterns of responses that sustained motivation challenges during collaboration or that negatively influenced the team motivation and learning. Overall, findings indicate that productive motivation regulation is more likely when team members (a) co-regulate peers in positive and encouraging ways, (b) are metacognitively attuned to the diverse needs in the group, and (c) in response, make use of diverse types of strategies.

Co-regulation of motivation plays a role in affording and constraining self- and shared-regulation. Co-regulation is a key metacognitive process that nudges and supports individual members' self-regulation and potentially promotes group members to regulate

collectively as a team (Hadwin et al., 2018). Findings from the dissertation studies demonstrated that using negative and directive language when co-regulating the motivation others may be perceived as domineering, leading to negative feelings and low task motivation. From a self-deterministic perspective, a collaboration involving persistent controlling behaviours by a group member may lower other group members' sense of autonomy and competence resulting in participation withdrawal (Ryan & Deci, 2000; see also empirical support in Näykki et al., 2014). Study 1 and 3 revealed incidences where co-regulation communicated in the form of directive commands thwarted productive self-regulation, and consequently constrained the group's ability to: (a) socially share their regulation and (b) strategically adapt during challenging events. Co-regulation that was proactive and positive appeared to promote a more productive self- and shared-regulation. During the positive co-regulation, group members also tended to be more open in expressing their emotions and struggles. In connection with previous research, this type of openness in communication is more likely when group members experience a sense of psychological safety, allowing them to speak their mind without fearing negative interpersonal consequences such as social rejection (Isohätälä, Näykki, Järvela, & Baker, 2018; Van den Bossche et al., 2006).

Given the text-based nature of the groups' conversation data in Study 1 and 3, directive co-regulatory statements were detected through capitalization of sentences, use of exclamation marks, and requests that restricted other members' abilities to flexibly explore different ways of doing things. In contrast, positive and supportive co-regulatory statements were often accompanied by emoticons and cheery chat expressions such as "*lol* or *hahaha*." For example, a group member may include a smiling emoticon when stating a request such as: "I think everyone should read their part before the meeting ☺." Study 1 and 3 showed that the use of emoticons

and positive acknowledgments were frequent in groups with more favourable socio-emotional experience and team learning productivity. This finding suggests that adding emotions and cheery expressions in group *text* conversations may reduce the likelihood of the messages being negatively misinterpreted, and consequently protect group members' motivation to collaborate.

In addition, research to date suggests that groups with a dominant co-regulator taking the lead were less effective than groups where the co-regulatory role was distributed among team members (Panadero & Järvelä, 2015). However, in Study 3, findings suggest that whether groups have dominant co-regulators during motivation regulation episodes play less of a role in influencing group productivity. The two groups examined in Study 3, each had two dominant co-regulators, but the groups achieved contrasting overall team learning productivity. Findings suggest that the affective tones that followed co-regulation seemed to matter more than the number of co-regulators in a group (see also Rogat & Adams-Wiggins, 2015). In other words, having a leader in a group who takes responsibility in guiding team members' motivation does not necessarily yield an unpleasant outcome. Instead, it depends on the affective tones used to communicate the information needed for regulation.

Co-regulating in a positive tone, however, may be difficult when individuals are frustrated by other members' lack of activity. Findings from Study 3 demonstrated that the group with low team learning productivity had a few group members who were not actively self-regulating but seemed to rely on others to regulate on their behalf. Group members who attempted to co-regulate the motivation of these individuals may have projected their frustrations in the process. Hence, students may require support in activating co-regulatory actions. Supports in the form of metacognitive sentence starters may guide students to discuss the issues productively and promote the necessary regulatory responses from group members (e.g., Hadwin

et al., 2010). Groups may also be provided with tools that allow some of the co-regulatory responsibilities to be offloaded, such as tools that can automatically remind group members of their tasks or display information about individuals' participation and task progress (e.g., Kay, Maisonneuve, Yacef, & Reimann, 2006).

The overlap between co-regulation of motivation and socio-emotional processes may lead some to question the conceptual and theoretical distinctions between the two processes. From the extensive literature on socio-emotional processes (Isohätälä et al., 2018; Kreijns, Kirschner, & Jochems, 2003; Rogat & Adam-Wiggins, 2015; Rogat & Linnebrink-Garcia, 2011), this construct concerns group members' interactive efforts in creating and sustaining a mutually respectful relationships between group members, and includes efforts to create a sense of belonging that fosters positive motivational and emotional experience within the group. In the dissertation studies, co-regulation of motivation can be described as occurring within episodes of socio-emotional processes. Specifically, co-regulation of motivation involves purposeful attempts at supporting group members' motivational appraisals of the task and situations (e.g., interest and adaptive efficacy beliefs; Järvenoja et al., 2018), which could afford or thwart the formation of a more positive socio-emotional atmosphere including perceptions of social cohesion, potency, or psychological safety (Edmonson, 1999). The implication of viewing co-regulation of motivation as a sub-process of socio-emotion is that the vast literature on socio-emotional processes might tell us more about co-regulation of motivation in collaborative contexts than what the current literature has documented about the same construct. Future research should investigate more closely the intertwined relations between social forms of motivation regulation and the distinct features of socio-emotional processes.

Metacognitive awareness of the group's diverse needs and experimenting with diverse types of strategies. Findings in Study 2 revealed that students mostly paid attention to group members' behavioural participation when reflecting on salient motivation challenges throughout the collaboration process. During the early phase collaboration, most students managed this challenge by eliciting and encouraging more participation (behaviour-control) and by manipulating the environmental features perceived to be a hindrance to participation (environment-control). Choosing to address the challenge using such strategies lead to a higher likelihood of students reencountering the same challenge during the later phase of collaboration. This set of findings point to an issue: by focusing on members' behavioural participation, students may neglect the possibility that group members' lack of participation may be due to them not having clear understanding of their role, the task goals, or the implicit values and utilities of the task (see Rogat et al., 2013). Failing to account for this possibility may result in students using a restricted number of strategies that do not necessarily address the root problem.

More productive groups are more metacognitively aware of the group's diverse needs (Bakhtiar et al., 2018; Bakhtiar & Hadwin, 2019; Malmberg et al., 2015; Rogat & Linnenbrink-Garcia, 2011). For instance, findings from Study 1 showed that the group with an overall positive socio-emotional climate had members who, at the beginning of the collaboration, expressed concerns regarding group members' varied expectations about how the group might work. This reflection showed that the group was more metacognitively aware of the needs to engage in proactive forms of regulation. In contrast, the group with an overall negative socio-emotional climate began their group work feeling that everything was fine despite most of them not being well-prepared. The overall negative climate group was also more rigid in their approach as evident by one group member persistently asking to stick with the plan rather than adapting to

emerging situational conditions and challenges. Adaptation is often inconceivable when students do not have feedback or are not metacognitively aware of the issues they need to address in their learning (see Butler & Winne, 1995). Future research should explore effective methods to prompt group members' metacognitive awareness of the potential and occurring challenges to promote more productive regulation.

Study 3 demonstrates that awareness of the group's diverse needs is often accompanied by diverse use of strategies geared to address the behavioural, cognitive, and affective dimension of motivation. This action was evident in the group that had higher team learning productivity but less so in the group with lower team learning productivity. Compared to the low productivity group, the high productivity group was less concerned with the logistical or environmental elements of the task and engaged in more planning in the form of building an understanding of the task purposes and goals. This finding is consistent with past research indicating that less effective groups often focus on regulating task timing or logistics, whereas effective groups tend to focus on regulating equally across the cognitive, behaviour, and socioemotional dimensions of the task (see Rogat & Linnenbrink-Garcia, 2011; Malmberg et al., 2015). In other words, arranging regular group meetings and changing the task environment are not enough to promote positive group motivation or reduce motivation challenges. Instead, to effectively attain a more productive team learning, groups must (a) cognitively engage in active negotiations of ideas, perspectives, and task goals, (b) support individuals' behavioural engagement in the task and (c) consider the motivation and emotions of individuals in the team and create a positive socio-emotional team atmosphere. Overall, in-depth metacognitive knowledge and awareness of the group's diverse needs and task situations are essential in adaptive motivation regulation.

Limitations

Exploratory approach. The aim of this dissertation research was to examine the processes students demonstrate when regulating motivation challenges during online collaboration. Given the dearth of research in the area, the studies conducted were exploratory. Across all studies, we attempted to establish an understanding of how the processes unfold during collaboration and how individual and group motivation regulation processes interact. A small number of groups were used in most studies (Study 1, 3) to gain an in-depth familiarity of the process, and so findings may not be generalizable to the population of collaborative learning groups at large. Also, when exploring an approach to capture the multidimensionality of motivation during collaborative processes, motivation challenges were broadly examined to include behaviour-, cognitive-, and emotion-focused challenges. Future research is needed to develop ways to robustly capture students' perceptions of the different dimensions of motivation related to themselves, others, and the group. Regardless of the exploratory approach, as laid out in the contribution section, findings across the three studies provide a solid foundation for designing a future program of research geared to examine and support motivation regulation in collaboration.

Metacognition was prompted by scripting tools as opposed to self-initiated. The scripting tools introduced in the dissertation studies, which involved asking students to reflect on their task motivation, motivation challenges, emotions, and regulatory responses, may have prompted students to activate regulatory actions. In the absence of a tool prompting reflection and proactive planning, students may not have thought about potentially problematic motivation situations or what actions would proactively address those challenges. However, students who collaborate without such support tools may demonstrate suboptimal patterns of regulation, which

makes it difficult to acquire information about effective regulation (see Winne, 2014). The scripting tools introduced in this dissertation at least revealed the types of supports that may be effective in promoting productive collaboration. Specifically, highly scripted individual task planning (Study 1) and prompts that direct students to proactively strategize for anticipated challenges (Study 2) contribute to groups' positive motivational and emotional experiences during collaboration. Scripting tools in the dissertation studies may be modified and extended to fit with the demands in other collaborative contexts. As more research is conducted with different scripting tools and prompts, it will become possible to examine support features that may be effective for motivation in collaboration.

Selection of a salient challenge. In one of the scripting tools used in the dissertation studies, students were asked to identify one motivational or emotional challenge viewed to be most salient in the moment. By focusing on one salient challenge, the complexity of students' experiences was discounted. In a given moment, a student may experience a range of motivation challenges and emotions that may be equally intense or difficult to comprehend. Methodologically, it was also difficult to capture what is salient at the group-level because individual group members may recall different challenges or emotions in their own reflections. However, individuals were asked to reflect on one salient experience for a practical reason. In practice, it is difficult for students to effectively take control of multiple things at once. Having students focus on one salient challenge allows them to operate more targeted regulatory responses and efficiently take control of the challenge that affects their learning most.

Interaction between task content processing and motivation regulation. Excluding Study 1, motivation regulation was examined in isolation from task-focused regulation or content processing. Consequently, the data was not able to show the interrelations and dynamics between

motivation regulation and task-focused regulation. Research indicates that successful collaboration necessitates groups drawing a balance between high quality joint processing of the task content and high-quality socio-emotional interactions involving proactive motivation regulation (Baker, 2015; Isohätälä et al., 2018; Järvelä et al., 2016; Rogat & Linnebrink-Garcia, 2011). Persistent and productive motivation regulation can contribute to the emergence of a more efficient shared processing of the task content, such as active negotiation, justification and elaboration of ideas and perspectives. Conversely, group members' active participation in task content processing may contribute to their motivation to engage in the task. Both types of regulation should occur in tandem, rather than in succession, for the team achieve a more successful outcome in their collaboration (Rogat & Linnenbrink-Garcia, 2011). Although the dissertation studies did not directly demonstrate the dynamic and intertwined nature of task- and motivation-focused regulation, findings still highlight features of motivation regulation that are more adaptive or contribute positively to teams' cognitive outcome and learning.

Future Directions

Based on the main findings in this dissertation, two broad directions for future research are recommended: (a) examine the standards students' hold for evaluating strategy effectiveness when regulating motivation and (b) design and test the efficacy of supports for motivation regulation in collaboration.

Students' standards for evaluating strategy effectiveness. Drawing from Winne and Hadwin (1998) COPES model of regulated learning, this dissertation research identifies the (a) motivational conditions or challenges that prompt regulation, (b) tactics and strategies students adopted in response to those conditions, and (c) products of the regulatory actions in collaborative learning settings. However, the studies comprising this dissertation did not

systematically examine the “standards” individuals and groups hold with respect to their motivation or socio-emotional outcomes, and the ways in which the standards guide students’ evaluations about strategy effectiveness. Winne and Hadwin assert that standards play a key role in evaluating the need to regulate (see also Butler & Winne, 1995). When standards are vague or unknown to other group members, it may limit the group’s ability to recognize the need for regulation.

Future research should examine the role motivation standards play in groups’ motivation regulation. Questions deserving more attention include: (a) Do group members reveal their individual expectations or standards about motivation and negotiate those standards with the whole team? (b) How might the standards influence individuals’ and groups’ ability to adapt in the face of motivational challenges? And (c) how might the standards influence students’ selection of tactic and strategies? Understanding students’ metacognitive thinking around what motivation means in group work is essential for identifying the foundational sources of information learners operate on when regulating motivation in that context. Furthermore, examining group members’ explicit standards may also reveal the cognitive operations students later use when interpreting cues that correspond or are inconsistent with their motivational standards.

Students’ interpretations of the effectiveness of the strategies they used for regulating motivation in collaboration must also be examined in future research. Steuer and colleagues (Engelschalk, Steuer, & Dresel, 2017; Steuer Eckerlein, & Dresel, 2018) provide three lenses for measuring the effectiveness of motivation regulation strategies, including (a) *fit*—choosing a strategy that appropriately addresses the problem, (b) *quantity*—the frequency and extent to which the strategy is used, and (c) *quality*—optimal implementations of the strategy. The

problem with using such indicators is that they rely on the researchers' subjective interpretations. When determining "fit," researchers are inferring that there must be a direct match between the type of challenge experienced and the type of strategy applied. For example, an interest enhancement strategy may be judged as most fitting for when individuals experience a low task interest. A mismatch between the challenge and strategy type would be construed as unfit, and so students may be evaluated as being less proficient at regulating motivation. This approach is questionable because research indicates that students do not necessarily demonstrate a match, but may still experience success in regulating their motivation (e.g., Järvelä et al., 2008; Wolters, 2003). The fundamental tenets of regulation dictate that regulation is intentional and goal-directed; individuals exercise personal agency by activating regulatory actions to attain internally set goals and standards. As such, researchers should examine strategy effectiveness based on students' own judgment in terms of how effective the strategy was in helping them attain the goals or standards they hold about motivation in the collaborative task.

Supporting motivation regulation in collaboration. A second avenue for research concerns designing the appropriate supports for motivation regulation in collaboration. Thus far, instructional supports for motivation are often ignored in computer-supported collaborative learning environments (see Belland et al., 2013). Two streams of supports are relevant for future development: technological tools and direct instructions on effective strategies for regulating motivation in collaboration.

In line with previous research (Hadwin et al., 2018; Hadwin et al., 2015; Järvenoja, Järvelä, & Malmberg, 2017), findings in this dissertation indicate that scripting tools introduced during pre-task planning may reduce the likelihood of students encountering intense motivational challenges during collaboration. Findings point to the importance of supporting individuals'

preparations for the collaborative task by guiding students to develop a better understanding of the task demands (Study 1). Highly scripted planning which prompted individuals to identify implicit and explicit task instructions seemed to contribute positively to groups' socio-emotional experience, compared to loosely scripted planning which prompted individuals to construct task understanding on their own. It is possible that when students take the time to consider the specific task demands, students would also be likely to reflect on the value of engaging in the task and constructing more concrete goals that direct efforts towards the task (Belland et al., 2013; Miller & Hadwin, 2015). Thus, support tools for motivation in collaboration may not necessarily need to involve reflecting on motivational beliefs or current motivation levels (e.g., Schoor Kownatzki, Narciss, & Körndle, 2014). Instead, the tools can include those that promote all members in the group to develop better clarity of the intended aims and purposes of the task.

The second promising scripting tool involved prompting metacognitive awareness of motivation challenges individuals or the group may anticipate during collaboration (Study 2). Such prompts may have encouraged students to engage in proactive regulation because students' ratings of the intensity of motivation challenges were lower during collaboration than anticipated during planning. However, future research would need to examine whether such prompts influence groups' conversations about motivation and truly promote proactive regulation.

Future research should also examine the effect of supporting group-level awareness of the various sources of motivation challenges in collaboration. Findings in Study 3 indicate that better awareness of the group's diverse motivational needs and challenges may contribute to more productive team learning. Hence, visualization tools that provide a summary of group members' perceptions of several types of motivation challenges and a strategy guide for each challenge type may promote groups to regulate equally across different dimensions of motivation.

Järvenoja et al. (2017) tested an awareness tool called the S-REG, which presents groups with information about the group's motivation and emotion level going into the task. Upon viewing the visualized information, groups were asked to identify sources that contribute to the group's motivation level, such as issues with task interest, competency beliefs, or goals. The tool subsequently prompted groups to select a strategy that corresponds well to the identified source of challenge. The study's findings demonstrate that the tool was effective in promoting a high frequency of co-regulation at the beginning of the task, but the high frequency could not be maintained during collaboration. Without supports during collaboration, group members may lack the metacognitive awareness of the emerging issues related to the group's motivation, therefore, less regulation is demonstrated during collaboration.

Furthrmore, support tools in the form of in-the-moment guidance should be examined to support group regulation during emerging episodes of motivation challenges. Designing such supports may require an unconventional approach that allows incidence of challenges to be detected automatically by technological tools. Researchers are beginning to explore physiological data collected using wearable technologies to detect "challenging" moments in collaboration (see Järvenoja, Näykki, Törmänen, & Järvelä, 2018). However, to offer a robust in-the-moment guidance, researchers must (a) take stock of the types of motivation challenges that may emerge during a collaborative process and (b) examine the types of strategies that could effectively address those challenges.

Direct instruction about effective strategies for motivation regulation in collaboration and related training may also be worthwhile in improving students' capacity to respond to motivation challenges in that context. For example, Steuer et al. (2018) trained students' individual motivation regulation skills by taking students through multiple vignettes of studying and

choosing strategies to either influence task value, success expectancy, or overall task motivation. Their training showed some promising results in terms of students' ability to choose a strategy that fits with the problem at hand, an increase in the frequency of strategy use and the quality of enacted strategies. Steuer et al.'s (2018) training can be adapted to focus on scenarios specific to collaboration, illustrating motivation challenges groups across different learning contexts commonly encounter. Students also need to be trained to practice regulating under different modes to develop skills for regulating individually, for others, and together with a team. Training students to develop motivation regulation skills for collaboration departs from the typical team-building training that tends to focus on communication and "team-building" skills (e.g., Hansen, 2008). The aim of motivation regulation training is not about increasing students' motivation level and eliminating motivation challenges. Instead, such training aims to improve learners' ability to strategically respond to emerging motivation challenges during collaboration across different contexts.

Conclusions

The three studies comprising this dissertation contributed to the main aim, which was to examine undergraduate students' regulatory decisions and actions to motivation challenges in the context of computer-supported collaborative learning setting. The COPES-based model of regulated learning used in the studies provided a valuable theoretical framework for examining students' motivation regulation during authentic and complex collaborative learning tasks. The conditions and challenges that trigger motivation regulation, the tactics and strategies students demonstrate during episodes of motivation regulation, and the dynamic interplay between self-, co-, and socially shared regulation of motivation were the cornerstones of this dissertation research. Overall, students, to some degree, exercised regulatory actions in response to

anticipated and experienced motivation challenges in collaboration. Students engaged in a cyclical regulatory process and dynamically oscillated between self-, co-, and socially shared-regulation as needed. Co-regulation coupled with a positive affective tone played a role in promoting productive self- and shared-regulation of motivation. Also, active self-regulation exercised in preparation for and early in the collaboration had a notable influence on groups' motivational experience. When individuals were well-prepared for collaboration and engaged in proactive forms of self-regulation, a more productive socially shared regulation was more likely. Without active self-regulation distributed across group members, co- and shared-regulation could become limited. In practice, motivation regulation may need to be highly supported at the individual level and this would likely transfer to a more productive co- and shared-regulation.

Motivation challenges in collaboration were less influenced by group members' motivational appraisals of the task but possibly emerged from the complex interactions between individuals and the task. Sources of motivation challenges in collaboration could originate from (a) behavioural difficulties related to effort, (b) cognitive beliefs about efficacy, task value, and goals, (c) emotional reactions towards the task or individuals in the task, and (b) environmental task features and distractions. The various strategies students used for regulating motivation challenges in collaboration were catalogued in this dissertation, providing a solid empirical and practical foundation for future research. Groups benefited from using diverse types of strategies rather than narrowing their practice to behaviour- and environment-control strategies. However, to activate diverse types of strategies, groups need to build a solid metacognitive awareness of the group's diverse needs and challenges as well as metacognitive knowledge about effective strategies.

Studies in this dissertation demonstrate a need to support students' practice of motivation regulation during collaboration. At this point, there is more to understand about students' motivation regulation in collaboration, such as the timing and manner in which self-, co-, and socially shared-regulation of motivation can be promoted and supported. Future research needs to examine ways to design effective technological tools and strategy instructions for supporting motivation regulation in collaboration. In doing so, researchers must draw from the goals and standards students hold about motivation in collaboration, and students' interpretations of success during motivation regulation practices. Understanding students' metacognitive thinking in terms of what motivation means in collaboration and what successful motivation regulation is could lead researchers to identify the foundational sources of information learners operate on when regulating motivation in collaborative contexts.

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Appendix A: Ethics Certificate

University of Victoria | Office of Research Services | Human Research Ethics Board
Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Certificate of Renewed Approval

PRINCIPAL INVESTIGATOR:	**Allyson Hadwin**	**ETHICS PROTOCOL NUMBER:**	**08-07-308b**
UVic STATUS:	**Faculty**	ORIGINAL APPROVAL DATE:	20-Jun-08
UVic DEPARTMENT:	**EPLS**	RENEWED ON:	13-Jun-18
		APPROVAL EXPIRY DATE:	19-Jun-19

PROJECT TITLE: **PAR-21: Promoting Adaptive Regulation for the 21st Century**

RESEARCH TEAM MEMBER Co-principal Investigator: Dr. Phil Winne (SFU);
COLLABORATORS: Dr. Sanna Järvelä (U of Oulu), Dr. Paul Kirschner (Open University of Netherlands), Dr. Margaret-Anne Storey (UVic), Dr. Peter Wild (UVic), Dr. Daniel Dinsmore (UNF), Dr. Meghan Parkinson (UNF), Dr. Lindsay McCardle (U of Ottawa), Dr. Mariel Miller (UVic), Dr. Todd Milford (UVic);
GRADUATE STUDENTS/RESEARCH ASSISTANTS (UVic): Elizabeth Webster, Aishah Bakhtiar, Rebecca Edwards, Shayla Starcheski, Sarah Davis, Priyanka Sharma, Natalie Usher, Sarah Greco

DECLARED PROJECT FUNDING: **Learning & Teaching Centre (2017); Technology Integrated Learning (2016); SSHRC Insight Funding (2012-2016); SSHRC Insight Funding (2008-2010); CFI-LOF (2009-2013); Learning Without Borders, Learning & Teaching Centre (2013); SSHRC Insight Grant (2018 - 2023)**

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

[redacted]

Dr. Rachael Scarth
Associate Vice-President Research Operations

Certificate Issued On: 13-Jun-18

08-07-308b Hadwin, Allyson

Appendix B: Consent Withdrawal Form

UVic Department of Educational Psychology & Leadership Studies	*Consent Withdrawal Form*	Technology Integration and Evaluation Research Lab

Why participate in research that evaluates student learning and the ED-D 101 Course?

In ED-D 101, you have the opportunity to experiment with your own learning in order to become a better learner. The information and practices that guide you through this process have been developed from theory and research about student learning. Each semester, ED-D 101 undergoes changes and revisions based on findings from the ED-D 101 research. Learning experiences from a large number of students are needed to continue to improve the course. By participating in this research you inform students, researchers, university instructors, and administrators who strive to help students succeed at university.

Purpose of the research

- To understand how to support students (like yourself) to become academically successful and develop lifelong learning skills.
- To compare learning processes and successes of ED-D 101 students with students who have not taken the course.
- To inform evidence-based decision making about ED-D 101 (expansion, course content, course activities).
- To inform theory and research about strategic regulation in educational psychology and educational technology.

Participation in this research involves:

- ***No additional work or time*.** Your regular coursework will be examined for research purposes after the course is completed and final grades have been submitted. Data include:
  - ED-D 101 course assignments, lab activities, tests, and discussions (online or audio/video recorded) submitted to CourseSpaces and Fluidsurvey;
  - ED-D 101 CourseSpaces data, including activity reports;
  - Course and assignment grades for concurrent Pathways course; and
  - institutionally collected performance indicators (e.g. GPA, yearly GPA, and exit surveys) throughout your undergraduate degree
- ***There are no known or anticipated risks.***

Participation is voluntary: You can withdraw at anytime

You may withdraw anytime this semester by clicking on the electronic consent form in CourseSpaces and indicating “decline to participate”. In the case of group work, withdrawal of participation will mean that an individual’s contributions to the group will not be examined. When individuals cannot be removed completely from the data sets (e.g., group project grade or shared planning forms), data will be used in summarized form with no identifying information.

Data will be confidential even though coursework is not anonymous

Course assignments and activities with your name or student ID are not anonymous. However, your confidentiality will be protected by (1) summarizing data in a spreadsheet with a random case number whenever possible and (2) summarizing data across many students or using pseudonyms when specific examples are used.

Course instructors will not know you are participating in this research

Instructors and teaching assistants will not know who has consented to participate in the research during the semester. Consent forms will be collected by a third party and released to the research team after course completion and grade submission.

What will happen to data and how will findings be reported and shared?

Electronic data will be archived and stored on a password protected server only accessible to the researchers. Files will be stored for approximately 10 years, after which they will be erased. Data will be analyzed by Dr. Hadwin and her research collaborators. Findings will be presented through academic publications/presentations, the research website (http://allysonhadwin.wordpress.com/), student theses, and reports to university administrators. Identifying information will be removed whenever examples are used in ED-D 101 or presentations.

Social Networking Privacy Notice

Some activities/assignments in this course use social networking platforms such as Google + or ZohoChat. Please be advised that data collected within these platforms are likely stored on servers located outside of Canada. As a result, retention, access to, and the secondary use and disclosure of any personal information you disclose are subject to the social networking site's terms of use, privacy policies and foreign law. You are encouraged you to read the social networking site's terms and conditions on their website prior to starting any activities. Students are encouraged to use first name and last initial only when using these networking tools.

UVic cannot require students to disclose personal information to technologies or organizations which may store information on servers located outside of Canada because disclosure of personal information to vendors, systems or services storing or accessing that personal information outside of Canada is restricted by Section 30.1 of BC's Freedom of Information and Protection of Privacy Act (FIPPA). Personal information is information about an identifiable individual; for example, your name or your email address. If you are not comfortable with your personal information being stored outside of Canada, you may sign up for the tool using a nickname and non-identifying email. However, you will be required to inform your instructor of the nickname and email you choose.

Contacts

Feel free to contact any of the following with questions, comments, or concerns:

- *During the course:* Dr. Tim Black or Dr. Ralf St. Clair
- *After the course:* Dr. Allyson Hadwin Note: Do not contact Dr. Hadwin during the course because she is a course instructor and cannot know which students are participating until course grades are submitted.]
- Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

This research (***Par21: Promoting Adaptive Regulation for the 21st Century***) is led by Dr. Allyson Hadwin (Principal Investigator) and funded by the Social Sciences and Humanities Research Council of Canada (SSHRC-INE grant) and the Canadian Foundation for Innovation (CFI-LOF).

By registering in ED-D 101, you are automatically included in research about student learning and success. Your signature below indicates that you would like to <u>withdraw</u> your consent from research in ED-D 101.

Name: _____ *Signature:* _____ *Date:*_____

Appendix C: Original Manuscripts

Manuscript 1: Bakhtiar, A., Webster, E.A., & Hadwin, A.F. (2018). Regulation and socio-emotional interactions in a positive and a negative group climate. *Metacognition and Learning, 13*(1), 57-90.

Note: Following is the accepted manuscript version. Per the publisher, the accepted manuscript version may be made publicly available 12 months after official publication. The final publication is available at https://link.springer.com/article/10.1007%2Fs11409-017-9178-x. The citation format in this manuscript followed the requested format of the journal.

Regulation and Socio-Emotional Interactions in A Positive and A Negative Group Climate

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Compliance with Ethical Standards:

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Abstract

Collaboration in an online environment can be a socially and emotionally demanding task. It requires group members to engage in a great deal of regulation, where favourable emotions need to be sustained for the group's productive functioning. The purpose of this cross-case analysis was to examine the interplay of two groups' regulatory processes, regulatory modes, and socio-emotional interactions that contribute to or are influenced by emotions and socio-emotional climate perceived in the group. Specifically, this study compared a group of 4 students unanimously reporting a positive climate to a group of 4 students unanimously reporting a negative climate after completing a 90-minute online text-based collaborative assignment. By drawing on two data channels (i.e., observed regulatory actions and socio-emotional interactions during collaboration and self-reported data about emotional beliefs and perceptions), four contrasting group features emerged: (a) incoming conditions served as a foundation for creating a positive collaborative experience, (b) regulation of emotions during initial planning, (c) negative emotions served as a constraint for shared adaptation in the face of a challenge, and (d) encouragement and motivational statements served as effective strategies for creating a positive climate. Implications for researching and supporting emotion regulation in collaborative learning are discussed.

Keywords: Cross-case analysis; Computer-supported collaborative learning; Regulation; Socio-emotional interactions; Emotions

Introduction

The ability to work well in a group is a highly valued and sought-after 21st century learning skill (Partnership for 21st Century Learning 2007). A growing emphasis on virtual teamwork in the workplace (Martins et al. 2004) makes learning to collaborate in online environments an important skill for university students to attain. Productive collaboration is a complex and challenging process requiring teams to leverage diverse expertise to optimize knowledge construction and output. Regulatory processes such as planning, monitoring, and adapting are touted as critical for facilitating productive collaborative learning outcomes (Hadwin et al. 2011). Furthermore, because these regulatory processes occur in a social context, interpersonal processes should also be taken into account when examining factors that contribute to productive collaboration (Barron 2003; Van den Bossche et al. 2006). Although performance is commonly used as an indicator of productive collaboration, another important indicator is group members' perceptions of their experience, as these perceptions are carried forward as beliefs and knowledge informing approaches to future collaborative work. This study aims to contribute to a growing literature examining both regulatory and social processes in the context of group work. We compare two groups with contrasting collaborative experiences, focusing on how socio-emotional interactions as embedded in regulatory actions contribute to each group's perceived socio-emotional climate over the course of an online collaborative assignment.

Regulating Learning in Collaboration

Regulatory processes. Theoretical frameworks describing regulation in the context of social learning are still at their nascent stage. With conceptions of self-regulated learning (SRL) as a foundation, researchers are beginning to define other social forms of regulation occurring in highly dynamic and interactive learning situations such as collaboration (Hadwin et al. 2011;

Järvelä and Hadwin 2013; Järvelä et al. 2008; McCaslin and Good 1996). For example, Hadwin et al. (2011) draw heavily from Winne and Hadwin's (1998, 2008) SRL model, in which regulation of learning is conceptualized as unfolding over four loosely sequenced and recursive phases: (a) task understanding, in which learners construct a mental representation of the task; (b) goal setting and planning, in which learners set goals and strategize to meet task demands; (c) task enactment, in which learners enact tactics to achieve goals; and (d) small- and large-scale adaptation, in which learners strategically adapt task perceptions, goals, and engagement within and across tasks. At the core of the recursive cycle is metacognitive monitoring—a process necessary to evaluate and make strategic changes to learning. In this paper, we refer to the actions of planning (encompassing the first two phases), enacting, adapting, and monitoring as fundamental *regulatory processes*, which are necessary for effective learning. Winne and Hadwin (1998, 2008) also emphasize each phase of SRL shapes and is shaped by five recursively cycling features referred to as a COPES (conditions, operations, products, evaluations, and standards). The COPES architecture, catalyzed by metacognitive monitoring, underlies each phase of regulation and guides transition across phases. Internal and external *conditions* provide a context for engagement in each regulatory phase. Internal conditions are comprised of factors internal to the student or group, such as prior knowledge, motivation, and emotions. In contrast, external conditions are comprised of factors external to the student or group, such as task demands, resources available, and time constraints. Students cognitively process or manipulate information through *operations*, resulting in *products* in each phase, which may in turn become conditions for the next phase (e.g., the product of task understanding in the first phase becomes a condition for setting goals in the second phase). Finally, students construct judgments or *evaluations* of the products by comparing them to set or perceived *standards*.

Modes of regulation. Contemporary perspectives of collaboration expand on prior work by emphasizing the role of three *modes of regulation* in productive collaboration, including self-regulated learning (SRL), co-regulated learning (CoRL), and socially-shared regulation of learning (SSRL; Hadwin et al. 2011; Hadwin et al. 2017; Järvelä and Hadwin 2013; Miller and Hadwin 2015a; Winne et al. 2013). SRL refers to a goal-directed process of planning, monitoring, and adapting cognitions, behaviors, motivation, and emotions in order to accomplish individual learning goals (Pintrich 2000; Zimmerman 1989, 1990). CoRL refers to individuals or groups temporarily supporting or influencing one or more team members' regulatory processes. Finally, SSRL refers to group members collectively negotiating and realigning or adapting group regulation processes in the service of a shared outcome. All three modes of regulation are vital in collaboration and can unfold in tandem while members are working alongside each other (Hadwin et al. 2011). Consequently, conditions, operations, products, evaluations, and standards (COPES) within collaborative contexts not only extend beyond an individual, but also dynamically interact across various regulatory modes. Importantly, the COPES-based model of regulation extended to co-regulation and shared regulation recognizes behavior, motivation, cognition, and emotions are conditions and products of regulation fueled by metacognitive knowledge, beliefs, and processes. Awareness or meta-knowledge of behavioral, cognitive, motivational, and emotional states as well as desired targets fuels regulatory action.

One underemphasized aspect of regulation in collaborative contexts is the regulation of motivation and emotion (Dillenbourg et al. 2009). Students assigned to work in groups can experience a range of emotions connected to themselves, the task itself, the task context or environment, one or more other group members, or the group's collective strategies as a whole (Järvenoja and Järvelä 2005; Wosnitza and Volet 2005). Regardless of the source, emotions may

facilitate or hinder the collaborative process and, ultimately, the cognitive, behavioral, and motivational outcomes of group work. Research indicates affect plays an important role in group work, with positive affect typically associated with beneficial outcomes such as engagement and higher levels of performance and satisfaction (Jehn 1997; Rogat and Linnenbrink-Garcia 2011; Volet et al. 2009). Negative affect, if strong and persistent, is typically associated with detrimental outcomes such as withdrawal and lower levels of performance and satisfaction (Chiu and Khoo 2003; Duffy and Shaw 2000; Linnenbrink-Garcia et al. 2011; Näykki et al. 2014). Thus, in addition to regulating cognitions and behaviors, the ability to regulate helpful or harmful emotions in a group setting may contribute to productive collaboration.

COPES in Group Regulation of Emotions

The COPES architecture described by Winne and Hadwin (1998, 2008) provides an ideal context for explaining how emotion regulation occurs within collaboration because the model takes into account micro-elements of regulation that are external and internal to the regulator. Figure 1 demonstrates where the constructs specific to this study can be found within an individual's or the collective group's COPES cognitive features. We first provide an overview of Figure 1, followed by a more detailed discussion of the main constructs examined in this study.

Overview. Individuals and groups enter each collaborative work session with a set of internal and external conditions, which set the stage for self-, co-, and shared regulation of learning. As individual members and groups as a whole move in and out of regulatory processes at the macro level (i.e., planning, enacting, and adapting), they create cognitive, behavioral, and affective products via the operations they engage. After being monitored and evaluated against set or perceived standards, these products then become conditions, influencing subsequent regulatory actions. In this study, we were specifically interested in the conditions and operations

that led to the emotional product and subsequent condition of socio-emotional climate. As shown in Figure 1, we posit conditions and operations should not be limited to affective processes. Rather, we extended our investigation to include cognitive and behavioral processes because these may also create emotional products. During collaborative learning, however, there may be situations that call for an increased focus on the emotional aspects of regulation. In these situations, individuals and groups may enact various strategies (instantiations of operations) to specifically manage their emotions and create or maintain a productive socio-emotional climate. In a text-based online environment, we view socio-emotional interactions among group members (e.g., politely acknowledging contributions) as observable operations; the products of manipulating these interactions may include renewed emotions and a positively or negatively enriched socio-emotional climate. Thus, in addition to a broader examination of the regulatory processes and modes engaged by the groups at the macro level, we specifically examined the nature of each group's socio-emotional interactions embedded within the micro elements of COPES. We view socio-emotional interactions as part of—rather than separate from—regulatory cycles because those interactions are assumed to serve the purpose of regulating emotions in social contexts. Finally, group members make judgments or evaluations of their emotional experiences during collaboration by comparing emotional products with perceived standards. Emotional products during and after collaboration play an important role in future collaboration (in this task or beyond; with this group or beyond) because they are conditions informing subsequent regulatory cycles.

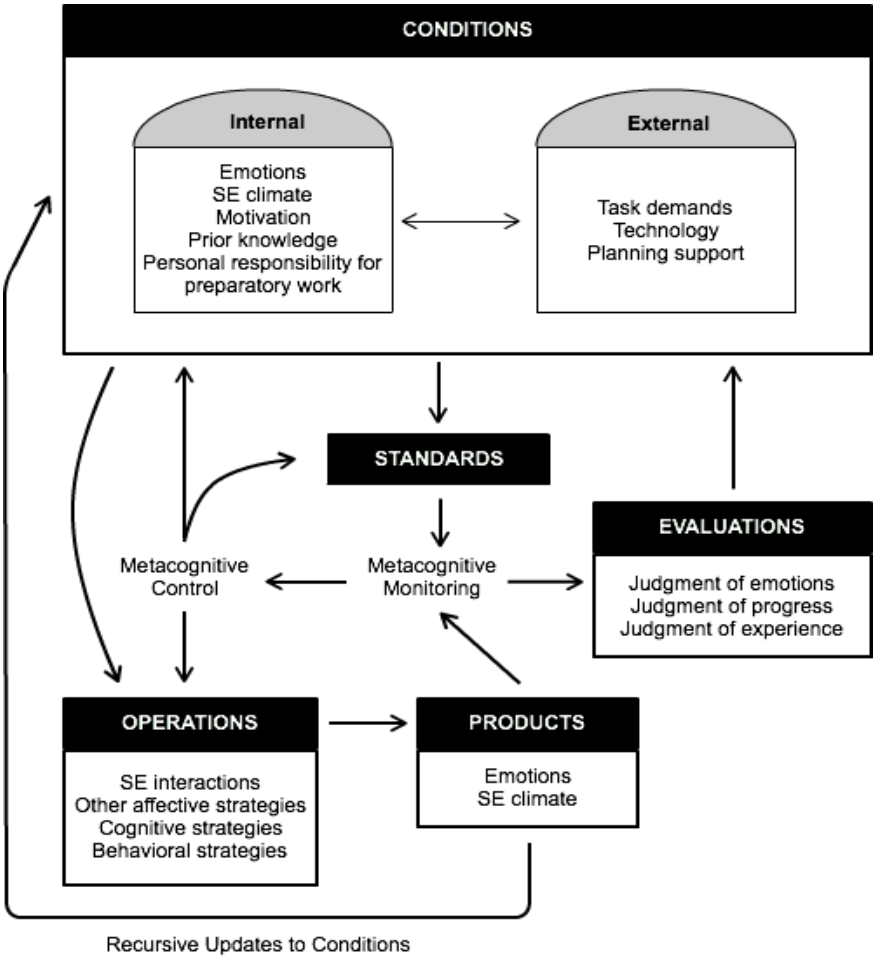

Fig. 1 Study constructs embedded within the COPES architecture. SE = socio-emotional.

Next, we further explain and distinguish three emotion constructs using the COPES typology: emotions, socio-emotional climate, and socio-emotional interactions.

Emotions as conditions and products. Emotions can be viewed as multi-componential entities made up of affective experiences or feelings, physiological responses, cognitive processes, behaviors or expressions, and/or action tendencies (Kleinginna and Kleinginna 1981; Scherer 2005; Solomon 2008). Although it is possible to distinguish among different affective constructs, such as mood and emotion (e.g., see Rosenberg 1998), we adopt a broader perspective in line with Boekaerts (2011) who indicates “the term ‘emotion’ is used in every-day

language to refer to affectively charged cognitions, feelings, moods, affect, and well-being" (p. 412). Other researchers have also treated constructs such as mood and emotions more or less interchangeably (e.g., Koole 2009; Pekrun 2006).

From the perspective of the COPES model (Winne and Hadwin 1998, 2008), emotion is viewed as both an internal condition that frames how individuals or groups engage in regulatory processes as well as a product of that same engagement. For example, as a condition, one member's anxiety may lead to poor monitoring of group work, and that low quality monitoring may result in the products of greater anxiety and a sense of dissatisfaction. As the cycle continues, anxiety and dissatisfaction become conditions for subsequent engagement. As shown in the Conditions box in Figure 1, we acknowledge that the internal condition of emotions may interact with external conditions such as task demands, technology, and/or experimental conditions (e.g., level of planning support). We also emphasize that a regulation of learning perspective focuses on learners' *perceptions* of their emotions rather than the physiological responses, of which learners' may or may not have metacognitive awareness. To reiterate, regulation of learning is fueled by metacognitive monitoring—without awareness of one's current and desired states, purposeful regulation will not occur. For instance, recognizing that anxiety adversely influences the quality of work enables the learner to deliberately select and experiment with strategies for decreasing that emotion.

Socio-emotional climate as a condition and product. The socio-emotional climate of a group is determined by the behaviors of and interactions among group members, such as when group members demonstrate reliability and support and encourage each other (e.g., Janssen at al. 2010; Kwon et al. 2014). The range of emotions experienced within a collaborative setting, collectively, can contribute to group socio-emotional climate (Järvenoja and Järvelä 2009;

Järvenoja and Järvelä 2013; Volet and Mansfield 2006). However, group members' emotional states (individually or collectively) are not synonymous with socio-emotional climate, but rather may influence the behaviors and interactions that determine perceptions of climate. The differences between emotions and climate can be viewed as analogous to the weather system, where emotions occur as events (e.g., rain or shine) and socio-emotional climate is the persistent pattern of shared emotions and behaviors over a longer period of time (e.g., temperate moist coastal climate). The relation between emotions and socio-emotional climate is likely reciprocal, with emotional reactions enriching the description of a climate and vice versa. For instance, when a group member perceives a positive climate of trust and support in his group, this may produce affective responses such as increased confidence and decreased anxiety. These responses may then promote further positive socio-emotional interactions, helping to maintain the positive climate.

In Winne and Hadwin's (1998, 2008) COPES framework, we view socio-emotional climate as a product impacted by incoming conditions and operations, subsequently becoming a condition for further regulatory processes. During collaboration, socio-emotional climate may be monitored and evaluated by group members, which may result in individual members or the group as a whole enacting strategies to create or maintain a positive working climate. Socio-emotional climate, thus, fits into the model the same way emotions do; however, we view climate as less malleable and more persistent because it involves aggregation over events and people, rather than being a situational, in-the-moment response like emotions.

Socio-emotional interactions as operations. Unlike the perceptions that comprise emotions or socio-emotional climate described above, socio-emotional interactions refer to the purposeful interchanges (often communication) among group members that shape perceptions of

emotions and socio-emotional climate, such as developing trust and cohesion, providing and seeking support, and building confidence and motivation (Kempler and Linnenbrink 2006; Kreijns et al. 2003; Marks et al. 2001). Ideally, socio-emotional interactions between and among group members are positive in character, encouraging harmonious group functioning and positive emotions during group work. However, it is possible for socio-emotional interactions to undermine group functioning, particularly when negative socio-emotional interactions persist (Rogat and Linnenbrink-Garcia 2011) or when students do not possess appropriate skills to navigate group work (Järvenoja and Järvelä 2009). Prior research demonstrates socio-emotional interactions are interconnected with other regulatory processes and play a role in regulation of emotions. For example, positive socio-emotional interactions have been linked to higher quality and facilitative forms of social regulation (Rogat and Adams-Wiggins 2015; Rogat and Linnenbrink-Garcia 2011), co-regulatory acts that activate discussion and metacognitive acts of evaluation (Lajoie et al. 2015), and conflict resolution and improvement in emotions and motivation (Ayoko et al. 2012; Linnenbrink-Garcia et al. 2011; Näykki et al. 2014). In contrast, negative socio-emotional interactions have been connected to less effective and more directive forms of social regulation (Rogat and Adams-Wiggins 2015; Rogat and Linnenbrink-Garcia 2011) as well as negative emotions and lowered motivation (Näykki et al. 2014).

When situated in the COPES architecture (Winne and Hadwin 1998, 2008), we posit socio-emotional interactions can be viewed as manifestations of operations, being influenced by internal and external conditions and contributing to the affective products of group members' emotions and socio-emotional climate. Thus, the regulation of emotional aspects of group work includes taking control of methods of communication that can induce or mollify positive or negative emotions, ultimately contributing to the group's productivity and socio-emotional

atmosphere (Järvenoja and Järvelä 2013; Kreijns et al. 2003). Note that both internal conditions and products include group members' individual and collective emotions as well as the emerging socio-emotional climate. As conditions and products, emotions and socio-emotional climate both influence and result from the operations of socio-emotional interactions. Indeed, it is likely the three constructs—emotions, socio-emotional climate, and socio-emotional interactions—continually interact with one another throughout a collaborative session, such as when frustration is provoked by a persistent negative atmosphere, calling the group to regulate that emotion by changing the tone of their interactions.

Section summary. In essence, the dynamic and multidimensional activities that occur in collaboration imply emotion regulation in such contexts should occur at both the individual and group level to ultimately create and maintain a positive group climate necessary for productive collaboration (Järvenoja and Järvelä 2009). More specifically, groups employ different modes of regulation where they (a) self-regulate their own emotional states, (b) co-regulate fellow group members to regulate their emotional states, and (c) socially share in the regulation of the group's emotional states (Hadwin et al. 2011). Research examining emotion regulation in collaboration is limited, but empirical evidence provides support for the use of both individual and group-level regulation to overcome socio-emotional challenges and maintain positive group functioning (e.g., Ayoko et al. 2012; Järvenoja and Järvelä 2009; Näykki et al. 2014).

Purpose

Although research examining the affective dimension of collaboration is growing, limited research examines the regulatory behaviors and actions that contribute to or are influenced by a positive or negative socio-emotional climate, particularly in the context of computer-supported collaborative learning (CSCL; Dillenbourg et al. 2009; Järvelä et al. 2015). Not only might

CSCL environments present different emotion-eliciting challenges than face-to-face environments, but the expression and regulation of emotions might also differ, particularly when group members are limited to chat-based communication where traditional non-verbal cues (e.g., facial expressions) are absent. In a review, Derks et al. (2008) found evidence to indicate intense negative emotions were expressed more frequently in online interactions than in face-to-face interactions, which the authors propose may be due to being unaware of the impact of one's negative emotional reactions on other participants. The finding suggests there may be a need for more or different types of regulatory actions to encourage harmonious group functioning during online collaboration. Although emotion regulation was not a focus of their review, Derks et al. posit emotions can be more easily regulated in online communications because (a) typing a message provides time to monitor and control one's emotional expression and (b) participants do not observe each other's non-verbal emotional expressions. We agree that chat-based interactions may facilitate self-control over one's emotional expressions, but it may also be the case that a lack of traditional non-verbal cues may impede co- and shared regulation of emotions because of the difficulty in noticing others' emotions. To our knowledge, research examining socio-emotional processes in the context of regulation has mainly relied on observations of these processes during video-taped face-to-face collaborative sessions (e.g., Lajoie et al. 2015; Näykki et al. 2014; Rogat and Adams-Wiggins 2015; Rogat and Linnenbrink-Garcia 2011), although investigations within online settings are beginning to emerge (e.g., Janssen et al. 2010; Kwon et al. 2014).

This study provides two important extensions to prior research. First, we performed an in-depth analysis of two contrasting groups' socio-emotional regulation embedded within their broader regulatory behaviors, triangulating our interpretations (see Pitman and Maxwell 1992)

by drawing on two data channels: (a) observed regulatory processes (i.e., planning, enacting, adapting, and monitoring), regulatory modes (i.e., SRL, CoRL, and SSRL), and socio-emotional interactions during online collaboration and (b) data about emotional beliefs and perceptions gathered through self-reports before, during, and after collaboration. Second, unlike past research, we drew heavily from Winne and Hadwin's (1998, 2008) model of SRL and current conceptualizations of self-, co-, and shared regulation (Hadwin et al. 2011; Järvelä and Hadwin 2013; Miller and Hadwin 2015a; Winne et al. 2013) to guide our investigation. Towards this end, our analysis acknowledged the possibility that regulation of emotions occurs at individual and group levels.

The purpose of this exploratory case study was to examine the regulation of socio-emotional aspects of collaboration demonstrated by two groups with contrasting socio-emotional climates (positive vs. negative). Three research questions guided the inquiry: (a) with what set of conditions did each group enter the collaborative task, (b) how did the observed regulatory processes, regulatory modes, and socio-emotional interactions fluctuate and interact in each group, and (c) what were group members' perceptions of the collaborative experience in terms of their emotional reactions? To answer these questions, we conducted a qualitative cross-case analysis of two groups of undergraduate students collaborating on an online case-analysis assignment. More specifically, we adopted Braun and Clarke's (2006) thematic analysis methods to draw dominant distinguishing features between the positive and negative climate group.

Methods

Instructional Context

The broader context of this case study was a semester-long undergraduate course about learning processes and strategies for academic success. The purpose of this course was to equip

students with the skills to engage in strategic, reflective, and adaptive individual and collaborative learning. Among other graded and non-graded assignments, where students individually applied research from the learning sciences into their own studying, the course included two online collaborative assignments. The collaborative assignments together accounted for 30% of the final course grade and were introduced once in the middle and once towards the end of the semester. Given the exploratory nature of this study, only the first assignment data were analyzed.

The assignment included macro and micro scripts to help students navigate the collaborative process. At the macro level, students were guided through three broad phases of collaboration including (a) solo and group planning and preparation, (b) task enactment of a collaborative case analysis task, and (c) reflecting in order to adapt in future collaborative work. Each phase contained one or more supporting micro scripts. Figure 2 shows the specific macro-script steps guiding groups through the collaborative learning cycle. In Step 1 (Group Coordinated Individual Expertise), groups met briefly in an online chat room and were given a chance to familiarize themselves with the chat environment. Here, groups decided who would become the “expert” for each of four assignment topics: task understanding, goal setting and monitoring, self-regulated learning, and memory and learning processes. Each member was then responsible for preparing a one-page summary sheet related to his or her topic to be used as a reference tool during the collaborative case analysis task. Collectively, groups had a summary sheet for each major course topic necessary to solve the case.

In Step 2 (Solo Planning), group members completed a solo planning tool that guided and recorded their individual perceptions about the learning objectives of the task, personal goals, and plans they might share with their group before jumping into the collaborative case analysis

task. In Step 3 (Group Planning), groups completed a planning tool guiding them to discuss and jointly respond to questions similar to those in the solo planning tool. Both solo and group planning tools were an online form pre-stocked with similar questions and prompts. However, the framing of questions tapping into learners' perceptions of the learning objectives (i.e., what are you being asked to do and why) varied depending on the level of support provided to the group. Specifically, groups were assigned to one of four planning support conditions: (a) high-solo and high-group; (b) low-solo and high-group; (c) high-solo and low-group; and (d) low-solo and low-group. The high planning support contained pre-stocked selections of potential answers, whereas the low planning support contained open-text fields. During group planning, access to a collective summary of individual solo planning tool responses was provided.

Step 4 (Collaborative Case Analysis Task) consisted of a timed collaborative case analysis task that involved analyzing a 1-page case scenario about a fictitious student's learning behaviors. More specifically, groups were required to (a) analyze the student's strengths and weaknesses using the group's knowledge of theories and research in learning sciences introduced in the course, (b) identify and explain the root cause of the student's behaviors, and (c) recommend and justify strategies the student could use to improve learning. Group answers were recorded in a wiki page viewable by all group members but editable by only one member at a time. Groups completed the group planning tool and the collaborative case analysis task (Steps 3 and 4) during the same in-class 90-minute online session, where discussions were held in the same online chat environment introduced at Step 1. Specific for this timed session, each student was required to sign in to a computer located in one of the university's computer laboratories, supervised by at least one course instructor. Computer stations were randomly assigned to students. Students accessed the text-based chat tool, shared wiki, and case scenario in different

windows on their computer. No face-to-face conversations occurred during collaboration. Finally, in Step 5 (Solo Reflection), group members individually completed a solo reflection tool in which they reflected on the collaborative experience. Solo activities (Steps 1, 2, and 5) were individually completed outside of class time, but students were required to submit these activities before instructor-assigned deadlines.

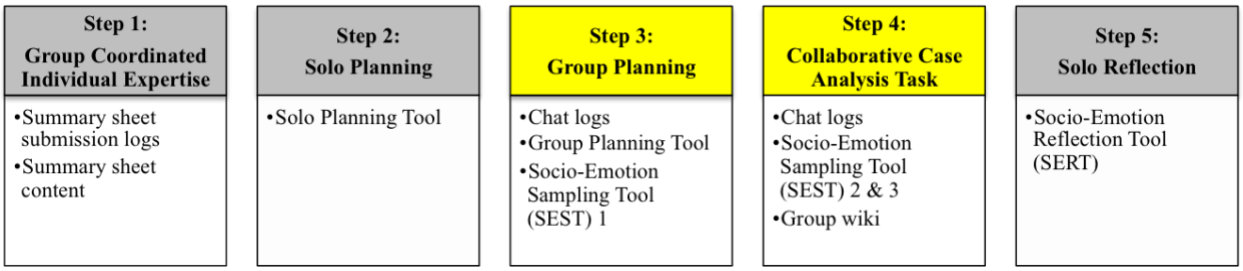

Fig. 2 Steps for collaboration in the first assignment are shown along with a list of data sources for each step. Yellow boxes indicate these steps took place in a timed online session.

All tasks in the collaborative assignment were delivered and completed via Moodle 2.4—learning management software familiar to students at the university. Students (N = 192 consenting students) worked in groups of three to five (48 groups in total) assigned by the course instructors. Course instructors did their best to make groups heterogeneous on the basis of gender, English as first language status, and prior knowledge as indicated by performance on the first course quiz. Because groups were assigned and students came from a wide array of programs and departments, group members were likely unfamiliar with each other personally beyond the course.

Data Sources

Figure 3 maps each data source onto the same COPES diagram presented earlier (see Figure 1). Following this, we describe the data sources used to measure each construct.

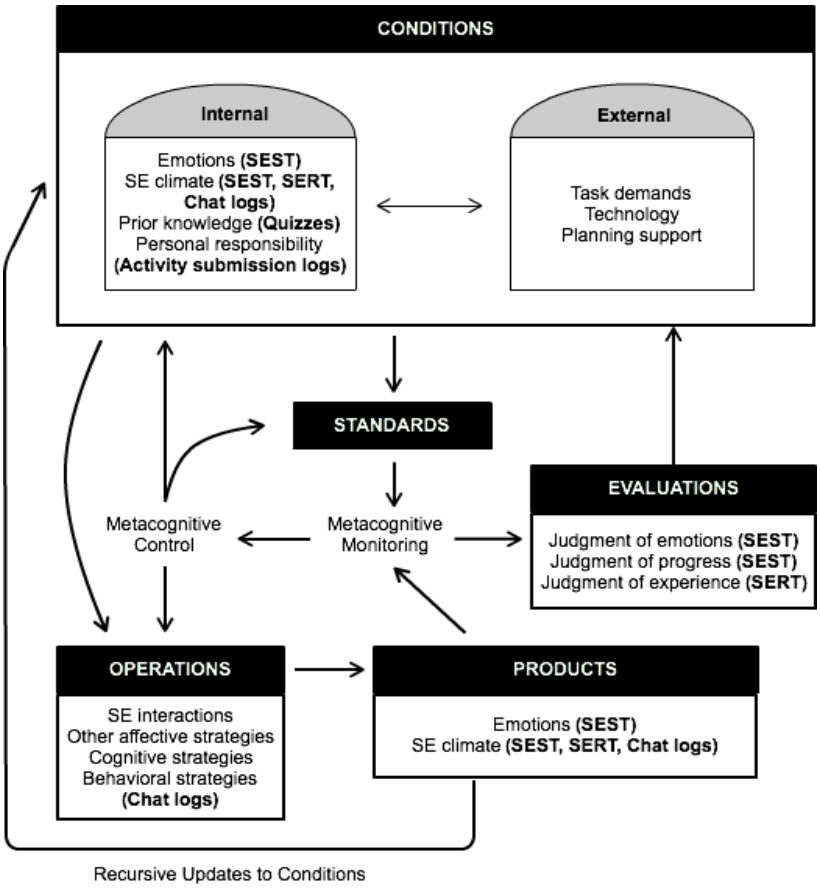

Fig. 3 Study constructs and data sources embedded within the COPES architecture. Data sources are listed in parentheses following the construct(s) they measure. SE = Socio-emotional; SEST = Socio-Emotional Sampling Tool; SERT = Socio-Emotional Reflection Tool.

Prior knowledge. This construct was measured by examining individual performance on three course content quizzes prior to collaboration (M_1= 70.0, SD_1=16.3; M_2= 78.4, SD_2=13.3, M_3= 69.6, SD_3=14.5), testing knowledge of four major topics covered in the collaborative assignment. Quizzes were developed and reviewed by a group of experienced course instructors and researchers in the area of regulation who ensured content validity of each quiz with respect to specific course topics and three levels of processing (understanding, connecting, and

extending). Each quiz contained 10 multiple-choice questions and was counted toward students' final grade. Cronbach's alpha coefficient based on the 30 quiz questions was .49.

Personal responsibility. A global judgment of personal responsibility demonstrated by individual group members prior to the task was developed by reviewing records of when group members submitted their summary sheet and solo planning tool (Steps 1 and 2 in Figure 2) along with the content of those activities.

Emotions. The Socio-Emotional Sampling Tool (SEST) provided information about individual group members' (a) current emotional states and plans for regulating those emotional states (internal conditions and products), (b) judgments of their emotional states (evaluations), and (c) satisfaction with the group's progress (evaluations). Group members individually completed the SEST at the beginning, middle, and end of the in-class collaborative session (Steps 3 and 4 in Figure 2). The SEST facilitated the construction of a self-narrative about students' salient emotion in the moment with respect to collaboration. Rather than including a set of isolated questions, the SEST was designed with drop-down menus embedded in first-person sentences, enabling students to quickly create a cohesive narrative of their current emotional state (see Figure 4).

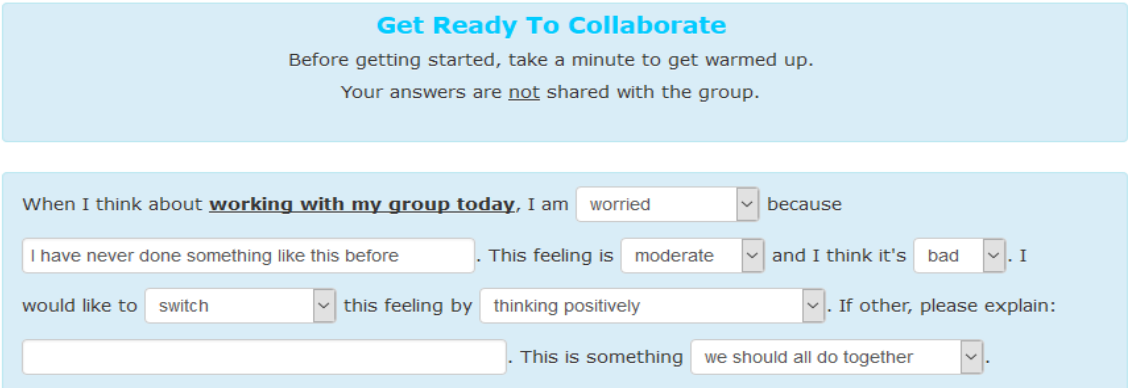

Fig. 4 Sample items from the Socio-Emotional Sampling Tool (SEST)

In particular, students indicated (a) a salient emotion they were experiencing related to working with their group from a drop-down list, (b) the source of their emotion in an open-text field, (c) the intensity of their emotion (from *very weak* to *very strong*), (d) whether their emotion was good or bad, (e) a goal for regulating their emotion (increase, decrease, switch, maintain, do nothing about), (f) a strategy they intended to use to regulate their emotion from a drop-down list, and finally, (g) if the strategy should be enacted individually or as a group. In the midpoint and final SEST, students also reported their level of satisfaction with progress (from *not very* to *extremely* satisfied). The drop-down list of emotions included six positive emotions (excited, optimistic, confident, happy, focused, calm) and six negative emotions (anxious, worried, stressed, doubtful, frustrated/angry, disappointed). There is little prior research on the specific emotions students experience during collaboration. These 12 emotions were chosen because they represented a balance of positive and negative emotions, were among frequently reported emotions in other data we have collected from students about their emotions during independent studying, and were relevant for a collaborative context. The drop-down list of strategies included eight strategies: creating a good plan, changing the plan or approach, focusing on the task, changing thoughts or beliefs, thinking positively, talking to others in the group, taking deep breaths and/or relaxing, accepting it and carrying on. This list was developed from existing theory and research in both individual and collaborative contexts (Gross 1998; Järvenoja and Järvelä 2009; Schutz et al. 2004; Webster and Hadwin 2014). Students also had the option to "do nothing about" their emotion or indicate they would do something else not on the list. The aim in developing the drop-down list was to include a limited number of strategies for students to choose from that met the following three criteria: (a) the strategies were appropriate for the

context; (b) the strategies were specific enough to be useful, but also adaptable to the student's particular situation; and (c) the list covered the major types of strategies identified in theory and research.

Individual perceptions of socio-emotional climate. Two measures provided information about group members' perceptions of the socio-emotional climate: (a) the midpoint and final SEST (described previously) contained one item assessing perceptions of the atmosphere (positive, negative, or neutral) and (b) the Socio-Emotional Reflection Tool (SERT) contained two items targeting perceptions of the collaborative experience. Preliminary examination of SEST data of the full sample of groups showed that very few students (3.1%) reported a negative atmosphere. This may be indicative of an unwillingness to report a problem in the group *during* the collaboration. The SERT was completed as part of the solo reflection tool (Step 5 in Figure 2). By prompting students to reflect on a positive or negative experience that occurred during the in-class collaborative session, the SERT aimed to build awareness of successes or difficulties so students could more effectively plan and prepare for future collaborative situations. Students were first asked to describe a salient experience in an open text field and then select from a drop-down menu whether the experience was positive or negative. This information was used as the first data point for selecting cases for analysis as described in the next section.

Socio-emotional interactions and observed socio-emotional climate. Chat logs provided evidence of outward instantiations of socio-emotional interactions and informed our perceptions of the socio-emotional climate as a product and a condition. ZohoChat—a synchronous text-based chat tool that contains a running record of all chat history and allows

students to enter the chat where it was left off—was used to host and record collaborative discussions during the timed online session.

Regulatory processes and modes. The chat logs described above were used to examine groups' regulatory processes (planning, enacting, adapting, monitoring) and regulatory modes (SRL, CoRL, SSRL) used to carry out the processes. Processes and modes occur at the macro level, where they can be aimed at taking control of cognition, behavior, motivation, and/or emotions.

Case Sampling Strategy and Case Descriptions

Extreme case sampling (Miles et al. 2013) was used to identify two maximally contrasting groups in terms of the overall socio-emotional climate during collaboration. We intentionally blinded ourselves to the planning support condition assigned to each group because we did not want the condition to bias our perceptions of the groups' socio-emotional climate. Judgments of socio-emotional climate were drawn from three main data sources: (a) rating of a salient affective event as positive or negative (SERT), (b) text based descriptions of a salient affective event that was positive or negative (SERT), and (c) overall positive or negative tone of the group chat discussion reflected in field notes recorded by two independent researchers (chat logs). Based on ratings of a salient affective event in the SERT, cases were narrowed down to six potential cases wherein (a) all four group members reported a salient affective event they rated as positive (four groups in total) or (b) all four group members reported a salient affective event they rated as negative (two groups in total) after collaboration. For all six groups, we confirmed that the affective event described in an open text field by each individual was consistent with that person's rating of the event as positive or negative. This collection of responses was used as an indicator of the group's global judgment of the overall socio-emotional climate of the group.

Importantly, these reflection data were used as a starting point to select our cases because retrospective reports reveal emotional perceptions or beliefs that are products of collaboration and likely serve as a condition informing future collaboration. It is possible during a collaborative task students experience a range of emotionally charged events, but the emotional memory that stands out for them—as reported in their reflections—is an important condition for future collaboration.

Finally, chat logs for each of the six groups were independently reviewed by two researchers tasked with documenting holistic impressions and observations in open field notes. Field notes particularly attended to overall tone and climate. Field notes were used to choose one of the four groups reporting a positive affective event and one of the two groups reporting a negative affective event. The two groups chosen represented maximal variation in the overall holistic impressions of tone and climate recorded in field notes. Herewith, we refer to one group as the positive climate group and the other as the negative climate group.

The positive climate group was consistent throughout their open-ended descriptions in the SERT describing a positive and supportive group that worked well together. Field notes about chat discussions corresponded with individual reports, noting polite and respectful exchanges and deliberations throughout the task. In contrast, the negative climate group reported running out of time as a salient negative event during collaboration. One member also noted the group did not know how to collaborate, suggesting the group struggled to function productively. Field notes about chat discussions noted multiple points of frustrations and tensions negotiating roles and contributions. Table 1 summarizes demographic information of the individuals comprising each group. All students were in their first semester of university. Hence, it is likely

these students had little, if any, previous experience with university-level collaborative work at the point of data collection.

Table 1 Summary of participants' demographic information

	Positive climate group	Negative climate group
Group members	Tom *(male; non-ESL)* Jessica *(female; non-ESL)* Angie *(female; non-ESL)* Suparna *(female; ESL)*	Jay *(male; non-ESL)* Steve *(male; ESL status not reported)* Seiko *(female; ESL)* Jing *(female; ESL)*
Mean age (years)	17.8	18.0

Note. All names used in examples are pseudonyms. ESL = English as a second language.

Chat Transcript Coding

Chat transcripts were coded on three dimensions: (a) regulatory processes, (b) modes of regulation, and (c) socio-emotional interactions. Drawing from Barbour (2001), we acknowledge that in the context of an in-depth cross-case analysis where complex processes and interactions are coded by two researchers, "concordance between researchers is not really important; what is ultimately of value is the content of disagreements and the insights that discussion can provide for refining coding frames. The greatest potential of multiple coding lies in its capacity to furnish alternative interpretations... Such exercises encourage thoroughness, both in interrogating the data at hand and in providing an account of how an analysis was developed" (p. 1116). With this in mind, we conducted multiple reviews of both the coding scheme and the coded data and engaged in discussions with other knowledgeable researchers in the field to reveal alternative interpretations and insights. Coding for each dimension progressed in a similar manner. First, an initial coding scheme was developed from existing theory and research. Second, the coding scheme was applied to the data by independent coders including the first two authors. The team then reconvened to discuss and revise the coding scheme to better reflect the data. Rather than dividing the chat into episodes and coding at the episode level, each utterance in the chat was

coded. An utterance could expand across multiple chat lines by the same student as long as all lines pertained to the same thought. This second step was repeated until code descriptions were agreed upon. The second author then applied the final coding schemes to all chat data. Initial Krippendorff's alpha between the first two authors for 20% of the data was .67 for regulatory processes, .62 for modes of regulation, and .69 for socio-emotional interaction codes. Finally, all codes were reviewed by the first two authors, who discussed any disagreements until a consensus was reached.

Regulatory processes. Table 2 presents the final version of the coding scheme for regulatory processes. Informed by an extended version of Winne and Hadwin's (1998) self-regulated learning model described by Miller and Hadwin (2015a), regulatory processes coded in this study included the acts of (a) planning, where learners construct task understanding and set goals, (b) enacting, where learners employ strategies for achieving task goals, and (c) adapting, where learners make changes in response to a perceived challenge. The authors not only describe how the three processes occur at an individual level but also take into account regulation that occurs at the social level. These regulatory processes—planning, enacting, adapting—can target cognition, behavior, motivation, emotions, or a combination of these facets of learning. In this study, coding of regulatory processes was not exclusive to emotion regulation; instead, we aimed to examine the emotional products and subsequent conditions that arise from engaging the regulatory processes (e.g., anxiety that follows ineffective planning and becomes a condition for task enactment).

In line with the SRL model, we included a code for metacognitive monitoring and evaluating, which fuel regulatory processes. On the basis of earlier iterations of coding, we also added orienting as a distinct subcode of monitoring, keeping it as a separate subcode because of

its high occurrence. Orienting represents low-level coordinating statements where the main purpose is to situate the group member(s) in terms of the environment and task (e.g., monitoring who is in the chat or what question is being worked on). Orienting differed from other forms of monitoring—such as monitoring progress—in its lack of connection to plans, goals, or standards. For example, establishing whether everyone is looking at the same question (coded as orienting) simply allows the group to move forward with their work, whereas stating the question needs to be completed in five minutes (coded as monitoring) is a form of monitoring progress against time standards.

Modes of regulation. The coding scheme for modes of regulation (Table 3) was informed by Hadwin and colleagues' (Miller and Hadwin 2015a; Hadwin et al. 2017) descriptions of self-regulated learning (SRL), co-regulated learning (CoRL), and socially-shared regulation of learning (SSRL). In addition to the three codes of SRL, CoRL, and SSRL, we included a code for co-regulatory requests where individuals requested support for their own regulation (Hadwin et al. 2017). The act of co-regulation (providing support) may or may not have occurred in response to these co-regulatory requests.

Because it is possible for regulatory processes to occur at individual and group levels simultaneously and for an individual to promptly switch from individual to group regulation within one speaking turn, codes for modes of regulation could overlap. For example, when a group member announced what he was individually working on (monitored his own progress) and asked for an update from his group (monitored his group's progress), this statement was coded as both SRL and CoRL. Furthermore, when a group member acted in response to co-regulatory support provided by another group member, the response was coded as both SRL and CoRL to indicate the transfer of regulation. The addition of this round of coding helped to

decode the social nature of regulation, which includes the dynamic interplay between an individual, others, and the group. For instance, a less supportive group may display fewer co-regulatory acts that are positive in nature.

Socio-emotional interactions. Outward instantiations of emotion regulation observed in the form of socio-emotional interactions were examined at this level. The coding scheme for socio-emotional interactions (Table 4) was informed by several pre-existing socio-emotional coding schemes in the literature (e.g., Ayoko et al. 2012; Lajoie et al. 2015; Linnenbrink-Garcia et al. 2011; Näykki et al. 2014; Rogat and Adams-Wiggins 2015; Rourke et al. 1999). Similar to modes of regulation, it was possible for turns to receive more than one socio-emotional code. In line with previous research, positive interactions included apologizing, humor or laughter, encouraging members' participation and motivation, and promoting trust and cohesion among group members. Negative interactions included discouraging participation and motivation, low cohesion (emphasizing the individual over the group), and pressuring others. Because text-based chats often involve the use of emoticons and symbols to express and emphasize emotions, we included a code for expressing emotions, which was also applied to the use of emotion language. We did not categorize expressing emotions as a positive or negative socio-emotional interaction because (a) regardless of what emotions are being expressed, the act of expression itself could be beneficial or detrimental to the discussion and (b) some symbols could be ambiguous with respect to what emotion the group member is intending to convey.

Table 2 Coding scheme for regulatory processes

Code	Description	Examples[a]
Planning	Defining task perceptions, setting goals, and making plans for cognitive, behavioral, and/or affective aspects of the task.	**Task perceptions** *Angie:* ok so it seems like in the first one the majority of us think that our task is to analyze the scenario, identify srl strengths and weaknesses, come up with a solution and back up our answers with examples **Making plans** *Jay:* So whos going to be the editor? Shoty not *Steve*: I would prefer not to *Jay*: I only want to opt out because I am not a super fast typer
Enacting	Indicator of strategy use. Purposefully adopting and adapting tools and strategies to attain goals and standards and mediate challenges. Also includes stating domain-related knowledge or content for the task product.	**Strategies for thinking / understanding** *Jay [making use of distributed expertise]:* Im having trouble seeing [domain concepts]... Seiko, this is your specialty. what do you think? **Strategies for behavior / task / team engagement** *Tom:* easily fixable for you Angie, just some cut and pasting *Jing [after realizing they are running out of time]:* don't spend too much time on the plan, we need to focus mainly on the challenge part, haha **Domain / content contribution** *Jing:* Brian does not pay attention in class, because he thinks that reading the textbook will get him good marks in the exam. He does not understand the connections between the concepts and the teacher's examples.

Monitoring and/or evaluating	Monitoring and/or evaluating task understanding, progress, and products in relation to behavioral, cognitive, or affective goals and standards.	**Task perceptions / plans** *Tom:* I didn't know we had to study the diagrams for this *Suparna [evaluating the correctness of the plan]:* Yeah thats what I was thinking too / everyone agree? *Angie:* yes me too **Task product or progress** *Jay [when not getting much response from group members]:* more contributions? *Suparna:* lol I just saw it before I came *Tom:* I think you got it Suparna
Orienting (subcode of monitoring)	Situating or positioning self or others in terms of the group, environment, and task. Low-level coordinating statements / announcements where the main purpose is to situate or move things along.	*Jay [while members are logging on to the chat]:* hey guys, are we all in the chat? *Angie:* Ok should we look at the group summery now then?
Adapting	Making a purposeful change to task perceptions, goals, plans, or behavioral / cognitive / affective strategies to overcome a challenge in the current task or in future tasks. Always a secondary code in relation to what the change is about. Often preceded by monitoring.	*Tom:* so I think only one person can edit at a time. *Angie:* yes / Samir copy and paste wht you wrote into chat and I will put it in? *Jay:* were really running out of time!! *Jing:* who is responsible for B / let's divide the last things
Off-task	Off-task statements and social greetings.	*Jing:* hello! *Seiko:* Who typed all caps hahaha
Uncodable	Partial statements and/or statements where the meaning is not clear.	

[a]Chat excerpts have not been corrected for grammatical errors, formatting, etc.

Table 3 Coding scheme for modes of regulation

Code	Description	Examples
Self-regulation	Individual deliberately plans, monitors, and/or regulates their own cognitions, behaviors, motivation, and emotions in the joint task.	*Seiko:* I am working on my answers. I will post them when I check it. *Seiko:* Still working on it. For strength, I have this so far.
Co-regulation	Individual or group supports or influences one or multiple members' individual regulation processes or the group's shared regulation processes. These regulatory processes can target cognitions, behaviors, motivation, and/or emotions. Co-regulation creates affordances and constraints for productive self-regulated learning and/or shared regulation of learning.	*Angie:* Sorry guys where are we here? *Tom:* Number 6 *Jessica:* Its #2 in the personal part but in the thing you're filling out it is Number#6. I think. *Angie:* oh right sorry yes I'm doing #6 too.
Co-regulatory request	Individual requests support for regulation.	*Angie:* Sorry guys where are we here? *[This is a request to the above co-regulation example]*
Socially-shared regulation	Group members collectively negotiate and realign or adapt group regulation processes targeting cognition, behavior, motivation and/or emotions. Shared regulation is transactive in that multiple individual perspectives contribute to the joint effort to take control of the task.	*Angie:* ok so it seems like in the first one the majority of us think that our task is to analyze the scenario, identify srl strengths and weaknesses, come up with a solution and back up our answers with examples. *Angie:* Does that sound about right? *Jessica:* I agree *Suparna:* Yeahh. They all have more than 75 % *Tom:* Agreed

Table 4 Coding scheme for socio-emotional interactions

Code	Description	Examples
Positive interactions		
Apologizing	Apologizing to another member / the group in response to a perceived challenge (e.g., confusion, making a mistake, taking too long, etc.). Could be considered a strategy to promote positive emotional reactions or to reduce or avoid negative emotional reactions.	*Suparna:* I am almost done / sorry *Jing:* im sorry Jay should have told you earlier :(
Humor / laughter	Using humor or laughter to potentially ease tension or create a positive atmosphere.	*Tom:* who's editing? not me because I lost this debate haha
Encouraging participation / motivation	Encouraging or facilitating others' participation by seeking feedback or contributions, promoting openness, providing positive feedback, making a polite request or suggestion, or providing reassurance. Also includes motivational or enthusiastic statements.	**Seeking feedback** *Jessica:* I think that the root of his problem must be [domain contribution]. Do you agree? Then we can discuss how it impacted the rest? **Providing positive feedback** *Tom:* you did a great job with the planner **Polite request** *Jessica:* Samir, could you put what is complete into the page and save it so that we can read them more easily and then add anything we think is needed? **Providing reassurance** *Suparna:* I am almost done / sorry *Angie:* no worries **Enthusiasm**

		Jing: :D lets get started!
Promoting trust / cohesion	Promoting trust and cohesion by appealing to external factors (e.g., task or instructor directions) to potentially ease tensions or using "we" statements to imply the group is working together or should work together.	**Appealing to external factors** *Tom:* [instructor] says we should be starting our scenarios shortly **"We" statements** *Jessica:* thanks everyone i think we did a really good job
Negative interactions		
Discouraging participation / motivation	Discouraging participation and undermining task contributions by criticizing another's work, ignoring feedback or questions, or rejecting contributions. Also includes undermining one's own or the group's abilities (low efficacy) and avoiding commitment to the task.	**Undermining another's contribution** *Jay [after another member has submitted an answer]:* are we not supposed to use past tense? **Low efficacy / commitment** *Jay:* I only want to opt out [of being editor] because Im not a super fast typer
Low cohesion	Statements that imply the group is not working together or that emphasize the individual over the group. Includes taking personal credit for or emphasizing one's own ideas.	*Jay:* WE DON'T DISCUSS UNTIL WE HAVE ANSWERED EVERY QUESTION IN THE CHALLENGE, in my opinion?? That was what I intended when we wrote the plan of attack
Pressuring others	Telling another member / the group what to do without asking, suggesting, or being polite. Includes overruling interactions where the member makes a decision for the group or rushes the group to move on without seeking more input.	*Angie:* group plan isnt being graded lets move on! *Jay:* lets goo people / I need your answers>>?

Expressing emotions	Expressing emotions by using emoticons, emphasis (e.g., caps lock, ??), or emotion language / expressions.	**Emoticon** *Jay:* I can be editor I guess.... :/ **Emphasis** *Jay:* whos the last person in our group and where are they?? **Expression** *Jay:* our supervisor said we should be done!! Ahh

Analysis and Findings

Analytical Approach

Loosely guided by Braun and Clarke's (2006) thematic analysis, we primarily used a data-driven technique to generate important themes describing the differences between the positive and negative climate groups. We began by documenting general observations of each data source, collected from the beginning to the end of the collaborative assignment. Next, using inductive and deductive approaches, we constructed and refined the coding schemes for the observation data (i.e., chat logs). Upon completion of coding, we examined the fluctuation in codes over time and the convergence between and among categories of codes to generate potential themes. Using all data sources, we iteratively reviewed and defined emerging themes until we reached an agreement that the final list of themes best reflected the differences in the two cases.

Code fluctuations over time. To examine the fluctuation of each code over the course of the online collaborative session, we broke the session into equal time segments and calculated code frequencies occurring in each time segment (for total frequencies across the whole session, see Table 7 in the Appendix). For regulatory processes and modes (Figures 5 and 6), we broke the session into three 30-minute segments with a fourth time segment representing overtime (i.e., the time group members stayed beyond the original 90-minute time limit). For socio-emotional interactions (Figure 7), we broke the session into six 15-minute segments plus overtime. A smaller time interval was selected because socio-emotional interactions were more dynamic, with codes changing relatively quickly over fewer turns—a characteristic that was less apparent with a 30-minute time interval. Examining the fluctuation in code frequencies allowed us to look for patterns that differentiated the groups in terms of (a) how actively each group demonstrated

the various regulatory processes, regulatory modes, and socio-emotional interactions and (b) how their actions changed over the course of the session.

As this was an exploratory study, our main purpose was to pinpoint differences warranting further research. We focused on frequencies because groups were given the same amount of time (90 minutes) to work on the task. No count statistics were performed to determine statistically significant differences. Rather, we were primarily interested in examining the nature of code transitions over time, which is in line with our assumption that regulation is a recursive and adaptive process that unfolds across phases. For example, a typical pattern of transitions in a productively regulating group might include a higher prevalence of planning early in the task, a higher prevalence of enacting in the middle of the task, and a higher prevalence of monitoring towards the end of the task (Winne and Hadwin 1998; Zimmerman 1989). We would also expect to see a productive group concurrently engaging in SRL, CoRL, and SSRL, with the latter two modes more prominent as groups work toward a joint outcome (Hadwin et al. 2011). Finally, given that we view socio-emotional interactions as operations within regulatory cycles, we examined the fluctuation of socio-emotional interactions over time in relation to the emotional products of emotions and socio-emotional climate. For example, negative socio-emotional interactions that occur early and persist throughout the task would likely have a debilitating effect on groups' socio-emotional climate (e.g., Näykki et al. 2014).

Overlapping codes. To demonstrate the interplay between and among regulatory processes, regulatory modes, and socio-emotional interactions, we graphed the co-occurrences of these codes for each socio-emotional climate (Figure 8).

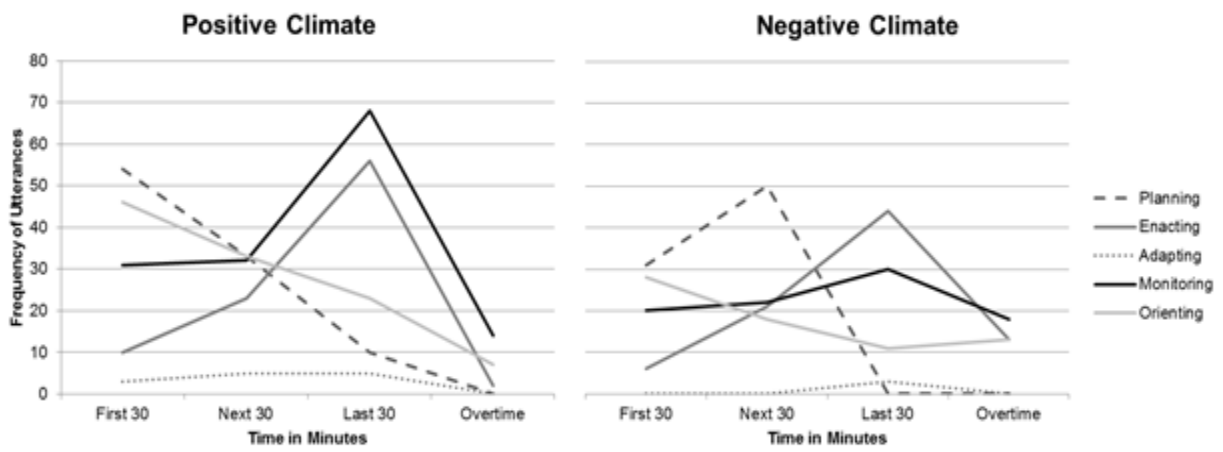

Fig. 5 Regulatory processes over time

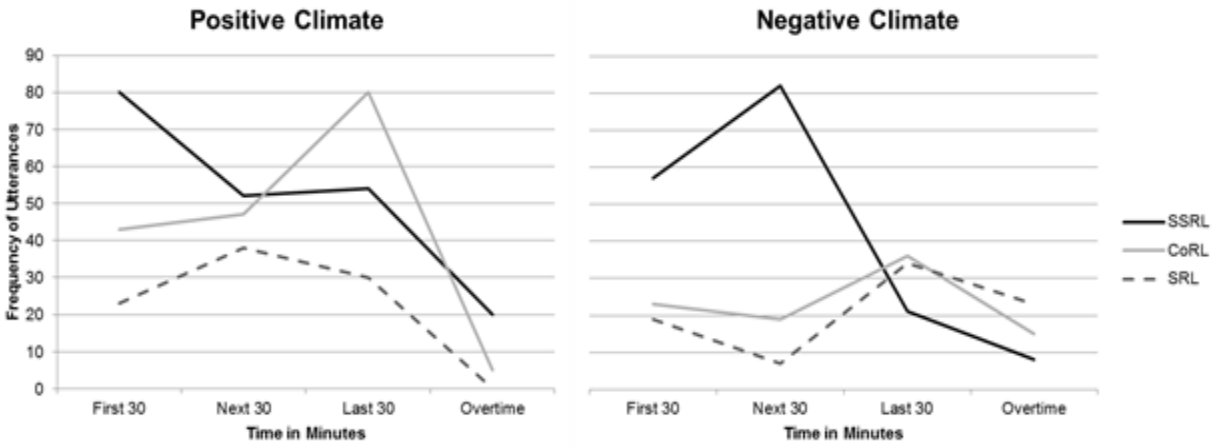

Fig. 6 Modes of regulation over time.

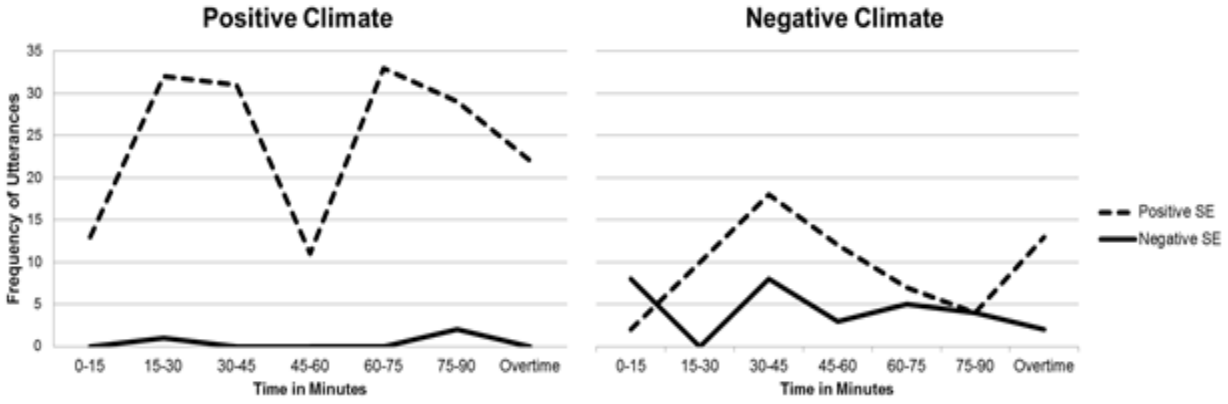

Fig. 7 Socio-emotional interactions over time

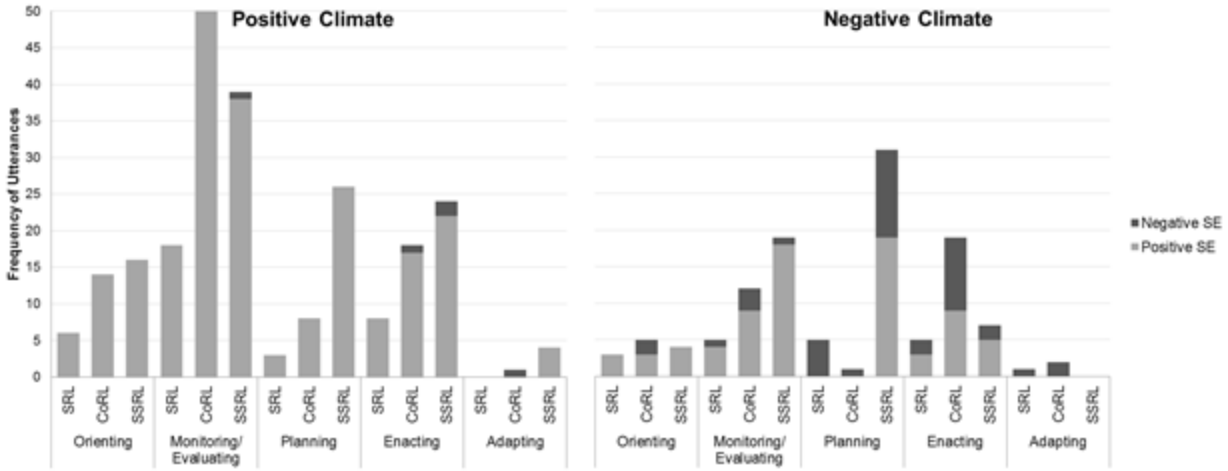

Fig. 8 The degree of overlap between socio-emotional interactions, regulatory processes, and regulatory modes in both groups expressed in frequency. SE=Socio-emotional interactions.

Overall, Figures 5 to 8 above demonstrate interesting interplay between regulatory processes, modes, and socio-emotional interactions. Informed by this pattern of interactions and corroborated by other data sources gathered at several points of the collaborative process, our analysis culminated in four broad themes that distinguished the two groups: (a) incoming conditions as a foundation for creating a positive collaborative experience, (b) regulation of emotions during initial planning, (c) negative emotions as a constraint for shared adaptation in the face of a challenge, and (d) encouragement and motivational statements as an effective strategy in sustaining a positive socio-emotional climate.

Theme 1: Incoming *Conditions* as a Foundation for Creating a Positive Collaborative Experience

In the COPES architecture of SRL (Winne and Hadwin 1998, 2008), incoming conditions are data upon which students base regulatory evaluations, judgments, and decisions in each phase of regulation. In our study, upon entering the collaborative online session, group members carried a set of conditions with the potential to influence their cognitions, behaviors, and affect

for group planning and task enactment. Our examination of a subset of those conditions (summarized in Table 5) suggests the following two factors may contribute to a positive collaborative experience: (a) overall better preparation in terms of prior knowledge of expertise topics and personal responsibility for submitting individual planning activities, likely influenced by differences in implicit guidance tools introduced at solo planning (Step 2, Figure 2) and (b) plans for shared regulation of emotions.

Table 5 Entering conditions for each group

Conditions	Positive climate	Negative climate
Prior knowledge		
Mean quiz scores for assignment topics	70.8%	68.3%
Range of prior knowledge	53.3% - 93.3%	56.7% - 80%
Preparation and personal responsibility		
Solo planner completed by deadline	3 students	3 students
Mean task understanding score for solo planner	62.5%	52.5%
Task understanding score for group planner	70.0%	80.0%
Summary sheet completed by deadline	4 students	2 students
Summary sheet contained adequate information	3 students	2 students
Responses on first SEST		
Positive emotion reported	1 student	3 students
Negative emotion reported	3 students	1 student
Plan to self-regulate emotion	1 student	4 students
Plan to regulate emotion together	3 students	0 students

Individual preparation. Individual preparation in the positive climate group differed from the negative climate group in three main ways. First, students in the positive climate group excluding Tom had better prior knowledge of course concepts related to their assigned expertise (summary sheet) topics as indicated by their individual course quiz grades (Table 6). Second, students in the positive climate group were better prepared in terms of submitting summary sheets on time and including adequate course concepts on the summary sheets. Taken together,

these data suggest members of the positive climate group knew the topic they had taken responsibility for and were in a good position to create a summary sheet with adequate information.

Table 6 Group members' expertise topics and quiz scores (%)

Group member	Expertise topic	Quiz 1	Quiz 2	Quiz 3	Mean
Positive climate					
Tom	SRL	**40.0**	60.0	60.0	53.3
Jessica	Task understanding	**90.0**	100.0	90.0	93.3
Suparna	Goal setting & monitoring	100.0	**80.0**	50.0	76.7
Angie	Memory & learning processes	50.0	50.0	**80.0**	60.0
Negative climate					
Jay	SRL	**70.0**	90.0	80.0	80.0
Seiko	Task understanding	**70.0**	70.0	80.0	73.3
Jing	Goal setting & monitoring	80.0	**50.0**	60.0	63.3
Steve	Memory & learning processes	50.0	70.0	**50.0**	56.7

Note. Bolded quiz scores indicate the quiz corresponding to the group member's expertise topic.

The third difference related to the level of individual planning support provided to each group. In particular, members of the positive climate group completed the highly guided individual planning tool containing questions with pre-stocked answer fields, whereas members of the negative climate group completed the loosely guided individual planning tool containing questions with open-ended answer fields. There was no difference between groups with respect to the level of support for group planning, with both groups receiving the highly guided group planning tool. Previous research using similar sets of tools revealed that, regardless of the level of individual support, a high level of group support was associated with more accurate group task perceptions (Miller and Hadwin 2015b). Consistent with this finding, the positive and negative climate groups were similar in their group-level task perception scores (70% for the positive

climate versus 80% for the negative climate; *M* = 63.3%, *SD* = 20.5). However, the high level of individual guidance provided to members of the positive climate group at solo planning seemed to improve the accuracy of their individual task perceptions as indicated by the range of scores in the group (mode of 70%). Having mostly high task understanding may have contributed to better preparation and higher levels of confidence in the positive climate group members' ability to perform the task. In contrast, although the negative climate group had a comparable average individual task perception score (*M* = 52.5% vs. *M* = 62.5%), the range of scores in this group was rather large, with two members scoring very low (10% and 20%) and two members scoring very high (80% and 100%). The two low-scoring members were the same individuals that submitted late summary sheets with relatively inadequate information, suggesting these two group members may have been less motivated or engaged prior to collaborating.

Emotions and planned strategies prior to collaboration. The groups also differed with respect to their SEST responses at the beginning of the online collaborative session (see Table 5). Of note was the contrast in emotions and planned mode of regulating those emotions. Emotions reported by the positive climate group prior to collaboration were predominantly negative (3 of 4 members), originating from group members' concerns regarding how well the group would work together, whereas emotions reported by the negative climate group prior to collaboration were predominantly positive (3 of 4 members), reflecting perceptions of confidence and being individually prepared for the collaborative task. It is possible that experiencing negative emotions prior to collaboration with a new group set the stage for a different approach to planning for collaboration in the positive climate group. Data indicated the positive climate group planned to share responsibility for regulating emotions with their group, reporting "this is something we should all do together." In contrast, the negative climate group planned for a more

individual approach for regulating emotions, with two members indicating “this is something I should do” and two members indicating “this is something each of us should do.” Perhaps influenced by this individual approach, the group may have paid less attention to the nature of their interactions, ultimately creating the observed negative socio-emotional climate. Of particular note, one group member (Jay) who was dominant in setting the observed negative tone appeared to be working toward the goal of maintaining his own focus on the task. Focusing on an individual goal may have come at the expense of creating a positive working environment.

Summary. Taken together, data gathered about groups’ incoming conditions point to two important factors for establishing a positive socio-emotional climate. First, engaging in adequate preparation or self-regulation prior to the task helps set the stage for a positive collaborative experience. Second, planning to share the responsibility of regulating emotions may be necessary for the group to successfully manage any negative emotions that might be harmful to the group’s productivity during collaboration. Accordingly, the positive climate group was observed regulating productively and interacting positively (described in the next section) despite perceiving negative feelings at the beginning of the task. On the other hand, when group members are less prepared and focused more on individual regulation during collaboration, they may be less successful in regulating the emotional aspects of collaboration, resulting in negative emotions that persist throughout the task, as demonstrated in the next section.

Theme 2: Regulation of Emotions (*Operations*) During Initial Planning

In line with research conducted by Fransen et al. (2011), initial group affect set the stage for more complex collaborative processes, such as building shared task perceptions, to take form. Within initial stages of collaboration, it is important for group members to build trusting relationships as a foundation for effective group functioning. According to Van den Bossche at

al. (2006), interpersonal trust is built when team members believe the group is ready to interdependently exist and each member has confidence the group can succeed (see also Williams 2007). Our analysis of the initial stages of collaboration indicated the positive and negative climate groups differed with respect to (a) productivity and conflict during initial planning and (b) valence of emotions experienced after initial planning.

Interactions during initial planning. Our examination of code fluctuations revealed that, in the first 15 minutes (initial planning phase), positive interactions dominated the positive climate group's discussion, whereas negative interactions dominated the negative climate group's discussion (see Figure 7). The initial planning session of the positive climate group was found to be brief and productive; Angie quickly volunteered to edit the group's wiki, allowing the group to move through the planning phase at a relatively faster pace. Whereas the negative climate group was still engaged in high levels of planning in the second 30-minute time interval (see Figure 5), the positive climate group had begun to analyze the case. Having more time to solve the case may have allowed the positive climate group to engage in a higher frequency of monitoring, particularly in the last 30 minutes of collaboration, when the negative climate group was still more highly engaged in enacting the task (see Figure 5).

The initial planning session for the negative climate group was lengthy with back-and-forth orders among members to take up the editor role. Compared to the positive climate group who chose an editor within 3 minutes, the negative climate group took almost 10 minutes to identify an editor, delaying progress on the task itself. While deciding the editor, two group members who were ESL speakers stated concerns with difficulties in communicating due to language barriers, and thus avoided being the editor of the group wiki. The other two members—Steve and Jay—avoided the role on the basis of a lack of ability to type fast. It is possible being

less prepared (see Theme 1) may have redirected the negative climate group's efforts away from establishing a productive socio-emotional climate towards focusing more on individual competency. Due to time constraints, the editor role was delegated to Jay, who used an emoticon to express disappointment or apprehension regarding the decision. Group members did not overtly acknowledge Jay's emotional reaction, but instead promptly suggested they begin the task, indicating a lack of co-regulatory support when faced with an emotional challenge. The lack of commitment and negative tone portrayed early in the negative climate group may have been pertinent in establishing the climate for the group.

Emotions after initial planning. Coinciding with each group's regulatory actions in the earlier phases of collaboration, by the midpoint and through to the end of collaboration, valence of emotions demonstrated in the emotion check-ins was reversed between the two groups. Positive emotions dominated the positive climate group (3 of 4 members), and negative emotions dominated the negative climate group (3 of 3 reporting members), with one member in the negative climate group failing to complete the final two check-ins. In the positive climate group, the only negative emotion was expressed by the editor, Angie, who was anxious about time and feeling rushed. Recognizing Angie's concern for time, the other group members attempted to co-regulate her anxiety by re-assuring her the group was doing well for time and apologizing for the amount of work she was responsible for as editor. The positive climate group concluded the assignment with 3 of 4 members feeling confident they had performed well. Angie, however, continued to feel anxious, reporting in her final check-in *"I felt really rushed in my parts and I was unable to look over what the others were doing so I was unable to help and monitor."* Despite her feelings of anxiety, Angie expressed very high satisfaction with assignment progress and reported a positive atmosphere at the midpoint and end of collaboration, suggesting she held

a positive perception of the collaborative experience. These positive evaluations were echoed by the rest of the group, who were extremely satisfied and perceived a positive atmosphere at both times.

In contrast, with one member ceasing to report emotions at the end of collaboration, the negative climate group reported negative emotions ranging from moderate to very strong in intensity. As one member put it, "*[the group] did not get off to a good start*" (Sean, SEST2). As demonstrated in Figure 7, group members may have attempted to improve the negative atmosphere by also engaging in positive socio-emotional interactions after the first 30 minutes had passed (i.e., during the 30- to 45-minute time interval). These attempts, however, appeared unsuccessful as negative interactions persisted (see Figure 7) and appeared to adversely affect group members' satisfaction with progress, with reports in the midpoint and final SEST of being not very or only moderately satisfied. Furthermore, the negative climate group was unable to fully complete the task. At the end of the collaborative session, group members reported feeling frustrated/angry, doubtful, and disappointed with the quality of their work.

Summary. Overall, the negative climate group's functioning was characterized by a downward trajectory starting with a predominance of observed negative interactions in the early phase of collaboration leading to strong negative emotions in some members. The lack of evidence for co-regulatory support in this initial phase—where members should ideally recognize and attend to others' negative feelings—may have intensified the negative emotions and thwarted later attempts at amelioration. On the other hand, the smooth beginning observed in the positive climate group may have created a foundation of interpersonal trust ideal for sharing the management of emotions and group work—an observation that is consistent with our next theme.

Theme 3: Negative Emotions as a Constraint (*Condition*) for Shared Adaptation in the Face of a Challenge

Examining groups' regulatory behaviors during challenging episodes provides opportunity to distinguish effective from ineffective regulators (Järvelä et al. 2013). One design-based challenge of this online collaborative task was time constraints. When time becomes limited, execution of task-related activities may need to be adapted to the time constraint. Unfortunately, the negative climate group appeared to be unsuccessful at adapting under time pressure. Although they recognized the need to come up with a new plan—reported at midpoint check-in—the group failed to negotiate a new strategy and mitigated the situation by conceding to the editor's co-regulatory prompts and concentrating on individual work. In their rare moments of re-strategizing or adapting, the negative climate group was confronted with cohesion issues. In the following excerpt, Seiko's suggestion for re-strategizing by dividing the last questions was ignored by her group. Instead, Jay took over and told the group what to do, leaving little room for a group discussion about how to change their plan.

Jay:	were really running out of time!!
Seiko:	who is responsible for B let's divide the last things
Jing:	me *[responding to Seiko's question]*
Jay:	I'm just throwing something together for A.. you guys move on and we'll come back if theres time
Seiko:	ok
Steve:	i'm already working on memory and learning for when we get there
Jay:	good
Seiko:	so im in E
Jay:	give answers when youre ready

Towards the end of the collaborative session, the negative climate group switched to completing their work more individually than as a group (see Figure 6), demonstrating little evidence of a collective effort in adapting to task constraints.

In contrast, under time pressure, the positive climate group reconvened and re-examined their plan of attack as a team. When adapting their task-execution strategies, group members typically discussed details of the strategy, and enactment of a new strategy was often dependent upon group members' agreement to the delivery of that strategy. The excerpt below provides an example of how group members collectively planned and adapted their plan for enacting part of the assignment. The discussion was prompted when Jessica indirectly sought feedback by posing her suggestion for their strategy as a question. About halfway through the excerpt, Jessica noted an issue with the strategy, which prompted the group to adapt their plan.

Jessica:	I think for the next portion and for the reading we should all try to focus mostly on our core concept?
Angie:	Yes i think so..
Suparna:	Yeah sounds good
Angie:	But mine is memory so where does that fit in?
Jessica:	Memory is section C
Tom:	See if he has trouble moving from sensory to working to long term memory
Angie:	Oh right thank u! Ok let's do that then
Jessica:	There's more sections than us though. we have to write 6 things mine is A
Angie:	I have 2
Suparna:	Mine is B
Angie:	And e is just in general
Tom:	I have D and we collaborate on E
Suparna:	We can work on those at the end
Tom:	Yeah, whoever has C does two
Suparna:	Yeah.
Angie:	Yes

When individual reports regarding planned approaches to regulating emotions were inspected (SEST data), a consistent theme was observed. The positive climate and negative climate groups differed in two important ways. First, members of the positive climate group were well aligned in terms of plans to regulate their emotions by focusing on the task, with 3 of 4 members planning this strategy at the beginning and midpoint of the task. In contrast, members of the negative climate group planned a variety of strategies at the beginning of the task. By midpoint, creating a good plan was identified as a strategy for all three reporting members, suggesting something was not working and needed to be changed. However, members of the negative climate group seemed to have different ideas about what a "good plan" was as evidenced in the chat—Jing wanted to divide the remaining work and Jay wanted members to focus on completing their already assigned work. Second, when reporting who should enact the strategies, the majority of responses in the positive climate group indicated the group should enact the strategies together, whereas the majority of responses in the negative climate group indicated the strategies should be enacted by the individual group member alone or each group member individually. It was not surprising to find the negative climate group lacking evidence of co- or shared regulation for decreasing negative emotions or maintaining/increasing positive emotions, as their plans for regulation were not viewed as part of the group's responsibility.

The above contrasting features suggest intentions and efforts to collectively execute a strategy are crucial in collaboration, particularly when the group encounters a setback. Furthermore, attempts to adapt to task constraints should not be communicated in a negative tone as that could create friction leading to dissolution of collective effort among members.

Theme 4: Encouragement and Motivational Statements as an Effective Strategy (*Operation*) for Creating a Positive Climate

A neglected aspect of instruction in collaborative learning is how students should be interacting with each other, particularly with respect to the socio-emotional dimension (Johnson and Johnson 1987; Kreijns et al. 2013). Often, the focus is on how students interact with the material presented in collaborative work or how group members interact with each other within the cognitive dimension or task context. Our examination of the co-occurrences of codes revealed that, within all three modes of regulation, the positive climate group demonstrated a higher frequency and proportion of positive socio-emotional interactions (see Figure 8). Closer inspection of the positive interactions in the positive climate group revealed that these interactions were comprised primarily of encouraging participation and motivation (f = 136), with 42.6% in the form of co-regulatory supports or requests for maintaining engagement in the task. Such encouraging interactions were not common in the negative climate group (f = 46), with a smaller proportion (28.2%) in the form of co-regulatory actions, possibly because the group was less proficient at engaging in such conversations, especially in the presence of one domineering group member. The excerpt below is an example of how members in the positive climate group encouraged each other. The conversation began with Jessica asking for feedback on her answer. The group then acknowledged Jessica's ability to construct a strong answer.

Jessica: Is that good?
Tom: Just bang out what you were just saying
Jessica: True yeah brilliant
Suparna: Yeah everything that was mentioned before was good.
Tom: I think Jessica has a good grasp on this.

The consistent supportive actions observed in the positive climate group were also acknowledged by the individual group members. In the SERT, all four members described a positive and supportive working atmosphere, in which they communicated and worked well together. In describing that atmosphere, group members reported positive emotions of happiness or confidence, with the exception of Angie, who recalled feeling stressed. Angie's stress, however, was likely related to her role as editor and did not reflect the positive atmosphere she perceived in the group. Angie thought her group was unaware of her stress, but predicted the group would have been supportive if they had known. On the other hand, members in the negative climate group recalled feeling negative emotions of stress and doubt. Seiko indicated the group did not know how to collaborate, which was consistent with the negative socio-emotional interactions observed in the chat logs.

Summary of Findings

The preceding themes describe the prominent factors that may contribute to a positive or negative socio-emotional climate. Figure 9 demonstrates how the findings might be embedded in the COPES model. Given the dynamic nature of COPES, it is important to note these figures represent a snapshot of COPES that may be observed at one time. Theoretically, the items listed in each box are continuously changing and shifting between boxes as groups move through the collaborative task. For example, the products of positive or negative emotions become conditions as groups move into the next iteration of regulation. From our findings, we posit incoming conditions set the foundation for a positive or negative collaborative experience, with these conditions contributing to the group's ability to regulate their emotions during the initial phase of collaboration. The emotions produced during early collaboration then become conditions influencing future regulatory actions, such as shared adaptation in the face of a challenge.

Finally, our observations of the groups' socio-emotional interactions throughout the whole session highlight the importance of communicating in a positive tone and minimizing negative interactions. Although both groups engaged in more positive than negative socio-emotional interactions, the frequency and proportion of negative interactions was higher in the negative climate group compared to the positive climate group (see Figure 7 and Table 7 in the Appendix). This suggests that, despite attempts to interact positively, the presence of persistent negative interactions may have detrimental effects, which can be seen in the negative emotions and lower satisfaction reported by members of the negative climate group.

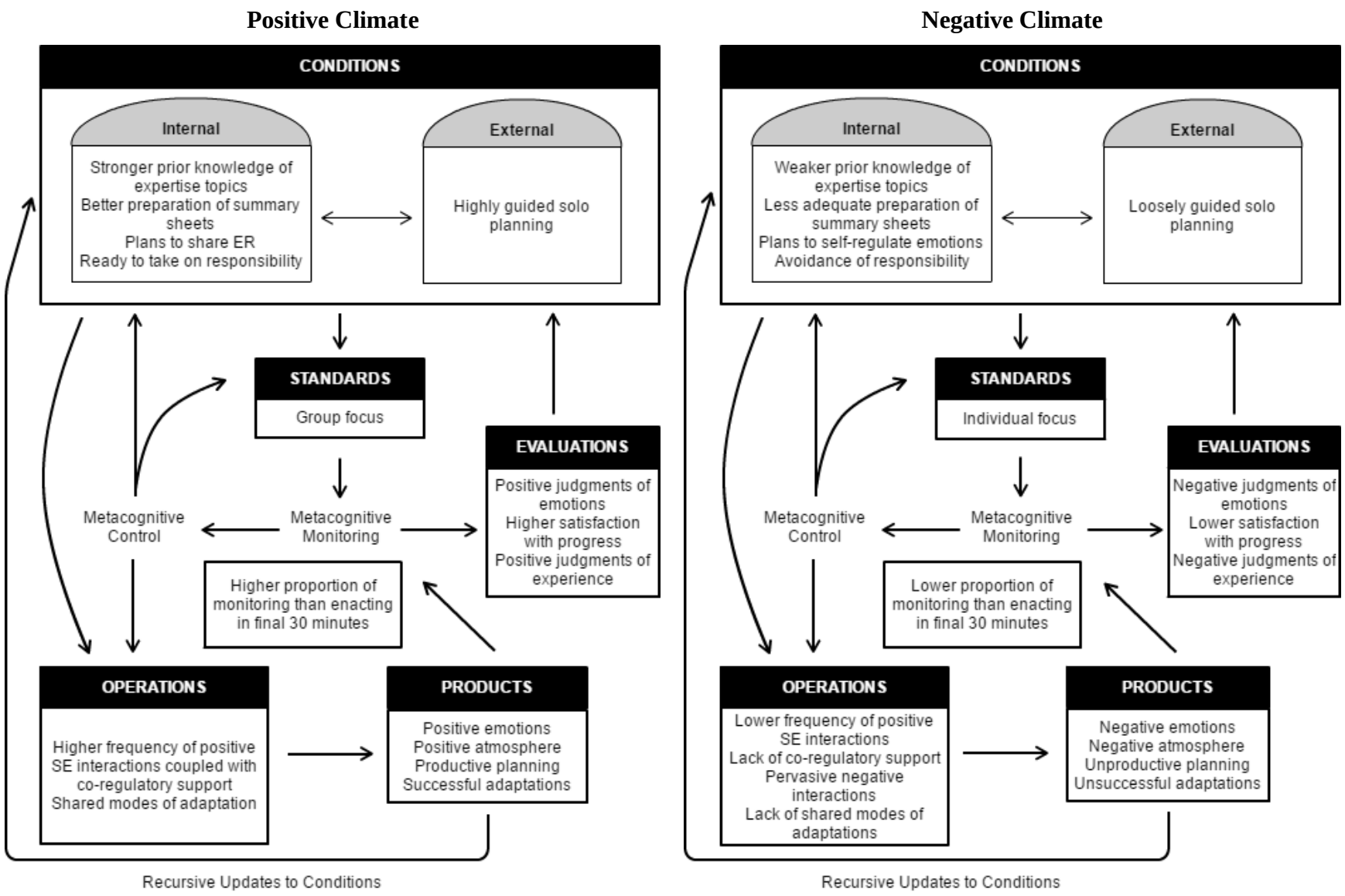

Fig. 9 Example of COPES occurring in each group.

Implications and Future Directions

This study set out to examine the regulation of socio-emotional aspects of collaboration in two groups with contrasting socio-emotional climates (positive vs. negative). Our in-depth analysis of various data sources led us to identify four emerging themes: (a) incoming conditions as a foundation for creating a positive collaborative experience, (b) regulation of emotions during initial planning, (c) shared adaptation in the face of a challenge, and (d) encouragement and motivational statements as an effective strategy in sustaining a positive socio-emotional climate. Overall, these findings lend support to theoretical accounts positing emotion regulation in collaboration as an active dynamic process unfolding across the individual and group level, where a multitude of conditions, operations, products, evaluations, and standards continuously interact over time (Hadwin et al. 2011; Järvelä and Hadwin 2013). The fluctuation and interaction of regulatory processes, regulatory modes, and socio-emotional interactions within the online environment (see Figures 5 to 8) contributed to the groups' contrasting socio-emotional climates in interesting ways. Our careful analysis demonstrates that a positive socio-emotional climate is possible when individual members accept personal responsibility to prepare for the task, actively engage in recognizing and supporting emotions that are experienced within the group, and collectively maintain shared responsibility to conquer challenging circumstances. Several areas of research should be further examined. First, this study indicates that instructional supports for members' *self*-regulation of learning in the service of the shared process are necessary for the group's productivity. This finding also suggests that creating a positive socio-emotional climate is not necessarily dependent upon establishing a strong social connection among group members outside of the task as argued in previous research (e.g., see Kreijns et al. 2013). The role self-regulation plays in collaboration aligns well with recent research by

Panadero et al. (2015), who found that individual regulatory skills (SRL) positively predicted group regulation (SSRL). Hence, support tools in collaborative contexts should not only be geared towards supporting the collective group, but should also support individual work within the group.

The current study also demonstrated the initial planning phase was a crucial window of time in the online collaborative session, indicating that appropriate scaffolds in the early stage of collaboration should be further examined. In this study, to support the development of shared and accurate task perceptions among group members, groups were provided an implicit guidance tool summarizing individual members' responses to the solo planning tool. No guidance tool was, however, targeted towards groups' motivation and emotion. We argue that awareness of in-the-moment emotions can be useful for members to promptly respond to unfavorable emotions within the group, ultimately taking joint control of the group's emotional climate. Therefore, guidance tools introduced in the initial phase of group planning should not only include members' perceptions of the task, but should also include other socio-emotional variables, which together can promote conversations about priorities, expectations, and motivations prior to engaging in the collaborative assignment (e.g., Järvelä et al. 2015).

In a similar vein, findings from this study point to the potential effect individual planning support can have on collaborative groups' emerging socio-emotional climate. In particular, we found the two groups differed in terms of the level of individual planning support they received. To follow up on this, we compared the conditions assigned to all six groups who met our initial selection criterion. Of the four groups who met the criteria for a positive climate (all reporting a positive experience), two groups came from the high individual support condition. In contrast, the two groups who met the initial criteria for a negative climate (all reporting a negative event),

both came from the low individual support condition. This trend indicates the level of support provided for individual planning may influence learners' engagement and, consequently, the socio-emotional climate experienced by the group. Although we did not observe major differences in group-level task perceptions between the two groups, future research should examine whether types of planning support affect socio-emotional climate in consistent ways across a large number of groups (see also Järvelä et al. 2016). Beyond planning, groups' ability to collectively adapt in challenging situations may be an important factor distinguishing effective from ineffective regulators (see also Winne and Hadwin 2008). Groups' adaptations in response to challenging situations can become important points for identifying the needs for regulatory supports within teams. Hence, we call for further research to examine groups' regulatory pathways from the point of encountering a challenge through to its resolution (or lack thereof).

Findings in the last theme suggest a positive socio-emotional climate is built upon feelings of trust portrayed through respectfully encouraging and supporting one another's participation and motivation. Interacting positively may not come naturally to group members and is, therefore, a skill that should be pedagogically encouraged and supported by instructors. Previous evidence suggests that effective collaborative learning largely depends on the quality of student interactions (Dillenbourg and Tchounikine 2007; Kobbe et al. 2007) and teachers' guidance in fostering beneficial interactions amongst collaborators (Webb 2009). Thus, supporting learners' regulation of emotions and motivation in collaboration is as important as supporting knowledge building between members in a team. One support instructors could provide is to proactively discuss with students interactions that might impede or benefit group functioning, also accounting for cultural differences that might be at play (see Volet 2001). Encouraging students to think about such topics beforehand may prompt them to make plans for

engaging positive socio-emotional interactions from the start and navigating negative socio-emotional experiences when the need arises.

One contribution of our study was examining socio-emotional interactions and regulation in a purely text-based collaborative session—a setting that may elicit different socio-emotional and regulatory processes when compared to face-to-face settings. For example, coordinating statements where the main purpose is to situate oneself and others in the learning environment (i.e., orienting) and explicitly expressing emotions using text emphasis and emoticons may be used more frequently in virtual collaboration. Investigating regulatory processes in online environments may, therefore, require that additional or different processes be considered. In other research, it has been argued that computer-mediated collaboration is often more task oriented with socio-emotional interactions decreasing as groups move along (e.g., Orvis et al. 2002), whereas face-to-face collaboration provides more opportunities for personal and socio-emotional interactions (Walther 1992). Though the decrease in socio-emotional interactions may be true for the negative climate group in our study, positive socio-emotional interactions remained continuously present in the positive climate group—a finding that is consistent with Kwon et al.'s (2014) 'good collaborators' (see also Malmberg et al. 2015). In other words, purposeful engagement in socio-emotional interactions and regulation of socio-emotional challenges seemed to be more dependent on group members' regulatory skills than the medium of collaboration itself. Above all, researching socio-emotional interactions and regulation in online environments provides opportunities for researchers to unpack those processes at several granularity levels. Apart from describing the types of regulatory and socio-emotional activities in collaborative groups (e.g., Kwon et al. 2014) and examining the influence of such activities on performance (e.g., Janssen et al. 2010), the sequential nature and the temporality of socio-

emotional interactions and regulatory actions can also be inspected. However, challenges in using online mediums do exist and include (a) technical difficulties in judging the temporal scope of meaningful socio-emotion and regulation episodes for data analysis and (b) the lack of non-verbal displays that may provide additional information about how group members are feeling and responding to the situation. Additional measures of learners' emotional processes may be useful for providing insight into learners' emotional reactions during collaboration, such as the self-report tools implemented in our study.

Another consideration for future research is the cultural or language challenges that afford or constrain the development of a positive socio-emotional climate. In our research, the negative climate group included two English-as-second-language (ESL) students who clearly expressed concern with their language skills. It is possible the focus on their perceived incompetence became a potent condition, changing the negative climate group's productivity. Another possibility is the ESL learners in the negative climate group may have carried a different set of culturally-bound working styles (see Volet 2001), creating differences in learning trajectories. Future research could examine to what degree culture or language differences interact with emotion regulation in group contexts.

Given the exploratory nature of this study, we focused on the first of two graded collaborative assignments in the course. It would be interesting to see how the groups' regulatory behaviors and socio-emotional interactions varied from the first collaborative experience to next. Presumably, the products of working together for one assignment would become conditions influencing the next collaborative cycle. For example, perceptions of a negative working climate may have prompted the negative climate group to engage in more detailed planning in the next collaborative assignment. Research is still being conducted to test the validity of that assumption.

Moreover, we did not explicitly examine groups' regulation in terms of quality because we were primarily interested in examining the change over time and interplay of regulatory actions. Examining the quality of regulatory processes was beyond the scope of this paper, but is another avenue of further research.

Finally, our selection of two cases demonstrating extreme differences in group members' perceptions of salient socio-emotional climate allowed us to generate two contrasting profiles, providing insights into the factors that differentiate a positive climate from a negative climate. Analysis of other group profiles, such as a mixed climate, may lead future research to demonstrate different salient factors that contribute to such climates. Regardless, our findings generally corroborate and extend those of other studies, thus offering a meaningful contribution to the research in this area. This exploratory study could lead to research with other groups and different contexts in order to further understand the regulatory mechanisms that contribute to productive and equally satisfying collaboration.

Conclusion

In summary, this cross-case analysis opens the door to many possibilities for research in regulation of collaborative learning. These possibilities span from (a) supporting regulation through encouraging higher levels of self-regulation prior to group work, providing scaffolds in the early stage of collaboration, and prompting groups to interact in a positive and respectful manner to (b) researching groups' regulation through challenging episodes and enactment of socially-shared regulation of learning. Certainly, the findings of this cross-case analysis demonstrate a need for researchers to further examine the important associations between groups' regulatory behaviors and the nature of groups' socio-emotional processes at a large scale.

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Appendix

Table 7 Code frequencies (and proportions) across coding categories

Codes	Positive climate	Negative climate
Regulatory processes	**466**	**339**
Planning	97 (20.8%)	81 (24.0%)
Enacting	91 (19.5%)	84 (24.9%)
Monitoring	145 (31.1%)	90 (26.6%)
Orienting	109 (23.4%)	70 (20.7%)
Adapting	13 (2.8%)	3 (0.9%)
Off-task	11 (2.4%)	10 (3.0%)
Modes of regulation	**474**	**344**
Self-regulation	91 (19.2%)	83 (24.1%)
Co-regulation	164 (34.6%)	82 (23.8%)
Co-regulatory request	13 (2.7%)	11 (3.2%)
Socially-shared regulation	206 (43.5%)	168 (48.8%)
Socio-emotional interactions	**205**	**118**
Positive interactions	190 (92.7%)	69 (58.5%)
Apologizing	6 (2.9%)	2 (1.7%)
Humor/laughter	13 (6.3%)	5 (4.2%)
Encouraging participation / motivation	136 (66.3%)	46 (39.0%)
Promoting trust & cohesion	35 (17.1%)	16 (13.6%)
Negative interactions	3 (1.5%)	30 (25.4%)
Discouraging participation / motivation	0 (0.0%)	9 (7.6%)
Low cohesion or pushing one's perspective	2 (1.0%)	8 (6.8%)
Pressuring others	1 (0.5%)	13 (11.0%)
Expressing emotions	12 (5.9%)	19 (16.1%)

Note: Proportions are of total category frequency.

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Strategies for Regulating Salient Motivation Challenges in Online Collaboration

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Abstract

Collaborating with peers in an online platform can raise a multitude of motivation challenges, including unequal participation, low efficacy or task value, and unproductive emotional reactions. Students are generally not proficient at regulating such challenges and use a limited number of strategies. Social reinforcement and task restructuring strategies have been found to be common in collaboration. However, it is unclear whether those strategies are consistently used throughout the collaborative process for various types of motivation challenges. This study examined the types of salient motivation challenges students identified in three phases of collaboration and the strategies they adopted in response. Participants were 139 students enrolled in an undergraduate course, where they worked in groups of three to five to complete a semester-long online collaborative project. Students identified behavioural difficulties related to effort initiation, distribution, and maintenance to be the most salient motivation challenge throughout collaboration. In response, most students (a) planned to check in regularly with group members during planning, (b) recalled providing social support in the early phase of collaboration, and (c) recalled promoting goal striving towards the end of collaboration. This study is one of a limited number that document motivation regulation strategies students planned and recalled using in online collaboration. Overall, the findings show that students adapt strategies for regulating salient motivation challenges during collaboration and highlight the importance of viewing strategies as related to a specific purpose rather than as a standalone set of procedures.

***Keywords*:** motivation, collaborative learning, self-regulated learning, computer-supported collaborative learning

Introduction

Today's interconnected global community demands graduates to be adept at collaborating and leveraging online technologies for productive collaboration. In response to this demand, online collaborative assignments are increasingly incorporated into post-secondary classrooms to promote the development of these skills (Chen, Donahue, & Klimoski, 2004). Such assignments typically involve a small group of students working together to solve ill-structured problems while the instructor plays a facilitative role by providing prompts and guidance (e.g., Miller & Hadwin, 2015). While there are benefits to collaboration, it can also raise various motivation challenges which may be exacerbated when the collaboration occurs online (Blumenfeld, Marx, Soloway, & Krajcik, 1996; Crook, 2002; Dirkx & Smith, 2004; Järvelä & Järvenoja, 2011; Järvelä, Järvenoja, & Veermans, 2008; Järvenoja, Volet, & Järvelä, 2013; Nokes-Malach, Richey, & Gadgil, 2015). For instance, online communications are easily ignored because they lack the immediacy of a face-to-face conversation, making it more motivationally challenging to collaborate (Dirkx & Smith, 2004).

Nonetheless, experiencing challenges creates opportunities for regulation. Regulating motivation is especially important because motivation is instrumental in directing and stimulating cognitive processing of the learning materials (Wolters & Pintrich, 1998). Groups that ignore motivation challenges are likely to work at a superficial level, and less likely to reap the benefits that come with in-depth negotiations of ideas and perspectives between group members (Malmberg, Järvelä, Järvenoja, & Panadaero, 2015; Mullin, Deiglmayr, & Spada, 2013). Regrettably, students are not well-equipped to effectively regulate motivation challenges in collaboration (Järvelä & Järvenoja, 2011). Yet, little has been done to support students in managing motivation during collaboration (Belland, Kim, & Hannafin, 2013).

Collaboration is a dynamic learning process. Distinct phases of collaboration may present different types of motivation challenges, and so require different types of strategic responses (Järvenoja, Järvelä, et al., 2018; Järvenoja, Järvelä, & Malmberg, 2017). However, little is known about how changing situational demands and challenges throughout collaboration influence students' regulation of their motivation. Although research has found common types of motivation regulation strategies collaborating students use (Järvela et al., 2008; Järvelä & Järvenoja, 2011), it is unclear (a) what type of motivation challenges the strategies are intended to address and (b) when the strategies are deployed in the collaboration process. This study contributes to the limited research on motivation regulation in collaboration by examining the types of salient motivation challenges that emerged in different phases of collaboration and the strategies students adopted in response.

Theoretical Framework: Motivation as a Target of Regulation

Conceptual models of regulated learning describe regulation as both *proactive,* such as when learners strategically engage in planning in anticipation of challenges, and *reactive,* such as when triggered by experienced cues that call for the learners to adapt (Boekaerts, 1996; Winne & Hadwin, 1998). Whether it be proactive or reactive, regulation is goal-directed, meaning it serves the purpose of bringing individuals closer to their goals and standards. Winne (2001) described two processes as essential in driving regulation: metacognitive monitoring and control. Metacognitive *monitoring* includes individuals identifying whether the information they attend to (e.g., about themselves, the task, social context, progress, and/or product) correspond to the standards they hold about that information. The process of monitoring does not necessarily need to be self-initiated; it may be prompted by other individuals (e.g., peers explaining task goals and requirements) or technological tools (e.g., a calendar reminder showing a task deadline; see

Hadwin, Järvelä, & Miller, 2017). When individuals detect misalignments between their current conditions and set goals or standards, a judgment may be made about whether further actions or interventions are warranted. Such situations present learners with a set of possible actions, including (a) deliberately ignoring the issue and hoping it will resolve on its own, (b) trying a strategy that could bring them closer to their goals and standards, (c) modifying a current strategy, and (d) exiting the task altogether to avoid dealing with the issue (Hadwin, Bakhtiar, & Miller, 2018; Hadwin, Davis, Bakhtiar, & Winne, 2019). Choosing to exercise a tactic or a strategy to address issues and challenges assumes that metacognitive *control* is in flight. As learners progress in a task, they may engage in several cycles of such metacognitive processes to further fine-tune their regulatory actions and responses (Winne & Hadwin, 1998).

Motivation is recognized as one target of regulation (in addition to behaviour, cognition, and emotions) that can be deliberately controlled and manipulated (Pintrich, 2004; Winne & Hadwin, 1998; Wolters, 2003). Motivation regulation may be discussed under the heading of volition control, in which volition is defined as the inner drive needed to complete a task (Corno, 1993). Miele and Scholer (2018) described motivation regulation as “the process by which one attempts to maintain the level and type of motivation needed to optimally pursue some goal” (p. 3). However, this regulation is not only limited to *maintaining* motivation but also includes *initiating* and *reinforcing* motivation for achieving a particular goal (Wolters, 2003). In essence, when regulating motivation, learners (a) must have some awareness of the challenges and issues that threaten their motivational goals and standards (metacognitive monitoring), and (b) operate some types of tactics and strategies to bring them closer to their motivational goals and standards (metacognitive control).

Winne and Marx (1989) described motivational information learners may manipulate, including the *attributions* they make about similar learning tasks, *efficacy* beliefs, *interest* in the learning activities, *outcomes* expected from engaging in the task, and *utility* or perceived benefits associated with the task. Wolters (2003) identified several strategies students use to manipulate the motivational information, which includes attributing learning outcomes to something within their control, taking smaller steps to build positive efficacy beliefs, finding exciting elements of a task, emphasizing the values and benefits for pursuing a task, and reappraising unproductive emotional reactions shown towards a task. Pintrich's (1999) provisional taxonomy of volition control suggests that the strategies learners use to regulate motivation involve controlling (a) behaviour (effort and persistence), (b) cognition or motivational beliefs (efficacy beliefs and goals), (c) emotions (interest, enjoyment, and attitude) and (d) the environment or task features. This categorization of strategies is useful for holistically capturing the varied strategies learners use for managing motivation in various learning situations. Overall, students' management of behaviour, cognitive beliefs, feelings, and environment can be considered forms of motivation regulation strategies as long as the intent is to influence the level of willingness to engage in a task (Wolters, 2003).

Motivation Challenges in Collaboration

Regulatory processes in collaborative contexts are complex. Hadwin et al. (2017) theorized that productive regulation in collaboration necessitates self-regulation, where individual learners focus on the regulation of their own learning process, and group level regulation. The latter encompasses two types of regulation: (a) co-regulation—learners temporarily guide or compensate for others' or the team's regulatory trajectories, and (b) socially shared regulation—learners regulate together as a team toward a shared outcome. This theory

implies that, in collaboration, individuals must not only regulate their own motivation, but must also play a role in recognizing and temporarily guiding or supporting the motivation of team members as well as jointly taking control of the team's collective motivation. Hence, learners need to consider many sources of motivation, beyond their own, when collaborating.

Traditional research on motivation suggests that individuals' motivation appraised preceding the task is predictive of their self-regulatory activities during the task (Boekaerts, 2002). Moreover, research in collaborative contexts shows that individual group members' enduring motivational traits and beliefs, such as intrinsic motivation for learning, are predictive of their attitudes and behavioural patterns shown during collaboration (Järvelä et al., 2008; Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009; Yang, Tsai, Kim, Cho, Laffey, 2006). Accordingly, it is fair to assume that group members' motivational characteristics and task-specific motivation would pose challenges to the group's motivation and engagement during collaboration. However, motivation in collaboration is not merely the sum of its parts. Having more individual members with positive motivation and task appraisal does not necessarily translate to the group being more motivationally engaged and thus experiencing fewer motivation challenges during collaboration (e.g., Schoor & Bannert, 2011; Wang & Lin, 2007).

For instance, Schoor and Bannert (2011) found that students' positive appraisal of their motivation for an individual preparation task, designed to get the students ready for collaboration, was related to having a higher frequency of cognitive engagement in the task. In contrast, such relation was not found when the same students participated in the associated collaborative task; students who indicated more positive motivation for the collaborative task were not necessarily highly engaged during collaboration. Schoor and Bannert measured task-

specific motivation using several dimensions involving individual appraisal of success expectancy, task value, and task anxiety (see also Boekaerts, 2002). Even when individual members' task appraisals were aggregated at the group level, Summers and Volet (2010) found that groups' mean appraisal of task utility and affective reactions towards the task were not predictive of the groups' levels of task engagement. This set of findings indicate that sources of motivation (and its challenges) in collaboration extend beyond individual group members' task motivation; many other sources of motivation challenges derive from the dynamic interactions between group members, the task, and context (Järvenoja, Järvelä, et al., 2018).

Our literature review indicates that motivation challenges in collaboration include at least three categories. First, *behaviour-focused* motivation challenges relate to students' effort initiation, distribution, and maintenance. One common behavioural issue reported in collaboration is social loafing, where some group members reduce effort and rely on others to do their share of work (e.g., Kreijns, Kirschner, & Jochems, 2003; Solomon, Davidson, & Solomon, 1992). Group members who reduce effort are not necessarily uninterested in the task, but they may withhold ideas and opinions when their contributions are perceived as insignificant, particularly when some members impose control over the task (Dirkx & Smith, 2004; Solomon et al., 1992). In an online collaboration, groups may also experience effort-coordination difficulties such as getting everyone to log in to the online system and staying on-task (Dirkx & Smith, 2004).

Second, *cognitive-focused* motivation challenges derive from cognitive beliefs about competence, task value, and goals. Group members may have conflicting expectations about the purpose of the task and may have difficulties seeing how the task is relevant to them (e.g., Järvelä & Järvenoja, 2011; Järvenoja, Volet, & Järvelä, 2013; Van den Bossche, Gijselaers,

Segers, & Kirschner, 2006). Research found that when individual members deem the task to be complicated or when they fear that other members are judging their ability, those individuals would likely exhibit lower efficacy belief and experience a decline in motivation (e.g., Dirkx & Smith, 2004; Rogat & Linnenbrink-Garcia, 2019). Finally, *emotion-focused* motivation challenges derive from group members' emotional reactions and responses which influence their enjoyment and engagement in the task (Järvenoja & Järvelä, 2009; Van den Bossche et al., 2006). Research has studied this last category of challenges by examining groups' socioemotional interactions which involve interactions that elicit group members' positive and negative feelings. For example, consistently domineering group members could create social tensions which led to some members to withdraw from the task (e.g., Bakhtiar, Webster, & Hadwin, 2018; Näykki, Järvelä, Kirschner, & Järvenoja, 2014).

Strategic Regulation of Motivation Across Different Phases of Collaboration

The presence of motivation challenges in collaboration may fluctuate depending on the situational demands that arise in distinct phases of collaboration. Prior to a task, motivation hurdles may come in the form of lacking task value and goals or experiencing anxious feelings about the act of doing the task (Kim & Bennekin, 2016; Wolters & Pintrich, 1998). Group management of emotions in their planning phase can significantly influence group members' motivation and engagement in the phases that follow (Ayoko, Konrad, & Boyle, 2012; Bakhtiar et al., 2018). Research indicates that providing supports to collaborating students at planning reduces the intensity and amount of challenges students experience in the task (Hadwin et al., 2018; Hadwin, Webster, Bakhtiar, & Caird, 2015). Once students are in the task, issues with self-efficacy may be more critical for pushing them to complete the task (Wolters & Pintrich, 1998). During this phase, groups were found to focus on getting the task done and spent less time

regulating emotions, particularly when the task was well-structured (Järvelä, Järvenoja, Malmberg, Isohätälä, & Sobocinski, 2016). As students progressed in their learning, Moos and Azevedo (2008) found that students' motivation in their hypermedia learning environment increased, and consequently decreased the students' use of strategies. Overall, these studies demonstrate that motivation regulation in a task is tightly connected to changing situational factors. Examining students' strategy use only after the collaboration has ended is insufficient to capture the dynamic interplay between students' strategy use and situational demands (Järvenoja, Järvela, & Malmberg, 2015).

There is a paucity of research examining the temporal changes in students' motivation regulation strategies during collaboration. However, the limited research in the area indicates common approaches students demonstrate in collaboration. For instance, Xu and Du's (2013) multi-level analysis revealed three factors that positively predicted engagement in motivation management during online collaboration: (a) individual members' time management skills, (b) attention to and manipulation of environmental features of the task, and (c) help-seeking activities. Järvelä et al.'s (2008) video analysis of two groups' collaboration across three tasks found that groups most often used social reinforcement strategies to regulate group motivation. Social reinforcement was defined as "students' identification and administration of reinforcements influencing their motivation and their joint behaviors," (p. 127). Similarly, Järvelä and Järvenoja's (2011) cross-data summary found challenges related to conflicts in goals and priorities and commitment issues were common motivation challenges groups encountered, and these challenges were typically regulated by socially reinforcing group members' effort and restructuring the task.

Despite research identifying frequently used motivation regulation strategies, more research is needed to examine factors that activate specific strategy use. Frequent strategy use does not necessarily imply consistent distribution throughout the collaborative process. Students may use a specific strategy early in the task, and later they may adapt to use another strategy given the changing social and contextual demands. Moreover, strategies are not merely a set of actions. Regulated learning frameworks acknowledge that strategies are driven by learners' metacognitive processes (Winne & Hadwin, 1998). A strategy is a tactic or technique used purposefully to address a specific situational demand or serve a specific goal. Hence, research is needed to examine strategy use in relation to the situational challenges or demands that trigger the strategic action.

Purpose

The purpose of this study was to examine types of salient motivation challenges (behaviour-, cognitive-, or emotion-focused motivation challenges) that emerged in different phases of collaboration (during planning, early during collaboration, and towards the end of collaboration), and the strategies students adopted in response. The specific research questions were:

i. Do group members' ratings of motivation challenges differ across phases of collaboration?
ii. Do ratings of challenge intensity correlate with group members' task appraisal?
iii. What were the main motivation challenges that triggered group members' regulation?
iv. What types of strategies were adopted in response to the identified main challenges?

For the first research question, we hypothesized that motivation challenges were expected to be higher during planning and lower during collaboration, as suggested by past research that

prompted metacognitive awareness during planning (see Hadwin et al., 2018). Regarding the second research question, we hypothesized that group members' task appraisal would negatively correlate to the intensity ratings of all three types of motivation challenges. However, these correlations might be low, given that many other sources of motivation challenges in collaboration could derive from other individual members, the situation, and context. The paucity of research about motivation regulation strategies in collaboration constrained the specificity of our hypotheses for the last two research questions. Broadly, we expected that students' salient challenges and the strategies adopted in response would be different across the three phases. Also for the last research question, we conducted a series of exploratory analyses to uncover the challenge-strategy patterns with a broad hypothesis that some strategies might be more effective in reducing the likelihood of re-encountering the same challenge in the latter phase of the collaboration.

Methods

Participants

Participants were 139 undergraduates (70 males; *mean age* = 18.95 years; 60% first-year students) enrolled in the same credit-bearing elective course in Educational Psychology at a mid-sized Canadian university. Students came from a broad range of disciplines and incoming levels of academic achievement with a mean entering Grade Point Average of 6.42 (*SD* = 2.15) based on a nine-point GPA scale. The course ran for 12 weeks and consisted of a 1.5-hour lecture and a 1.5-hour lab each week. Weekly, students were (a) introduced to learning and academic success topics in educational psychology in lecture, and (b) guided to apply the introduced concepts to their own academic studying and learning in lab.

One of the assignments in the course included an applied collaborative project. Students completed the project in groups of three (6 groups), four (18 groups), and five (11 groups) students. The total number of participants was 139 because five students withdrew consent and one student had incomplete data. Students were assigned to groups within their own lab section in the second week of the course. Groups were made heterogeneous based on students' prior course knowledge (assessed at the beginning of the course), sex, and English-as-a-second-language status.

The Collaborative Project

The collaborative project (cumulatively worth 35% of the course mark) required groups to generate and present a strategy for tackling one topic of their choice related to university learning (test-taking, notetaking, reading, or studying for exams) in the form of an infographic. An infographic is a visual representation of information and data related to the chosen topic. The infographic required students to highlight (a) how to implement the strategy, (b) why the strategy should work, and (c) an example of the strategy in use. Students approached the project in nine phases across eight weeks in the course, with the last two phases conducted in the same week. Activities related to the collaborative project covered about one-third of the total classroom activities and were interspersed throughout the course (see Figure 1). Details about the graded components and grading criteria are included in Appendix A.

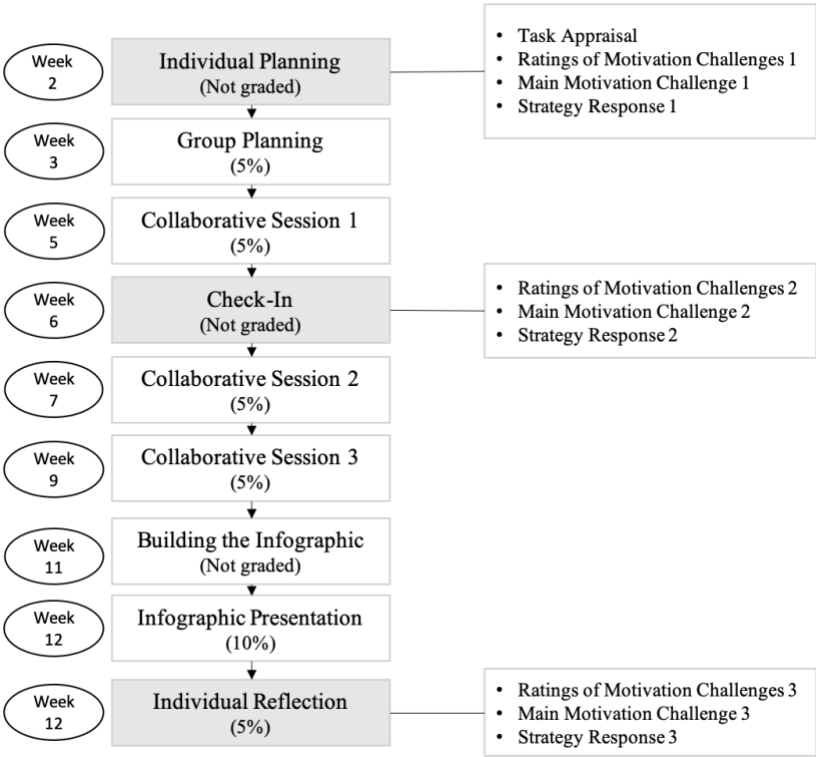

Figure 1. Timeline of the collaborative project. The bulleted lists display the variables collected at the planning (Individual Planning), early (Check-In) and end (Individual Reflection) phase of the collaboration. Percentages in parentheses refer to how much the activity contributes to the total course mark. Some weeks are missing because the project was not conducted in those weeks.

Individual planning. During individual planning, students completed a guided activity to prepare for the task. Individual students (a) reviewed task instructions, (b) appraised their task motivation (c) thought about challenges they might anticipate, and (d) proactively strategized about how to address those anticipated challenges. Students were allocated 10 minutes to complete this activity in lab.

Group planning. During group planning, groups (a) negotiated task perceptions and interpretations, (b) aligned goals and priorities, and (c) constructed a plan of attack for addressing anticipated challenges during collaboration. Groups were given 30-40 minutes to plan online using text-based chat tool called Google Hangouts.

Collaborative sessions. To generate the infographic, groups gathered relevant resources on their topic. Resources were primarily drawn from class readings but could include external scholarly work students located on their own. Groups gathered and compiled resources and ideas in three separate shared online Google Docs completed in three separate collaborative sessions. Each session had a different discussion topic, carried out in the following order: (a) the concept of self-regulated learning, (b) factors that determine effective learning, and (c) evidence-based strategies for the chosen topic. Google Docs were pre-stocked for each group with prompts to guide topic-oriented discussions (see Appendix A for a list of specific prompts).

During each collaborative session, all participants opened two online applications: (a) Google Hangouts for communicating and (b) Google Docs for documenting the group's knowledge and ideas (Figure 2). All collaborative discussions were conducted online in Google Hangouts. Groups were given ~60 minutes of lab time for each discussion topic. Additional time outside class was provided to complete discussions and submit the Google Docs (due within the week). All groups made use of this additional time to refine their answers. Students were

required to use Google Hangouts when communicating even when discussions occurred outside of class.

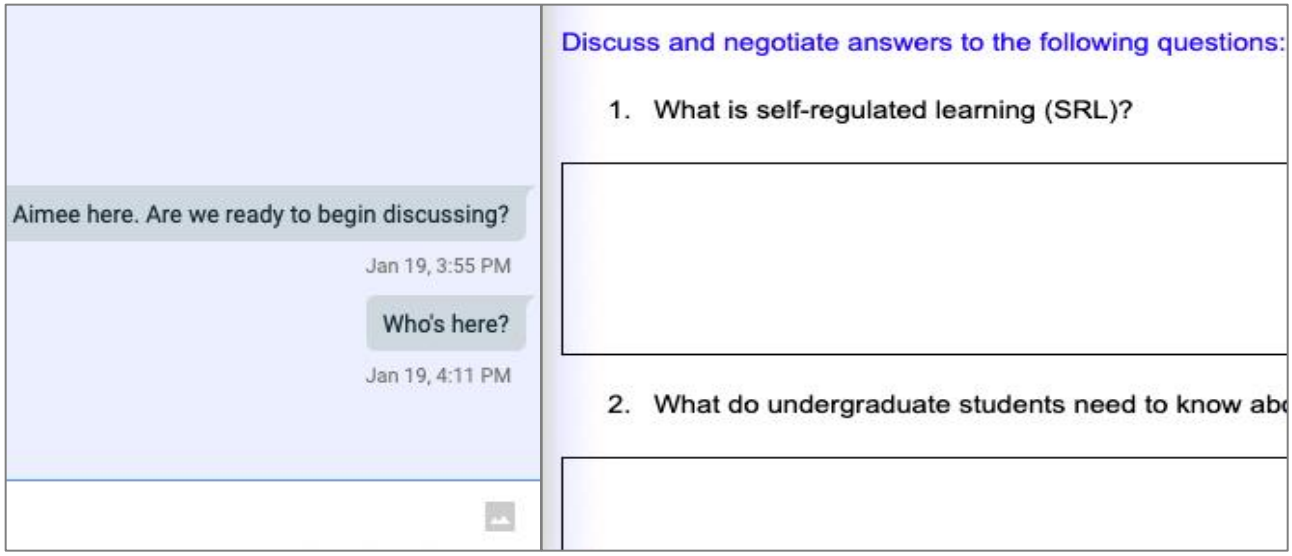

Figure 2. Example of a group's online session. Google Hangouts (left) and Google Docs(right).

Check-in. A week before the second collaborative session, individual students were prompted to think about and report on (a) their team progress, (b) challenges encountered to date, and (c) a motivation regulation strategy used to address a salient motivation challenge experienced in the early phase of the collaboration. The time placement of this survey was intended to capture the crucial experiences that occurred early in collaboration (see Bakhtiar et al., 2018).

Building the infographic. During this session, groups translated resources and ideas into a presentable infographic. The infographic was built within the Google-Suite environment using available templates prepared in Google Slides. Within the environment, all members were able to concurrently access and edit their infographic and track changes made to the artwork.

Infographic presentation. In the final week of the course, groups presented their finished infographic to students in their lab while being graded by the course instructor.

Individual reflection. At the end of the project, students reflected on their collaborative experience including (a) an assessment of team effectiveness and behaviour, (b) challenges they encountered in the latter phase of collaboration, (c) the strategy used for addressing a main motivation challenge experienced in that phase, and (d) a plan for improving future collaborations.

Individual-Level Variables

Task appraisal. Group members' motivational appraisal of the collaborative project was assessed during individual planning using a short questionnaire that included ratings of task interest (1 item), task value (1 item), task utility (2 items), self-efficacy (1 item), and overall readiness to engage in the task (1 item). The construction of this scale was informed by Boekaerts' (2002) online pre-task motivation appraisal questionnaire that included questions relating to task attraction, difficulty, utility, and self-efficacy. The rationale for constructing a separate questionnaire was so that we could align the wording of the items to the instructional aim of the individual planning activity designed for the course. Internal consistency based on all items as denoted by Cronbach's alpha was .72. A reliability coefficient of .70 or higher is considered "acceptable" in social science research (Taber, 2018). Responses on the items were collected on a five-point Likert scale, from 1= *Strongly disagree* to 5 = *Strongly agree*. See Appendix B for a full list of items.

Ratings of motivation challenges. Students were prompted to reflect on several types of collaboration challenges similar in research by Hadwin and colleagues (Hadwin et al., 2018; Hadwin et al., 2015). The challenge items students rated included planning, understanding of the

learning materials, using technological tools, participation and engagement, motivational beliefs, socio-emotional climate, checking progress, and general working styles. For the purpose of this study, we focused on ratings on three items capturing three broad types of motivational challenges: (a) "*Difficulties getting individuals to participate, getting the work done, or staying on task*" (behaviour-focused), (b) "*Lacking confidence or a sense of purpose or goals for the task"* (cognitive-focused) and (c) "*Difficulties maintaining positive emotions about the task, the group, and the situation"* (emotion-focused). Once at planning, students rated how much they anticipated experiencing the three types of motivation challenges. Then, once at check-in and once at the end of the collaboration, students rated the extent to which they experienced the challenges during the early and later phase of collaboration, respectively. Ratings were collected on a five-point Likert scale from 1 = *Not a problem* to 5 = *Major problem*.

Main motivation challenge. Students were subsequently asked to identify the main motivation challenge they deemed to be the most salient. Students chose one main challenge from a list containing the following items: a) *Difficulties getting individuals to participate, getting the work done, or staying on task* (behaviour-focused), (b) *Lacking confidence or a sense of purpose or goals for the task* (cognitive-focused), (c) *Difficulties maintaining positive emotions about the task, the group, and the situation* (emotion-focused), or (d) *Other* for a challenge that was not listed. When "other" was chosen, students were prompted to explain in a text-field what that meant. Students selected a main motivation challenge three times: at planning (anticipated main challenge) and at check-in and individual reflection (experienced main challenge).

Main strategy response. After identifying the main motivation challenge, students were asked to construct a plan for regulating that challenge (at individual planning) or report the type

of strategy they used to address the main challenge they experienced (at check-in and individual reflection). Students described their strategies in open-ended text-fields.

Analysis

The unit of analysis of this study was the individual group members. Analyses were performed in three stages. *Stage 1(Motivation Challenges)* included examining individual students' ratings of motivation challenges across the three phases of collaboration, and how those ratings might be related to task appraisals. At the end of this stage, the main motivation challenges students recalled in each phase of collaboration were examined.

In *Stage 2 (Strategy Response)*, students' responses to all the open-ended text fields about their planned and reported motivation regulation strategies were qualitatively coded. Specific to the data collected at planning, several students had a plan that involved two types of strategies. When this happened, both strategies were coded and the frequency of each type of strategy across students was calculated. The first author coded all reported strategies through multiple rounds of inductive and deductive coding before codes were labelled and a coding scheme was developed. Deductive coding was informed by Wolters (2003) who catalogued motivation regulation strategies learners use in individual learning and studying. Upon reaching saturation in the coding scheme, a senior research assistant then performed a reliability check for 20% of the data in two coding sessions, with 10% in each session. Between the two sessions, coders discussed their codes and together refined the descriptions of the strategies to improve clarity in the coding scheme. Inter-rater reliability between the two coders was high: Cohen's kappa κ was .85 (SE = .04) for the first round and .84 (SE = .04) for the second round.

At the end of Stage 2, coded strategies were categorized based on Pintrich's (1999) provisional taxonomy of volition control: (a) behaviour control—strategies that relate to

managing one's behavior and performance in the task, (b) cognitive control—strategies that relate to managing one's thoughts or motivational beliefs about the task and/or the team, (c) emotion control—strategies that relate to managing how one feels about the task, situation, or the team which may involve either inducing positive emotions or decreasing negative emotions, and (d) environment control—strategies that relate to management of the task features and aspects of the learning environment (Table 1). Table 1 also specifies the target motivation construct(s) associated with the strategies were specified.

Finally, in *Stage 3 (Challenge-Strategy Pattern)*, we conducted a series of exploratory analyses to examine (a) the probabilities of using specific strategies for the salient motivation challenges identified in the early phase of collaboration, and (b) whether the chosen strategies would lead to having low probabilities of re-encountering the same salient challenge in the latter phase of collaboration. Probabilities were plotted on a transitional probabilities map, which helped uncover the most dominant patterns of responses (see Hadwin et al., 2018).

Table 1. *Behaviour-, Cognitive-, Emotion-, and Environmental Control Strategies Students Described Using for Regulating Motivation*

	Target Motivation	**Strategy**	**Examples†**
Behaviour control: Managing how one behaves and performs in the task.	Effort, Persistence	*Social Support:* Encouraging or facilitating others' participation by seeking and providing feedback, promoting openness, accommodating needs, and demonstrating tactics/strategies.	*Demonstrate to others how to work on the task. Hear each other out on all of our ideas and work slower.*
		Task Completion: Requesting individual(s) to merely complete the task and exert effort; Spending more time/effort; Completing the work on one's own.	*Spend more time working on the project. Ask others for contribution.*
		Check In: Checking in with group members about the task, progress and/or product; Increasing group check-in frequency.	*Check in consistently with the rest of the group to make sure we have done what we need to do.*
		Reward: Provide some rewards if the job gets done or if the goal is reached.	*After completing certain sections of the work, I want to have a group reward that helps us stay engaged.*
Cognitive control: Managing one's thoughts or beliefs about the task, self, and/or the team.	Efficacy Beliefs, Task Value, Perceived Utility, Goals	*Plan and Goal*: Planning and setting goals to improve the clarity of individual or group goals and not merely about task assignment.	*Explain clearly what our plan is to ensure that what we think will work has no errors in it.*
		Promote Goal Striving: Reminding self or team members about what they need to strive for; Encouraging others to achieve a set goal; Reminding oneself that one can be successful and have the capabilities to do the task.	*To build up self-confidence so I can be successful in attaining my goal and would be in better shape to encourage my group members.*
		Utility and Value: Thinking about the benefits and value of engaging in the task.	*Further understand why we are being asked to do this project, the benefits we and classmates will get out of it etc.*

		Information Processing: Improving mastery and understanding of course concepts by seeking relevant resources.	*Tried to organize our thoughts and find new information and resources on the project.*
Emotion control: Managing how one feels about the task, situations, or the team.	Interest, Enjoyment, Positive Emotions	*Interest & Enjoyment*: Focusing on something that interests oneself or that is fun and enjoyable; Inducing positive affect.	*Figure a way to make this project look more enjoyable to complete.*
		Expressing Emotions: Expressing or communicating emotions; Expressing concerns and/or challenges.	*To reduce personal frustrations regarding differences in work quality/effort, I remind myself to voice concerns.*
		Emotion Regulation: Reappraising the emotions by sorting out frustrations or becoming flexible with differences causing the frustrations; Decreasing negative emotions.	*Keep positive that the project will be completed with little stress*
Environment control: Managing aspects of the environment.	Attention	*Environmental Restructuring:* Reducing distractions; Finding a better work condition, or time to work on the group project; Revising timing for the group to meet.	*We started meeting up as a group outside of class. We got so much more work done than when we worked on it in class.*
Did Nothing			

Note: †Examples were taken from students' exact wording.

Findings

Do Group Members' Ratings of Motivation Challenges Differ Across Phases of Collaboration?

To examine the changes in group members' perceptions of motivation challenges across time, a repeated measures analysis of variance (ANOVA) was conducted for each challenge type (Table 2). The sphericity assumption required for the analysis was met in all three ANOVAs. As hypothesized, findings showed significant within-person differences with regards to intensity ratings of motivation challenges over time (last column in Table 2). Specifically, the intensity of all three types of motivation challenges was lower during collaboration than anticipated during planning.

When ratings between types of motivation challenges were compared, findings showed that behaviour-focused motivation challenges were most commonly anticipated during planning ($F_{(2,260)}$ =16.36, p <.001), and recalled in the early phase of collaboration, ($F_{(2,279)}$ = 6.43, p <.01) and at the end of the collaboration ($F_{(2,264)}$=12.95, p <.001). Students viewed behavioural participation issue as most problematic throughout collaboration compared to issues related to cognitive beliefs about motivation and goals as well as issues related to emotional reactions in the task. Means and standard errors of rated motivation challenges are reported in Table 2.

Table 2. *Means and Standard Errors (in Parentheses) of Motivation Challenge Ratings, and F-Ratios of the Repeated Measure ANOVAs.*

	Anticipated During Planning	Reported in the Early Phase	Reported at The End of Collaboration	Across Time (F-ratio; significance; effect size)
Behaviour-Focused: Difficulties getting individuals to participate, getting the job done, and staying on task	3.10 (.08)	2.03 (.09)	2.35 (.09)	$F(2, 244) = 45.80$, $p<.001$, $\eta^2 = .27$
Cognitive-Focused: Lacking confidence or a sense of purpose or goals for the task	2.60 (.08)	1.75 (.08)	2.03 (.09)	$F(2,244)=34.60$, $p<.001$, $\eta^2 = .22$
Emotion-Focused: Difficulties maintaining positive emotions about the task, the group, and the situation	2.73 (.08)	1.72 (.09)	1.85 (.08)	$F(2,244)=49.78$, $p<.001$, $\eta^2 = .29$

Do Ratings of Challenge Intensity Correlate with Group Members' Task Appraisal?

We hypothesized that task appraisals would have low negative correlations with intensity ratings of all three types of motivation challenges. Correlational analysis revealed that individual pre-task motivational appraisal and intensity ratings of motivation challenges had low to no correlations (Column 1 in Table 3). The lack of correlations suggests that the challenges experienced in collaboration originate less so from individual members' task appraisal but from multiple other situational factors that emerged through interactions between the self, social, technological tools, and task. However, findings showed that ratings of behaviour-, cognitive-, and emotion-focused challenges in each phase were significantly related to each other, demonstrating the overlapping nature of these challenges (bolded in Table 3). For instance, students who reported experiencing more difficulties with behavioural engagement were more likely to report experiencing negative affect as well as unproductive cognitive beliefs for the task.

Table 3. *Zero-Order Correlations Between Ratings of Behaviour-, Cognitive-, and Emotion-focused Motivation Challenges and Task Appraisal*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Appraisal	-									
2. BevCh1	.05	-								
3. CogCh1	-.12	**.32****	-							
4. EmCh1	-.09	**.50****	**.40****	-						
5. BevCh2	.12	.10	.12	.03	-					
6. CogCh2	-.18*	.21*	.14	.21*	**.28****	-				
7. EmCh2	-.02	.04	.21*	.15	**.43****	**.37****	-			
8. BevCh3	-.02	.19*	.11	.15	.25**	.16	.06	-		
9. CogCh3	-.17	.04	.10	.10	.05	.30**	.11	**.30****	-	
10. EmCh3	-.13	.02	.02	.02	.17	.27**	.32**	**.35****	**.43****	-

Note: * p<.05; ** p<.01. Correlations in bold refer to the correlations between challenge types at each time point. BevCh refers to behaviour-focused, CogCh refers to cognitive-focused, and EmCh refers to emotion-focused motivation challenge.

What Were the Main Motivation Challenges that Triggered Group Members' Regulation?

We expected to see differences in terms of the types of main motivation challenge reported across phases of collaboration. However, as indicated in Table 4, a high proportion of students reported behaviour-focused motivation challenges that included difficulties getting individuals to participate, getting the work done, or staying on task, to be their main motivation challenge anticipated during planning *(Chi- square statistics,* $x_2(2) = 57.40$, $p < .001$), and experienced at the early phase ($x_2(2) = 18.81$, $p < .001$) and toward the end of collaboration ($x_2(2) = 93.95$, $p < .001$).

Table 4. *Frequency and Percentage of the Main Motivation Challenges Across Time*

Main Motivation Challenge	Anticipated During Planning Freq. (%)	Reported in the Early Phase Freq. (%)	Reported at The End Freq. (%)
Behaviour-Focused: Difficulties getting individuals to participate, getting the work done, or staying on task	84 (64%)	52 (49%)	76 (79%)
Cognitive-Focused: Lacking confidence or a sense of purpose or goals for the task	19 (15%)	38 (36%)	16 (17%)
Emotion-Focused: Difficulties maintaining positive emotions about the task, the group, and the situation	28 (21%)	16 (15%)	4 (4%)

What Types of Strategies Were Adopted in Response to the Identified Main Challenges?

As hypothesized, the types of strategies students adopted in response to anticipated or experienced motivation challenges were somewhat different across phases (Table 5). Frequencies and proportions of behaviour-, cognitive-, emotion-, and environmental control strategies showed that, during planning, the most commonly selected strategies included behaviour and cognitive control. Specifically, strategies with the highest percentage during planning involved checking in with group members or increasing the frequency of check-ins during the collaboration (25%). Other commonly planned strategies included planning and goal setting to improve members' understanding of the task goal and purpose (19%), promoting efficacy maintenance and goal striving (18%), and promoting interest, enjoyment, and positive emotions in the task (17%).

Next, in the early phase of collaboration, most students focused on behaviour control (41%). However, the common type of strategy slightly differed from the planning phase. The most common strategy they reported using in the early phase was providing social support to group members by facilitating their participation, demonstrating relevant tactics or strategies, and accommodating needs (25%). The same type of strategic planning and goal setting reported prior to

the collaboration was found to be used again during this phase at a similar frequency (16%). The third highly reported strategy was environmental restructuring, where learners controlled various aspects of their environment including meeting location, medium of communication, time of day or week, and/or external distractions (15%).

Finally, 53% of students reported using a cognitive control strategy towards the end of the collaboration. Specifically, the cognitive control strategy included promoting self or group members' efficacy maintenance and goal striving (38%). This strategy may be deemed useful in pulling together the group's remaining tasks or efforts toward completion of the project. The strategies that followed were reported much less frequently, including providing social support (14%) and strategic planning and goal setting (13%).

Table 5. *Motivation Regulation Strategies Students Planned and Reported*

Strategy Type	Planned Prior to Collaboration Sum (%)	Recalled in the Early Phase Sum (%)	Recalled at the End of Collaboration Sum (%)
Behaviour control:	**54 (43%)**	**53 (41%)**	**41 (31%)**
Social Support	16 (13%)	32 (25%)	18 (14%)
Task Completion	2 (2%)	11 (9%)	5 (4%)
Check In	31 (25%)	10 (8%)	16 (12%)
Reward	5 (4%)	0 (0%)	2 (2%)
Cognitive control:	**53 (42%)**	**40 (31%)**	**71 (53%)**
Plan and Goal	24 (19%)	21(16%)	17 (13%)
Promote Goal Striving	23 (18%)	8 (6%)	51 (38%)
Utility and Value	6 (5%)	0 (0%)	0 (0%)
Information Processing	0 (0%)	11 (9%)	3 (2%)
Emotion control:	**40 (32%)**	**4 (3%)**	**6 (5%)**
Interest & Enjoyment	21 (17%)	2 (2%)	6 (5%)
Expressing Emotions	7 (6%)	1 (1%)	0 (0%)
Emotion Regulation	12 (10%)	1 (1%)	0 (0%)
Environment control:	**12 (10%)**	**19 (15%)**	**11 (8%)**
Did nothing/Ignore	**0 (0%)**	**13 (10%)**	**4 (3%)**
TOTAL	**159**	**129**	**133**

Note: The total frequency was higher in the planning because some individuals chose two strategies at planning.

Challenge-strategy patterns. The within-person transitional probabilities maps are shown in Figure 3. As shown in the top panel in Figure 3, behaviour-focused motivation challenges (i.e., difficulties getting individuals to participate, getting the work done, or staying on task) were most often addressed using behaviour control strategies (p = .50), particularly in the form of providing social support during the early phase of the collaboration. The next two common strategies were environment control (p = .21) and cognitive control (p = .19) strategies. Findings also showed that the likelihood of experiencing the same behaviour-focused challenge again in the next phase of collaboration was higher compared to the other types of challenges. This finding was indicated by the at-chance (50%) and higher than chance probabilities of re-encountering the behaviour-focused challenge. Of interest, students who did not use any strategy were most likely to re-encounter the same behaviour-focused challenge (p = .75). In contrast, students who used cognitive control strategies involving planning and goal setting were the least likely to re-encounter the same challenge (p = .50).

Cognitive-focused motivation challenges (middle panel in Figure 3), which included issues relating to efficacy and a sense of purpose or task goal, were often regulated using cognitive control strategies (p = .65). Planning and goal setting strategies, which focused on improving the clarity of task purposes and goals, topped the list (p = .35). A low proportion of students who chose this dominant regulatory pathway re-encountered the same challenge, suggesting that these strategies can be effective in addressing difficulties related to having poor cognitive beliefs about competence, task value, and goals.

Finally, emotion-focused motivation challenges (bottom panel in Figure 3), which included difficulties in maintaining or achieving positive emotions, did not demonstrate a dominant regulatory pathway. There was a slightly higher probability of students choosing cognitive control strategies (p = .36), which suggests attempts to shift attention away from the experienced emotions. However, emotion control and behaviour control strategies were equally likely at p = .29 and p = .21, respectively. In all instances, students did not experience the same main challenge again. While it was possible that the strategies students used were effective in regulating their emotional difficulties, it was also possible that the intensity of the challenge dissipated due to the transient nature of emotions.

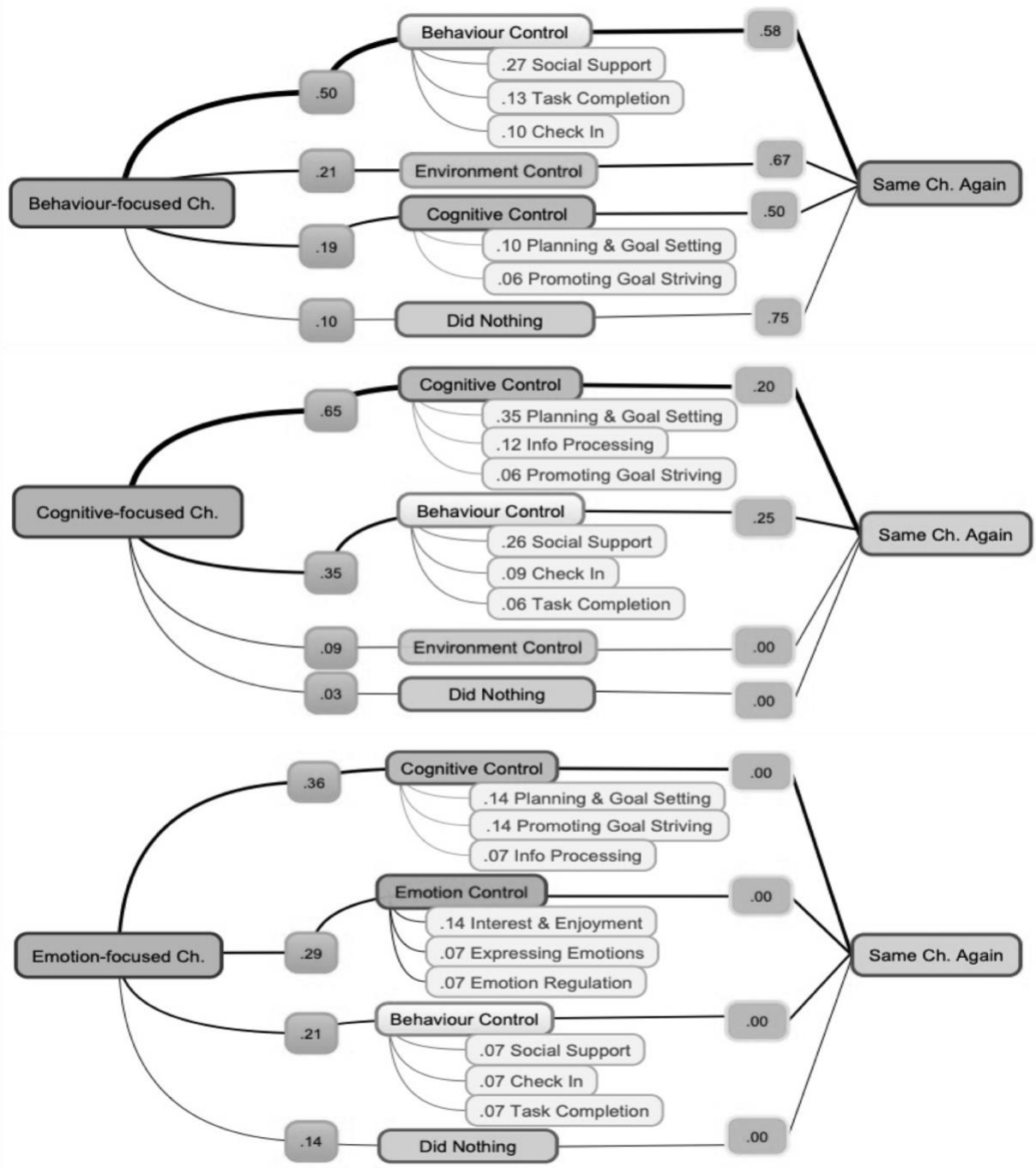

Figure 3. Within-person regulation in response to behaviour-focused (top panel), cognitive-focused (middle panel), and emotion-focused (bottom panel) motivation challenges. Numbers represent the probabilities of the succeeding event occurring. The weight of the lines corresponds to the probability of transitioning into the succeeding event.

Discussion

The aim of this study was to examine the motivation regulation strategies students selected in response to broad types of motivation challenges that emerged in different phases of collaboration. Specifically, students' motivation regulation strategies were contextualized based on two factors: (a) timing in the collaborative project, and (b) types of salient motivation challenges identified in the moment. The findings from this study contribute to the research on motivation regulation in online collaborative learning in three ways. First, this study is one of a limited number of studies to identify the specific strategies students described using and planned on using for regulating salient motivation challenges during online collaboration. Through inductive and deductive coding of students' open descriptions of their strategies, findings showed that the strategies learners chose varied and included strategies aimed to control behaviours, thoughts or beliefs, emotions, and the external environment (see Pintrich, 1999).

Second, unlike previous research that only reported the types of strategies collaborating students used frequently, this study highlighted that changing situational demands in the collaborative process may change the type of strategies students exercise. Findings show differentiated use of motivation regulation strategies across the three phases of collaboration, particularly between the early phase and towards the end of the collaboration. In terms of regulation, the differentiated use of strategies indicates (a) metacognitive awareness that not all strategies are equally effective for addressing all types of motivation challenges, but some strategies are more helpful than others in specific situations, and (b) strategic adaptation is necessary when strategies are not effective at ameliorating experienced challenges.

Third, this study took on a multidimensional approach of viewing motivation challenges in collaboration as deriving from (a) behavioural difficulties related to effort initiation, distribution, and maintenance; (b) cognitive beliefs about one's competence, task value, and goals; and (c) emotional difficulties related to task and social enjoyment. By doing so, we acknowledge that motivation in collaboration is a complex process: motivation is not only influenced by one's judgment of their motivational beliefs and goals but also influenced by perceived issues related to group members' behavioural participation and emotional reactions during the task. Research that considers the multi-dimensionality of motivation is needed to reflect the complex motivational processes during collaborative learning (see also Schoor & Bannert, 2011).

Regulating Salient Motivation Challenges at Different Phases of Collaboration

The change in ratings of motivation challenges across the phases provides evidence for the fluctuation of motivation in a collaborative learning process. Students' anticipation for motivation challenges was high prior to the collaboration, but the extent to which motivation challenges were experienced was lower than anticipated. The planning tool introduced in this study, which asked students to think about foreseeable challenges and possible responses, may have prompted learners to engage in strategic actions, reducing the likelihood of encountering intense challenges during the collaboration. Research that employed similar planning supports demonstrated similar findings (Hadwin et al., 2018). Hadwin et al.'s (2015) study showed that teamwork challenges, related to group members' participation and engagement, decreased the most from anticipated intensity to experienced intensity when planning supports were provided. Furthermore, our findings showed that individual members' task appraisals did not relate to anticipating or experiencing more or less intense motivation challenges. This set of findings may indicate that individual members enter the collaborative task with rather stable motivational appraisals, but perceptions about the possible

challenges group members or the task may present and what actually happened during the collaborative situations seemed to have more influence on students' ratings of challenges (see Järvenoja et al., 2018).

In line with the theory of regulation that describes regulation as both proactive and reactive (Winne & Hadwin, 1998), this study examined individual students' planned strategy for the main motivation challenge they anticipated in collaboration as well as strategic responses to motivation challenges experienced during collaboration. During planning, students raised concerns about difficulties getting individuals to participate, getting the work done, and staying on task. In response to the anticipated challenge, most students planned to use either a behaviour control or a cognitive control strategy. Specifically, the most commonly planned behaviour control strategy was checking in with team members, and the most commonly planned cognitive control strategy included planning and articulating goals and reminding self or others to strive for the set goals. Previous research shows that planning and goal setting activities during the initial stage of collaboration are common among groups but are qualitatively different between successful and unsuccessful groups (Bakhtiar et al., 2018; Rogat & Linnenbrink-Garcia, 2011; Sinha et al., 2015). Unsuccessful groups' planning tended to be brief and involve a decision to work on the task individually (i.e., divide and conquer approach) as opposed to transactive negotiations of shared task goals. Quality of the planning strategy, however, was not examined in this study.

As this study collected students' interpretations of their strategic responses twice after the collaboration began, it allowed us to examine the relation between experienced challenges and related strategy use in relation to collaborative task progress from the early to the later phase of collaboration. The findings demonstrated that the majority of students relied on strategies aimed to control behaviour (providing social support) when motivation challenges arose during the early

phase of collaboration, and then students shifted to primarily using strategies aimed to control thoughts and beliefs (promoting goal striving and efficacy) towards the end of the collaboration. Further research explaining the shift in strategy use or strategy adaptation is needed, but the findings indicate that the selection of motivation regulation strategies is not related to not only with the nature of the challenge but also with the situational needs set by the context, particularly the task conditions. That is, at the beginning of the collaboration, it is beneficial and necessary to build a feeling of social belonging and engagement (Bakhtiar et al., 2018; Van den Bossche et al., 2006). On the contrary, when the end of the task or deadline is approaching, it is more reasonable to strive for task completion than building social cohesion.

By design, the strategies reported at three different time points in the collaborative project were a response to a specific type of motivation challenge students anticipated or experienced. The challenge-strategy interactions revealed some dominant patterns for regulating behaviour-focused and cognitive-focused motivation challenges but not for emotion-focused motivation challenges. Behaviour-focused motivation challenges were most frequently addressed using behaviour control strategies, and cognitive-focused motivation challenges were most frequently addressed using cognitive control strategies. However, when students encountered difficulties in achieving or maintaining positive emotions, students did not necessarily focus on regulating the actual emotions but used a variety of other strategies such as goal setting and focusing on task completion. It should be noted that emotion regulation here was studied as part of regulated learning, which means the ultimate aim was to improve learning and collaboration. A previous study indicated that a strategy focusing on the learning task can be more effective than a strategy focusing on suppressing or decreasing negative emotions during learning (Davis, DiStefano, & Schutz, 2008).

Students' emphasis on behaviour control strategies at planning and in the early phase of collaboration is in line with previous research that assessed students' self-regulated learning strategies in individual studying settings (e.g., Cooper & Corpus, 2009; Pintrich et al., 1993). Specifically, students typically engaged in effort regulation most frequently, followed by environment management and metacognitive strategies such as goal setting and planning. Behaviour control strategies may be perceived as yielding the most profit and easier to enact compared to cognitive control strategies. When the former strategies do not work, only then the latter strategies may be considered (see Cooper & Corpus, 2009).

Limitations

Several limitations of this study should be acknowledged. The analyses of this study were performed at the individual level and so may overestimate the prevalence of some challenges or strategies over others. For instance, two individuals from the same group may recall experiencing the same salient motivation challenge and using the same strategy which they shared as a team. The mix of quantitative and qualitative data in this study precludes the possibility of multi-level analyses that account for the possible similarities between individuals belonging to the same collaborative group. Previous research that used a multi-level analysis to examine students' management of motivation in online group work indicated that a large proportion of the differences were at the individual level, suggesting low similarities between individuals from the same group in terms of motivation regulation strategies (Xu & Du, 2013).

Collecting data about students' self-reported *main* motivation challenge and its associated regulatory strategy limited the types of analysis that were possible. Specifically, these data provided less information about the frequency of challenges and regulation, and more information about students' interpretations of what was salient to them in terms of motivation challenges and

associated tactical responses at different phases of collaboration. Recalling what was salient is highly subjective to the individual and creates difficulties for capturing the entirety of the experienced challenges. Regardless, motivation itself is a highly subjective experience, and data about learners' subjective interpretations of their motivational experiences are still needed.

While learning about regulation may have influenced participants' regulatory actions and decisions, we argue that the research context of this study was appropriate. This is because all participants were exposed to the same amount of background information about self-regulated learning, but they still demonstrated different actions when placed in a task. In a way, students' knowledge about regulation was loosely controlled for, allowing us to examine how students exercise regulation based on that knowledge. Winne (2014) also argued that students are generally poorly equipped with a variety of tactics and strategies for regulating learning. As a result, it limits researchers' ability to observe any meaningful "patterns" of regulation. A suggested remedy includes training students to engage in regulatory processes (goal setting, selecting tactics and strategies, reflecting) which consequently prepares students "to be in a stronger position to express variances in exercising [self-regulation of learning] SRL" (p. 235, Winne, 2014). Hence, the current research context provides a richer dataset for examining students' unfolding regulatory actions and decisions during authentic collaborative learning.

Implications and Future Directions

By examining students' selected strategies at different phases in collaboration, nuances in learners' motivation regulation in that context were detected. If we had focused on the central time period of students' collaboration, social support would have been concluded as the most common strategy, and this ignores students' strategy adaptation that may be related to time in collaboration (see Järvelä et al., 2008). However, we employed a process-oriented research design that considered

students' changing situational challenges and associated tactical responses. The strategic adaptation observed in this study has the potential to inform the design of motivation supports for online collaborations. In particular, during planning, students and groups can be supported to (a) plan a more effective and concrete way for checking in with each other throughout the collaboration, and (b) discuss task values and construct goals that orient group members to the task (see Belland et al., 2013). During the early phase of collaboration, when group members raise concerns regarding difficulties related to initiating and staying on task, strategies geared towards clarifying task goals and values could be re-introduced as these strategies seemed to reduce the likelihood of re-encountering the challenge. Finally, strategies that help groups find the momentum to finish the task, such as reminding others of what they need to strive for and building positive efficacy beliefs, could be introduced towards the end of the collaboration.

The method of providing differentiated supports throughout the collaborative process needs to be further examined because previous research has focused on providing supports at planning only. Although planning supports have been shown to positively affect students' collaborative experience (Hadwin et al., 2018; Järvenoja et al., 2017), limited advancement has been made in supporting students when difficulties emerge in situ. In those situations, students must strategize on their own, or they may choose to ignore the problems altogether, risking productivity loss. Future research could explore ways to provide just-in-time guidance to collaborating students, but this work requires researchers to identify motivationally challenging moments in collaboration and collect data about motivation regulation strategies proven effective for collaboration.

The motivation regulation strategies examined in this study were categorized into Pintrich's (1999) provisional taxonomy of volition control, which includes behaviour, cognitive, emotion, and environment control. This approach allowed us to capture the broad types of strategies students

described using. This broad scope is necessary because motivation manifests not only in cognitive beliefs about competence, task value, and goals, but also in students' behavioural engagement and persistence as well as emotional expressions in the task (Keller, 2008; Miele & Scholer, 2018). This multidimensional approach can also be useful for students to make sense of the potential factors that contribute to their self or group motivation. Past research shows that providing groups with feedback about their members' motivation as a unidimensional construct (high-average-low motivation) was not helpful in changing groups' task productivity and engagement during collaboration (Schoor, Kownatzki, Narciss, & Körndle, 2014). Groups may benefit from having detailed feedback on their motivation that includes information about group members' behavioural participation, motivational beliefs and goals, and emotional reactions towards the task, group, and situation.

Considering research on motivation regulation strategies in collaboration is relatively new, the broad conceptualization of the strategies in this study provides a useful stepping stone for exploring the possible need for (re)operationalizing motivation regulation strategies as taking place within group members' interactions. Thus far, empirical studies investigating motivation regulation at a group level have relied on research on self-regulatory strategies. However, co-regulation and socially shared motivation regulation strategies can be inherently different (Hadwin et al., 2017), and it is insufficient to revise individual strategies to depict group strategies. Once the operationalization of motivation regulation strategies is streamlined, the effectiveness of specific strategies for improving collaboration productivity can be systematically examined.

Conclusions

Overall, the types of motivation regulation strategies students adopted in response to different types of motivation challenges in different phases of collaboration indicate students'

metacognitive awareness that not all situations in collaboration call for the same types of motivation regulation strategies. This study highlights the importance of examining strategies as related to a specific situational demand, rather than as a standalone set of procedures learners exercise. In practice, supporting motivation regulation in collaboration may need to involve guiding students to diagnose the situational demands they encounter and then identify strategies that are well suited for their unique motivationally challenging situations.

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Appendix A

Table 6

Detailed Information of Each Activity in The Collaborative Project

Activity	% of Course Mark	Marking Guide	Question Prompts
Individual Planning	Not graded	-	• Assessing task requirements • Appraising task motivation • Anticipating potential challenges • Proactively strategizing for the most anticipated motivation challenge and the task overall
Group Planning	5%	Excellent group planning was defined as the group making full use of the task to prepare for the collaborative project by creating a detailed plan for the next steps in the following parts of the project. To get a high mark, groups must also be planning as a team where all members actively discussed their task perceptions, goals, priorities, concerns, and ideas.	• Getting to know group members • Negotiating common task perceptions • Aligning goals and priorities • Sharing, anticipating, and planning for potentially challenging situations • Making a plan for the infographic project
Collaborative Session 1	5%	Two components were considered: • The group product (Google Docs) to gauge mastery of course concepts and the ability to communicate ideas in a concise manner, and • Teamwork as demonstrated in Google Hangouts and track changes in the Google Docs. Higher scores reflect an exceptional understanding of the course concepts, and active collaboration and negotiation of ideas between team members	• What is self-regulated learning (SRL)? • What do undergraduate students need to know about SRL? • What are the phases of SRL? What is needed to engage in SRL? • Why is it important for undergraduate students to know about SRL? • What is the connection between SRL and task understanding and goals? • How can we best convey SRL in our infographic?
Individual Check-in	Not graded	-	• Assessing team progress • Reflecting on the challenges encountered to date • Recalling the strategy used to address a salient motivation challenge experienced to date

Collaborative Session 2	5%	Same as Collaborative Session 1	• Describe the most and the least effective study techniques from the assigned reading? • Why are learning conditions/context and student characteristics important in determining whether studying techniques are effective? • Based on what we know about cognitive processing, which 1 or 2 of the techniques described in the reading that has the greatest potential for helping you learn and remember? Which 1 or 2 of these has the lowest potential? Why?
Collaborative Session 3	5%	Same as Collaborative Session 1	• Name and describe three possible strategies our group can include in the infographic • Which one are we going to choose for our infographic? Why is this the best strategy for our topic?
Building the Infographic	Not graded	-	-
Infographic Presentation (+ the infographic)	10%	Higher scores reflect an exceptional mastery of course concepts, and effective synthesis and presentation of critical information in the infographic and the verbal presentation.	-
Individual Reflection	5%	Higher scores reflect a thoughtful and honest reflection that was true to the student's demonstrated participation and engagement in all parts of the project.	• Assessing team effectiveness and learning behaviour • Reflecting on the challenges encountered since the last check in • Recalling the strategy used for addressing a salient motivation challenge experienced in that latter phase • Constructing a brief plan for improving future collaborations
Total	35%		

Appendix B

Table 7

Descriptives of Each Item on The Task Appraisal Scale

	Mean	SD	Skewness	CA(*)
This collaborative project is interesting to me	3.62	.84	-.62	.62
This collaborative project is useful in helping me learn to work in groups	.87	.72	-.19	.64
This collaborative project is useful in helping me learn how to study better	4.09	.74	-.26	.69
When I think about this collaborative project, I am confident that I can produce an excellent infographic	3.75	.78	-.19	.73
Overall, I am motivated to do this collaborative project	3.76	.78	-.50	.64

Note: Cronbach's alpha if the item is deleted.

Manuscript 3: Bakhtiar, A., & Hadwin, A.F. (2019). *Dynamic interplay between modes of regulation during motivationally challenging episodes in collaboration*. Manuscript in submission.

Dynamic Interplay between Modes of Regulation During Motivationally Challenging Episodes in Collaboration

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Abstract

The cognitive and social demands of collaboration can raise significant motivation challenges. Task progression relies on team members strategically taking control of the problems and adapting accordingly. Theory indicates that productive collaboration involves groups using three modes of regulation: self-regulation, co-regulation, and socially shared regulation. Despite research demonstrating the occurrence of all three modes in collaboration, it is unclear how these modes interact and how co-regulation supports the emergence of self- and shared-regulation of motivation. The aim of this study was to examine the role co-regulation played in dynamically stimulating the emergence of self- and shared-regulation of motivation. A cross-case comparison was conducted between two groups who experienced high levels of motivation challenges but achieved contrasting perceptions of the overall team learning productivity. During analysis, groups' dynamic regulatory processes within the online environment were visually represented using a tool called the Chronologically-ordered Representation for Tool-Related Activity (CORDTRA). Findings demonstrate that co-regulation of motivation may afford and thwart the emergence of self- and shared-regulation, and these processes interacted with the group's situational challenges and the regulatory skills group members possessed. Comparisons between the two groups indicated that groups' motivation regulation should (a) match the demands of the challenges at hand, (b) be positively supported by group members through co-regulation, and (b) involve a more varied strategic responses so that the group may continue to learn and co-construct knowledge effectively as a team.

Keywords: motivation; collaboration; self-regulated learning; co-regulation; socially shared regulation; CORDTRA diagram

Introduction

In recent years, there has been a surge of research examining students' collaboration in physical classrooms and online learning environments (Puntambekar, Erkens, & Hmelo-Silver, 2011; Järvelä & Hadwin, 2013). Research on collaborative learning (a) investigates how group members co-construct and build upon each other's knowledge and ideas and (b) examines groups' and individual members' regulation of cognition, behaviour, motivation, and emotions in the learning task (Järvelä & Hadwin, 2013). The focal point of the second line of research is the dynamic interaction between individual and group regulation. Hadwin, Järvelä, and Miller (2017) posited that regulation in collaboration involves three modes: self-regulation, socially shared regulation, and co-regulation. *Self-regulation* refers to individual learners' processes of regulating their own cognition, behaviour, motivation, and emotions for personal goals or in the service of the group goal. *Socially shared regulation* (referred to as shared regulation hereafter) involves the group jointly regulating their cognitive, behavioural, motivational, and emotional states toward a shared outcome. In line with the sociocultural lens of Hadwin et al.'s (2017) work, the emergence of self- and shared-regulation are temporarily supported or thwarted through *co-regulation* (Bakhtiar & Hadwin, forthcoming; Hadwin et al., 2017). This process involves the reciprocal interaction between the personal, social, and cultural elements, which may facilitate or frustrate the internalization of regulatory skills or information at the individual and group level (McCaslin & Vriesema, 2018). Thus, co-regulation is more than just capable individuals supporting the learning of less capable individuals. It can be initiated by a single individual, multiple individuals, tools, or the physical task, and it can be directed toward either individuals or the group. However, in many studies, co-regulation is often limited to prompts and guides directed toward individual learners (e.g., DiDonato, 2013; Järvelä, Malmberg, & Koiveneimi, 2016). Limited research investigates co-

regulation as a process that benefits or undermines either self- or shared-regulation. Addressing this scarcity requires an in-depth and in-context investigation of the intertwined individual and group processes.

In addition, most research on collaboration concerns cognitive regulation and cognitive outcomes. Motivation regulation and motivational outcomes are largely ignored (Rogat, Linnenbrink, & DiDonato, 2013). Even when thinking about the design of computer support for collaborative learning, the motivational aspect of collaboration is often neglected (Belland, Kim, & Hannafin, 2013). Research, however, shows that motivation is instrumental in directing and stimulating cognitive processes which are needed when learners work on joint tasks (Rogat et al., 2013). Research demonstrates that shared regulation of motivation affords opportunities for the groups to engage in other forms of regulation, particularly those that involve regulating differences in perspectives and understanding related to the cognitive aspect of the task (Järvelä, Malmberg, & Koivuneimi, 2016; Malmberg, Järvelä, Järvenoja, & Panadero, 2015). Nonetheless, working in small groups can raise significant motivation challenges. Inadequate responses to these challenges can lower learners' motivation to engage in future collaboration (Ruiz Ulloa & Adams, 2004). This negative consequence counters the very aim of collaborative learning which is to promote high engagement with the learning materials (Blumenfeld, Kempler, & Krajcik, 2006). Motivation challenges have been frequently reported to be a barrier to collaborating with others (Järvenoja, Volet, & Järvelä, 2013). These challenges may originate from multiple sources including variations in individual members' motivation and attitude toward the collaborative task (e.g., Wosnitza & Volet, 2014), interpersonal dynamics related to work ethics and personalities (e.g., Tucker & Abbasi, 2016), and difficulties in negotiating multiple perspectives, ideas, and goals related to the task (e.g., Barron, 2003). Although motivation challenges are common, it is unclear how multiple

individuals with diverse motivational beliefs and goals negotiate their motivation for the group task. It has been proposed that motivation is fostered, influenced, and maintained through an ongoing process of co-regulation (McCaslin & Hickey, 2001). Hence, this study aimed to investigate the role co-regulation plays in stimulating self- and shared regulation of motivation in collaboration.

Co-occurrence of Self, Co, and Shared-Regulation

Research indicates that self-, co-, and shared-regulation co-emerge and mutually reinforce one another. For example, Panadero, Kirschner, Järvelä, Malmberg, and Järvenoja (2015) demonstrated the link between individual members' self-regulation skills and the groups' ability to socially share their regulation of learning, motivation, and emotions. On the basis of self-report data about individual and group regulation, Panadero et al. found that groups composed of individuals with greater self-regulation skills in managing their cognition, motivation, and emotion were more likely to demonstrate better shared-regulation during collaboration. Similarly, Bakhtiar et al. (2018) found that a group who was more successful in adapting as a team had individuals who (a) were more punctual with their individual assignments and (b) had a better understanding of the task instructions. In Pino-Pasternak, Whitebread, and Neale’s (2018) study with pre-schoolers, group members possessing higher global self-regulation skills were found to actively co-regulate their peers and consequently increase team productivity. Overall, research suggests that for shared processes to occur efficiently, individual members must actively self-regulate and support the regulation of others in the service of the group goal.

Group dynamics and processes have also been shown to play a role in promoting and shaping groups' shared regulation of motivation. By analyzing groups' interaction, dialogue, and behaviour, research demonstrates that positive socioemotional interaction is associated with instances of high-quality and more adaptive shared regulation (Bakhtiar et al., 2018; Isohätälä,

Jävenoja, & Järvelä, 2017; Rogat & Linnenbrink-Garcia, 2011). Positive socioemotional interaction has been operationalized as involving group members being attentive to one another, acknowledging others' contributions, and respectfully soliciting opinions. Research also demonstrates that co-regulation when performed in a directive, rather than facilitative, manner can negatively influence the group dynamics and shared processes (Rogat & Adam-Wiggins, 2015). Rogat and Adam-Wiggins characterized directive co-regulation as involving the co-regulator asking individuals to comply with specific ideas and approaches without much consideration of the other person's point of view. In contrast, facilitative co-regulation considers the well-being and motivation of team members and is often pro-actively activated to avoid experiencing challenges that might disrupt progress. These studies highlight the importance of positive reciprocal contributions and participations among group members when regulating as a team.

A review on shared regulation indicates that the phenomenon has often been characterized through qualitative data on groups' conversations during collaboration (Panadero & Järvelä, 2015). The same authors point out a trend suggesting that collaboration with higher instances of co-regulation characterized by one individual taking the lead has been less optimal for performance than collaboration with higher instances of shared regulation. However, research evidences mixed findings about the frequency effect of co- and shared-regulation on group performance. For example, Schoor and Bannet (2012) reported no difference in the amount of shared regulation between high- and low-performing dyads who collaborated on a task involving the production of a handout on a statistical topic. However, we argue that the frequency of "sharedness" is less important than activating appropriate regulation modes to fit the situational demands and challenges. This argument is particularly relevant in motivation regulation because research indicates that self-regulating one's motivation and co-regulating other members' motivation alone

can be sufficient without needing shared-regulation to frequently occur (Järvenoja, Järvelä, & Malmberg, 2017). In Järvenoja et al.'s study, co-regulation of motivation involved one or several group members trying to "increase motivation within the group or offered support, advice or encouragement when group members expressed a lack of motivation or negative feelings affecting the group work" (p. 6). For instance, when an individual experienced a lack of interest, having another group member suggest making the task personally relevant was enough to increase the individual's motivation. Fundamentally, self-, co-, and shared regulation are activated based on the needs and challenges the situation presents (Hadwin et al., 2017).

Regulating During Motivationally Challenging Situations

Hadwin et al.'s (2017) conceptualized self-, co-, and shared-regulation as being driven by the same cognitive architecture described in Winne and Hadwin (1998). This cognitive architecture is represented by the acronym COPES (conditions, operations, products, evaluations, and standards) which describes several interacting elements during a process of regulation. The COPES-typology highlights the need for viewing regulation as triggered by specific contextual demands or challenges that stall goal progress. Specifically, a person's *conditions* create contexts for regulation. In collaboration, conditions can exist in three areas: (a) self, (b) group, and (c) task and context (Hadwin et al., 2017). Self-conditions include personal characteristics, beliefs, and histories individuals bring to the task. In contrast, group conditions include individual perceptions of their group's shared characteristics, knowledge, norms, and histories. Finally, task and context conditions include individual perceptions about the situation, including affordances and constraints found in the task and the environmental context, such as time constraints and the availability of instructor supports. All three conditions dynamically interact and produce complex contexts for regulation.

Conditions are realized through metacognitive monitoring either self-activated or nudged by others or tools. When the conditions are evaluated as warranting further interventions, learners may exert control by engaging cognitive *operations* to process and manipulate relevant information. In terms of motivation regulation, the information is motivation-related (Winne & Marx, 1989). For example, an individual may search for information about their efficacy belief, boost that belief by assuring they can do the task, and focus on that information to persist in the task (SRL). Likewise, individuals can help others recognize that information and use it to support others' regulation (CoRL). When regulating as a team, group members may articulate personal concerns regarding the group's overall engagement and negotiate to work toward one common goal. The results of operations create *products* that can manifest cognitively (e.g., increased understanding of task goal and value), behaviourally (e.g., persistence in the task), and emotionally (e.g., in the state of flow) during the task. Learners then construct judgments or *evaluations* of the products by comparing them to specified or perceived *standards* or goals.

Research demonstrates that groups' regulatory processes are different under varying levels of challenges (Sobocinski, Malmberg, & Järvelä, 2017). Sobocinski et al. examined the temporality of the regulatory phases (forethought, performance, and reflection) in high and low challenge events across eleven collaborative groups. High and low levels of challenges were determined based on groups' aggregated responses related to their cognitive, motivational, and emotional states collected at the beginning of each collaborative session. The observed moment-by-moment regulatory actions in each challenge level were then fed into a process mining software to detect the most common sequence of actions. Findings showed that the frequency of regulatory processes was similar in high and low challenge level events. However, the sequential pathways of the processes slightly differed: during a high level of challenge, groups switched between forethought and performance more often.

Although there was little information on the types of difficulties the groups experienced and the intended purpose of engaging in the frequent switch, Sobocinski et al.'s findings suggest that more intense challenges require learners to adapt and refine their approaches more frequently.

Experiencing more challenges, however, does not necessarily equate to performing poorly in the task. Groups who experienced similarly high levels of challenges may end up with different outcomes as each group's situational affordances and constraints may vary (Järvenoja, Järvelä, & Malmberg, 2015). Researchers argue that successful regulated learners are identified by their ability to overcome situation-specific challenges; these individuals often exhibit more accurate metacognitive awareness of their situations and possess a more varied strategy repertoire (Hadwin & Winne, 2012). Responses that are not fitting with the task demands or the challenges present in the task would theoretically be less effective than responses that directly address the situational needs and challenges (Hadwin & Winne, 2012). Examining what many learners do in response to highly challenging situations may bring to light critical features of strategic actions that may be more adaptive for learning.

Motivation challenges in collaboration emerge from a variety of individual and situational sources (Rogat et al., 2013; Järvelä, Järvenoja, & Veermans, 2008). Bakhtiar, Hadwin, and Järvenoja (2019) argued that there are several types of motivation challenges. The challenges can be categorized into (a) *behaviour-based*—difficulties related to effort initiation and maintenance; (b) *cognitive-based*—difficulties related to cognitive beliefs about one's competence, task value, and goals; (c) *affective-based*—difficulties related to task enjoyment; and (d) *externally-based*—difficulties related to environmental distractors pulling away one's attention from the task. These challenges can lower individuals' and the group's motivation to engage in a collaborative task.

Bakhtiar et al. (2019) found that group members tended to resort to behaviour control strategies to address difficulties related to group members' effort initiation and participation in the task. These strategies were in the form of providing social support, focusing on task completion, and checking each other's progress. Behaviour control strategies were more dominant regardless of the data indicating that cognitive control strategies, such as planning and setting or revising goals, to be better at reducing the likelihood of encountering the same type of motivation challenge again. Bakhtiar et al.'s (2019) analyses were based on data about individual members' perceptions of their strategy use. It is still unclear how motivation regulation strategies are performed under co- or shared-regulation modes. This current study addressed this gap by exploring motivation regulation strategies learners deployed individually (SRL), for others (CoRL), and collectively as a team (SSRL).

How Can the Dynamic Interplay Between Modes of Regulation be Captured?

Investigating how individual team members dynamically negotiate their motivation for the group task involves examining the specific actions that unfold during groups' episodes of motivation regulation. Such an undertaking often requires researchers to intricately code group members' utterances across multiple dimensions of regulation to make sense of the multi-layered processes (see Volet & Vauras, 2013). These dimensions can include micro-processes (planning, monitoring, adapting), targets (behaviour, cognition, motivation), and modes of regulation (see Bakhtiar et al., 2018; Rogat & Linnenbrink-Garcia, 2011). However, code frequencies are typically examined according to one dimension at a time, which undermines the dynamic interactions between the coded processes. Our aim to examine the dynamic interplay between modes of regulation during motivationally challenging episodes implicates finding a method that can holistically capture (visually) the complex processes. The use of each mode of regulation must also

be contextualized by including information about (a) the individuals involved in the regulation, and (b) the specific motivation regulation strategy enacted within the episode.

Thus far, previous studies have explored three approaches for capturing groups' regulatory processes using (a) process mining tools (e.g., Malmberg et al., 2015), (b) social network analysis (e.g., Wijga, Endedijk & Veldkamp, in prep), and (c) probabilistic decision pathways (Hadwin, Bakhtiar, & Miller, 2018). In these approaches, groups' regulatory activities are visually represented to aid the analysis of related events: process miners generate common sequences of regulatory events, social network analyzers produce a network of relationships between group members' regulatory activities, and probabilistic pathways are represented using directed graphs to map learners' transition from one event to another. One limitation of using these approaches lies in their inability to holistically capture the activities involved in multiple episodes of regulation. At best, the visualization focuses on either the dynamic person-to-person relationships (person-focused) or the frequently traversed sequence of actions (activity-focused) aggregated across episodes of regulation.

In this study, we explored a method for visually representing the dynamic interplay between individual and group motivation regulation called the Chronologically-ordered Representation for Tool-Related Activity (CORDTRA) diagram (see Hmelo-Silver, Chernobilsky, & Jordan, 2008). The CORDTRA was initially designed to capture group members' interactions with support tools in a computer-supported collaborative learning environment. For instance, a diagram may show that, within a defined time block, specific individuals are viewing a discussion board while also generating ideas aloud. The CORDTRA diagram is adaptable to data about group regulation because the diagram can visually represent fine-grained and multi-dimensional codes associated with regulation. Specifically, the diagram is a scatterplot time-series of coded data that can

represent individual members and specific regulatory actions. Arranging each group member's activities chronologically allows researchers to unpack how individual and group regulation evolve during the collaboration. CORDTRA diagrams provide opportunities to examine the larger patterns that emerge between codes and foster holistic visualization of the dynamic processes. During pattern identification, researchers may cycle back and forth between the diagram and the actual conversation data for further context on the specific utterances involved during those activities.

Purpose

The purpose of this study was to examine the role co-regulation of motivation plays in dynamically stimulating the emergence of self- and shared-regulation of motivation in two groups with contrasting perceptions of their overall team learning productivity. A cross-case analysis was conducted between two groups who experienced similarly high-level motivation challenges but demonstrated contrasting outcomes in terms of their team learning behaviour or effectiveness in co-constructing ideas and knowledge during collaboration. Groups were compared based on three guiding research questions:

i. What motivation challenges trigged regulation?

ii. How were self- and shared-regulation used in relation to co-regulation?

iii. What strategies were used during episodes of motivation regulation?

Methods

Case Study

A case study method was chosen for conducting the cross-case comparisons for three reasons. First, the dynamic interplay between groups' self-, co-, and shared regulation in response to motivation challenges is a complex social phenomenon, and it is not clear *how* the dynamic process occurs during learning. Case studies have been argued to be appropriate for answering the *how*

questions (Yin, 2003). Second, case studies involve in-depth and in-context empirical investigations in which there is no manipulation of behaviour. Instead of examining the effect of a specific manipulation, case studies involve using multiple data sources to understand the phenomenon in question. The collaborative interaction examined in this study was not manipulated as we were interested in investigating learners' responses to naturally occurring motivationally challenging events. Third, while case studies are not meant for generalization to populations, findings are generalizable to theoretical propositions (Yin, 2003). In this study, we tested (and consequently informed) the theory relating to self-, co-, and shared regulation as proposed in Hadwin et al. (2017).

Research Context

Participants were taking a first-year elective Educational Psychology course on learning strategies and academic success. Students came from a wide range of disciplines (predominantly outside the Faculty of Education) and levels of academic achievements. In the course, students were required to complete a graded semester-long collaborative project in groups of three to five. The project required groups to produce and present a strategy for tackling one aspect of university learning in the form of an infographic. Students approached this project in eight work sessions distributed across the semester: individual planning, group planning, three online discussion sessions, building the infographic, presenting the final infographic, and individual reflection. Cumulatively, the project was worth 35% of the course mark. All grading work was completed by the lead and lab instructors of the course. The first author was one of two lead course instructors. Details of the work sessions are described below.

Individual planning. This activity was designed to guide students through a process of systematically unpacking information about the project and using that understanding to strategically

plan for and anticipate potential roadblocks. Individual students (a) summarized their understanding of the task, (b) evaluated examples of past students' infographics, (c) reflected on their goals and task motivation, and (d) constructed a plan for tackling their anticipated main motivation challenge. Students were given 15 minutes to complete the task during lab.

This task was worth 5% of the course mark. An excellent individual planner showed that the student leveraged the task to get ready for the project and provided thoughtful answers. Short cryptic answers indicated poor planning. Planners were graded by two lead course instructors who cross-checked their marking for inconsistencies. After grading individual planners, students within course sections were assigned to groups based on their planning score. Specifically, students were distributed to include group members with high (5%), moderate (3-4%), and low (1-2%) planning scores. This distribution was so that all groups had similar variability in terms of how well prepared its members were (see Bakhtiar et al., 2018).

Group planning. Group members met in person during group planning. Guided by eight open-ended prompts prepared by the instructors, groups were tasked to plan their approaches and interactions for the project. An example of a prompt included: *What is our strategy for preparing for and tackling each part of the project?* Groups were given 20 minutes of class time to plan and were encouraged to record their meeting minutes on a shared online document. Group planning was not graded. Consequently, the meeting minutes from this session were cryptic and shallow, making them unusable for data analysis.

Online discussions (3 sessions). In the next three sessions, groups collaboratively discussed and documented ideas using shared online documents (Google Docs). Each session had a different topic focus: self-regulated learning topic in the first session, followed by effective learning topic in the second session, and effective strategies topic in the third session. In all three sessions, groups

were required to use an online text-based chat tool (Google Hangouts) to interact and discuss topic ideas. Specifically, during each session, each student had two online applications on their individual computer screens: (a) Google Hangouts for communicating and (b) Google Docs for recording ideas and resources (Figure 1). Groups were given 60 minutes of class time to work on each topic. Incomplete work was assigned to be completed outside of class time using the same Google classroom tools. Groups were given a week to submit work from each session.

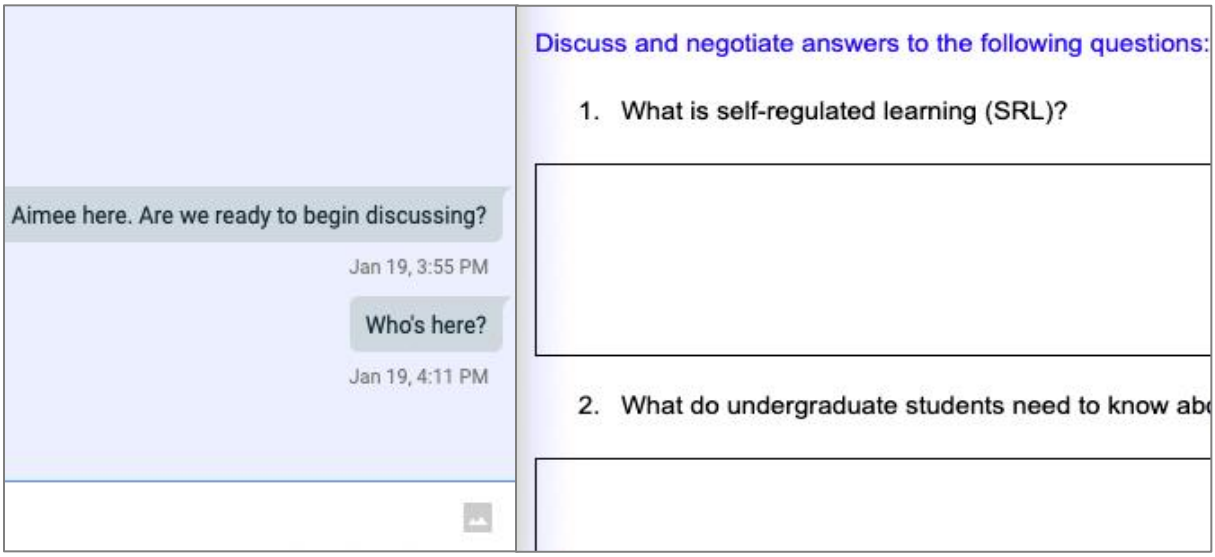


Figure 1. Example of a group's online work session. Google Hangouts environment (left) and Google Docs environment (right).

Building the infographic. Groups built an infographic face-to-face during lab. In this phase, groups turned their resources and ideas into a presentable infographic. The infographic was produced within the online environment using available templates in Google Slides. Group members were able to concurrently access, edit, and track changes to their infographic.

Presenting the infographic. In the final week, groups presented their finished infographic to other students in their lab. The final infographic and the accompanying group presentation were worth 10% of the project mark. Higher scores reflected (a) exceptional mastery of course concepts

and (b) effective synthesis and presentation of critical information in the infographic and the verbal presentation.

Individual reflection. At the end of the project, students reflected on the overall collaborative experience which included (a) assessment of their team learning behavior and the final product, (b) reflection on experienced challenges, and (d) a plan for improving their future collaborations. This portion of the assignment was worth 5% of the project mark. Students were graded on the overall thoughtfulness of their reflection that was true to their engagement in all parts of the project.

Data Sources

Table 1 provides an overview of the data sources gathered for the purpose of this study. Descriptions of each data source follow.

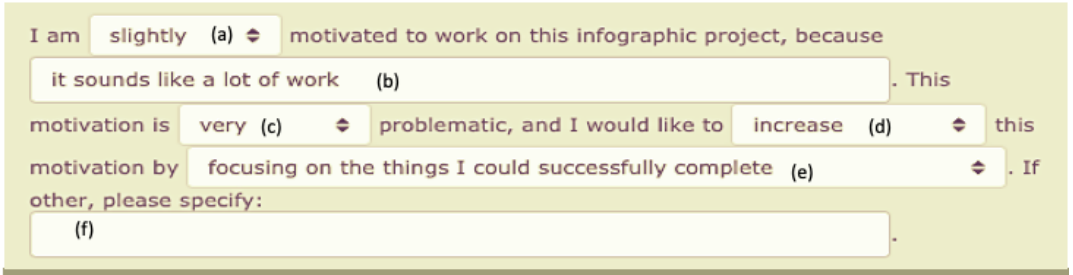
Table 1

Overview of Data Sources

Phase in the Collaboration	Data Sources
Individual planning	• Individual pre-task motivation and planned response
Online collaborative sessions	• Chat records • Scores for active collaboration in each online discussion • Activity logs associated with the groups' online documents
Individual reflection	• Ratings of experienced motivation challenges • Main motivation challenge and strategy response • Ratings of the team learning behaviour

Individual pre-task motivation and planned response. During individual planning, students completed a narrative constructor tool to reflect on their motivation for the task (Figure 2). For each prompt, students select a response option from a drop-down menu. The tool asked individuals to (a) rate their task motivation, (b) provide a reason for that rating, (c) evaluate whether

that motivation was a problem, (d) provide a goal for regulation, and (e) describe a strategy response. If the strategy was not one of the options, students had to specify their planned strategy in a text field.



Section	Response options for each section
(a) Individual pre-task motivation	Not at all, Slightly, Moderately, Very, or Extremely
(b) A justification for that motivation	Open-ended text field
(c) Evaluation of the consequence to learning	Not at all, Slightly, Moderately, Very, or Extremely
(d) Regulation goal	Increase, Decrease, Maintain, or Do nothing
(e) Strategy response	Demonstrating to others how to work on the task, Ignoring the problem, Promising a reward for completing the task, Focusing on something I could successfully complete, Reminding myself of the goals and priorities, Taking control of emotions that were harmful for productivity, Focusing on making the task interesting, Revising my plan, Doing a better job monitoring my conditions and progress, Giving my bear minimum, or Other.
(f) Description of "Other" strategy	Open-ended text field

Figure 2. A narrative constructor tool for collecting data about individual pre-task motivation and planned strategic response.

Chat records. Groups' text-based conversations during the three online collaborative sessions served as the primary data source because they provided evidence of groups' self-, co-, and shared-regulation. For each text-based utterance, Google Hangouts provided a timestamp, date, and the username belonging to the utterance.

Scores for active collaboration in each online discussion. For each online discussion session, the course instructors rated each group's quality of collaborative conversations. Groups received a score representing their teamwork quality involving team members' active attempts at

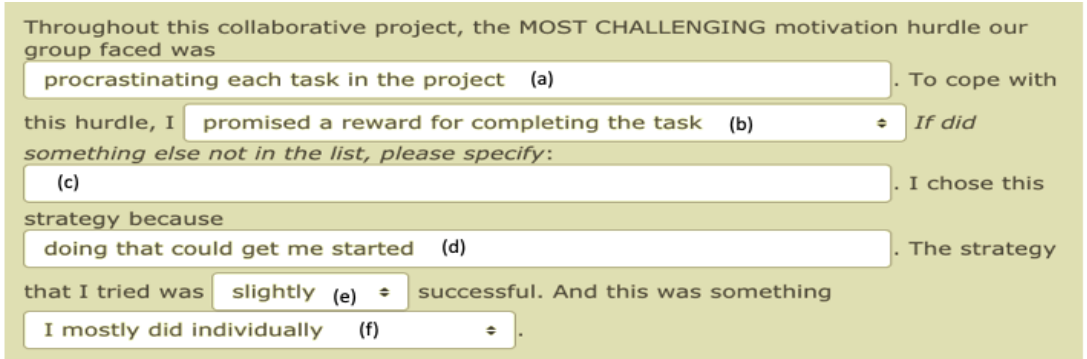
co-constructing ideas and knowledge. Groups received a full mark (2 out of 2) if every member in the team actively contributed in meaningful ways. A half mark (1 out of 2) was given if there was evidence that group members were trying to contribute in some ways but lacked active co-construction of ideas and knowledge. Groups received a score of zero if they did not meet online to complete the assigned work.

Activity logs associated with the shared online documents. Students' activity logs within each Google Document were automatically collected in the online environment. Each log contained information about (a) who viewed or edited a document, (b) the document name, and (c) when the activity was performed. For each group member, the percentage of editing work the person completed relative to their group in each shared document was calculated. For example, when a person edited the group's document 5 times out of the group's total of 50 times, the person's percent editing work for that work session would be 10%. This calculation was used to gauge each member's contribution to each collaborative session

Ratings of experienced motivation challenges. At the end of the project, each member rated the extent to which they experienced several types of motivation challenges during collaboration. Three items were used to collect ratings about motivation challenges including (a) difficulties in getting individuals to participate, getting the work done, and staying on task (behaviour-based); (b) difficulties with cognitive beliefs about one's competence, task value, and goals (cognitive-based) and (c) difficulties in maintaining positive attitudes and emotions about the task, the group, and the situation (affective-based). Ratings were collected on a five-point Likert scale from 1 = *not a problem* to 5 = *major problem*. For each student, ratings on all three items were summed to produce an individual score of experienced motivation challenges. At the group level, group members' summed scores were averaged to produce a score of the group's experienced

motivation challenges. Within-group agreement regarding the challenges was denoted using the standard deviation of the group's average.

Main motivation challenge and its regulation. Students were subsequently asked to reflect on one main motivation challenge their group encountered during the collaboration (Figure 3). This reflection required students to construct a narrative about (a) the main motivation challenge the group experienced, (b) the strategy used to address the challenge, (c) why the strategy was selected, (d) the strategy effectiveness, and (e) who was involved in enacting the strategy.



Section	Response options for each section
(a) Main motivation challenge	Open-ended text field
(b) Strategy response	Helped others to work on the task, Ignored the problem, Promised a reward for completing the task, Focused on something I/we could successfully complete, Reminded myself/others of the goals and priorities, Took control of emotions that were harmful for productivity, Focused on making the task interesting, Revised the plan, Did a better job monitoring the conditions and progress, Give my bear minimum, or Other.
(c) Description of "Other" strategy	Open-ended text field
(d) A reason for strategy choice	Open-ended text field
(e) Strategy effectiveness	Not at all, Slightly, Moderately, Very, or Extremely
(f) Individuals involved	I did it individually, I helped others, Others helped me, and We all did

Figure 3. A narrative constructor tool for collecting data about the main motivation challenge and strategy response.

Ratings of the team learning behaviour. At the end of the project, group members also evaluated their team learning behaviour using a nine-item Team Learning Behaviour questionnaire adopted from Van den Bossche, Gijselaers, Segers, and Kirschner (2006). Scores on the questionnaire describe the degree to which group members construct, co-construct, and build upon each other's ideas and contributions. Higher ratings indicate a more positive team learning behaviour demonstrated during collaboration. An example of an item on the questionnaire included, "*My team members elaborated on each other's information and ideas*." All responses were collected on a seven-point Likert scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*.

Case Sampling Strategy

Two groups were sampled from a pool of 20 groups using two criteria. (1) Informed by research that indicates challenging events as opportunities to exercise regulation, both groups must have experienced similarly high levels of motivation challenges thereby having had similar opportunities to regulate motivation. (2) The two groups must have maximally different perceptions of the overall team learning productivity (i.e., team learning behaviour ratings). This latter criterion was chosen to identify the types of regulatory actions that were more successful and less successful in influencing team motivation and productivity. Accordingly, groups were selected based on data collected at the end of the collaborative project related to group members' post-collaboration judgment of (a) the level of motivation challenge experienced during collaboration and (b) the overall team learning behaviour their group demonstrated.

The sample was identified in stages. First, groups with missing data from at least one member were removed. Next, groups' ratings of motivation challenges were categorized as: (a) *high*, including scores falling above 0.5 SD from the mean, (b) *medium*, including scores between -0.5 to 0.5 SD around the mean, and (c) *low*, including scores falling below 0.5 SD from the mean.

Demarcations of the standard deviations were based on the average group ratings of motivation challenges across all groups in the sample (*M* = 6.15, *SD* = 1.71). Next, to obtain the richest regulation data, we retained groups in the *high* challenge category (*n* = 5) assuming these groups had the most opportunities to regulate motivation challenges. Finally, the group with the highest (Group F) and the group with the lowest (Group K) team learning behaviour score were selected because they represented maximally different group perception of the overall team learning productivity. The difference in team learning behaviour scores between the two selected groups was more than one standard deviation away based on the overall mean ratings of team learning behaviour across all groups (*M* = 56.21; *SD* = 6.27). Hereafter, the group with a more positive perception of their overall team learning productivity was referred to as the high productivity group, and the group with a less positive perception of their overall team learning productivity was referred to as the low productivity group. Table 2 summarizes the characteristics of the case groups.

Table 2

Characteristics of Each Case Group

	High Productivity (Group F)	**Low Productivity** (Group K)
Group mean (SD) age	19.75 (2.06)	19.40 (1.51)
Number of males	2	3
Number of females	2	2
Group infographic score out of 10	7.80	7.30
Group mean (SD) ratings of experienced motivation challenges	7.25 (2.75)	7.60 (2.88)
Group mean (SD) ratings of team learning behaviour	55.00 (5.75)	46.60 (5.46)

Note: Excluding group performance score, parentheses refer to the within-group standard deviation associated with the mean. Productivity was defined as group members' aggregated perceptions of

their team's overall ability to build upon on each other's ideas and contributions and work efficiently as a team.

Analysis

Data analysis was conducted in four steps. This systematic approach was essential for maintaining the chain of evidence and establishing rigour (Seale & Silverman, 1997).

Step 1: **Data gathering.** The first step involved becoming familiarized with the data sources. Elaborative running records of the groups' conversations and activity logs were created by matching the timestamp of the activity logs and the chat conversations, providing a summary of all the events that occurred during each group's online collaboration. Individual members' self-reports were also reviewed and cross-checked with the objective data.

Step 2: **Coding of chat data**. Groups' chat records from their online discussion sessions were coded in four waves (see Appendix A for coding schemes). The unit of coding was at the episode level. Given the nature of the chat data, a code could be assigned to a single utterance, multiple utterances that may have been separated in between another code, or several consecutive utterances as long as the utterances were still related to one purpose of actions. Codes were mutually exclusive. In each wave, 30% of the data were given to a second-rater (a senior research assistant) for a reliability check. Inter-rater reliability was determined by Cohen's Kappa statistics. Indices between .80 to .90 were considered strong reliability (McHugh, 2012).

Wave 1: Task-focused versus socioemotional-focused episodes. First, group conversations were segmented into task-focused and socioemotional-focused episodes following Järvenoja et al.'s (2017) coding scheme. Task-focused episodes referred to utterances related to task details, including domain related knowledge or items to include in the group's shared product. Socioemotional-focused episodes referred to utterances about motivation and emotions related to

individuals, a group of individuals, task features, progress, or product. In the high productivity group, 39.59% of the utterances were socioemotional-focused. Comparably, in the low productivity group, 36.38% of the utterances were socioemotional-focused. Inter-rater reliability index for coding in this wave was *Cohen's K* = .89.

Wave 2: Types of motivation challenges. The socioemotional conversations were further scrutinized for utterances depicting motivation challenges. 2.15% of socioemotional utterances in high productivity group and 7.46% of socioemotional utterances in low productivity group were not considered related to motivational challenges. The eliminated utterances pertain to off-task conversations, where group members shared about personal events (e.g., leaving town to see a family in the weekend) or general remarks about their university courses. Groups' remaining socioemotional utterances were broken down into several episodes of motivation challenges. In other words, the beginning of a challenge episode is marked by utterances that led to the emergence of a motivation challenges or related challenges (e.g., unclear task goals with low engagement), and the end of a challenge episode is marked by utterances that led to a dissolution of a challenge or related challenges. There were instances where a dissolution was not reached; the end of those episodes was marked by group members' shifts in the topic of conversations. Utterances that depict instances of motivation challenges were identified by demonstrated difficulties initiating or engaging in the task, or explicit statements about encountering a motivation hurdle. Motivation challenge utterances were deductively categorized into four types: (a) *behavioural*—effort initiation and task persistence, (b) *cognitive*—competency beliefs, task value and utility, and goals, (c) *affective*—interest, enjoyment, positive and negative emotions, and (d) *external*—environmental distractors (Bakhtiar et al., 2019). Inter-rater reliability index of the motivation challenge coding was *Cohen's K* = .83.

Wave 3: Modes of regulation. Instances of self-, co-, and shared regulation enacted as a response to the motivation challenges were then identified. Coding in this wave was guided by the coding scheme in Bakhtiar et al. (2018). Next, instances of self-, co-, and shared-regulation were grouped into a larger motivation regulation episode to identify when the regulatory actions for a challenge began and ended. It was possible to have more than one regulation mode within one motivation regulation episode because a challenge can be addressed using multiple modes at the same time. Inter-rater reliability index was *Cohen's K* = .81.

Wave 4: Motivation regulation strategies. In the last wave, the types of motivation regulation strategies enacted within the regulation episodes were identified. Coding in this wave was guided by Bakhtiar et al.'s (2019) coding scheme outlining types of motivation regulation strategies in online collaborative contexts. Inter-rater reliability index was *Cohen's K* = .85.

Step 3: Code revision and visualization. Next, codes were reviewed, revised as necessary, and visually represented in chronological order on a CORDTRA diagram (e.g., Figure 4). The preparation of the diagram was guided by Hmelo-Silver et al. (2008). However, three modifications were made to the diagram. First, instead of listing code names in the legend, each row represents a code. Second, episode breaks were added to show that the episodes were not necessarily on a continuous timeline. Third, horizontal lines between categories of codes were added for clarity. Each group's processes were visually represented on three levels: (a) *person*—showing each group member's initiation of and participation in the regulation, (b) *mode*—showing whether self-, co-, or shared was involved, and (c) strategy—showing the types of motivation regulation strategies applied in the episode.

Step 4: Summarization of data across sources. For each group, the frequencies of self-, co-, and shared-regulation instances were summed across episodes. Then, the group's percentage of

co-regulation that promoted self- and shared-regulation were summed by inspecting the episodes represented on the group's CORDTRA diagram. Group's conversation data were cross-checked for further context about the regulatory actions demonstrated within each episode. For example, in Episode 4 in Figure 4, Person B can be seen co-regulating Person M by using a social support strategy. The co-regulation promoted Person M's self-regulation who later regulated by expressing his emotions to Person B. Note that Person B's co-regulatory utterances were interleaved by Person M's self-regulatory utterances; however, this is considered one instance of co-regulation and one instance of self-regulation. The dashed lines indicate the beginning of episodes and episode numbers are marked on the top edge of the lines. Codes' sequences on the diagrams were also examined in terms of their chronological information (how early or late a code occurs), in terms of their overlap with other codes, and if a specific sequence of codes frequently occurs in multiple episodes. For instance, in Figure 4, expressing emotions strategy (green diamond) precedes social support strategy (yellow diamonds). There is also a pattern of social support strategy (yellow diamonds) being used during co-regulatory utterances (pink triangles) and commonly activated by Person B (blue circles). At the end of Step 4 of data analysis, each group's data across all sources were synthesized and a cross-data summary for each group was prepared.

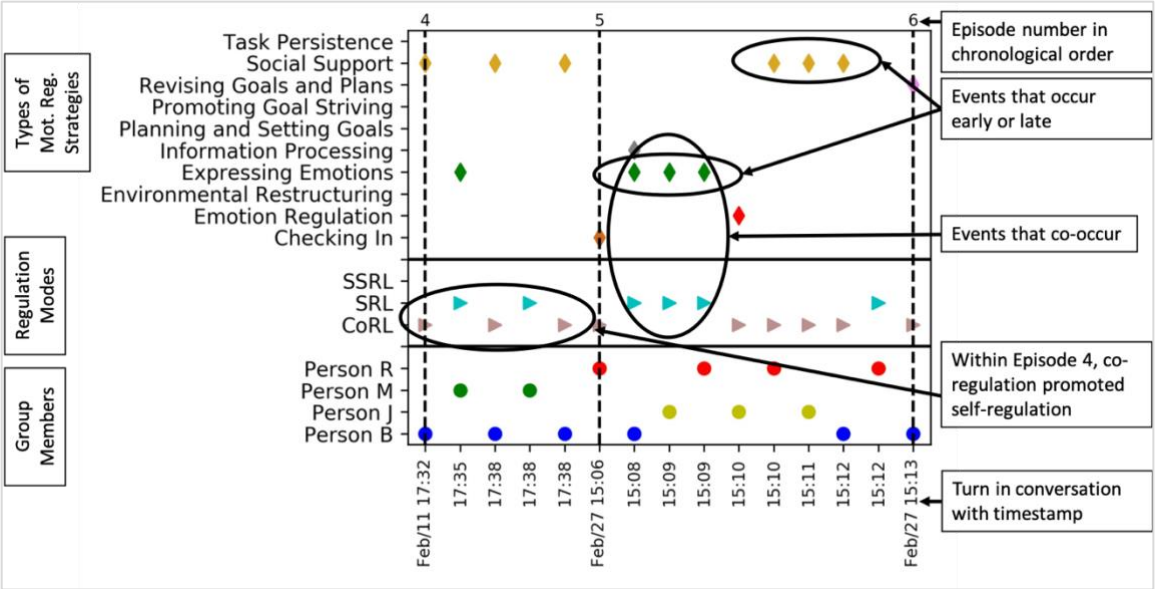


Figure 4. Example of a CORDTRA diagram adapted for this study. The *x*-axis represents the timestamp for each conversation turn. One conversation can have multiple codes. The *y*-axis represents three categories of codes separated by horizontal lines: types of motivation regulation strategies (top), regulation modes (middle), and group members involved (bottom). Each dashed line represents the beginning of an episode, with the corresponding episode number marked above the line.

Step 5: Case comparisons. The last step involved a cross-case analysis of the key similarities and differences between the two groups as guided by the research questions. This analysis was recursive involving identifying emerging themes, looking for data reference that either support or contradict the themes, and revising the overall themes.

Findings

What Motivation Challenges Triggered Regulation?

The regulation of learning model used as a framework for this study (Hadwin et al., 2017) highlighted the importance of contextualizing students' regulation by examining the conditions that

triggered regulatory actions. For this reason, groups' motivational challenges were first examined. Analysis of data revealed two areas of differences: (a) task participation level and (b) motivation challenges triggered by self- versus group conditions.

Task participation level. In both groups, there were imbalances in terms of each member's percentage of editing work. Some group members contributed to the product notably more than others (Table 3). However, these imbalances were less evident in the high productivity group compared to the low productivity group. Data indicated that all members in the high productivity group were involved in all collaborative sessions. In the second and third sessions, the group actively discussed their ideas and knowledge as evident by the teacher-rated collaboration score. Group members' reflections indicated overall satisfaction with group members' contribution frequency.

In contrast, the low productivity group started strong; they actively collaborated in the first session and were given a full mark for active collaboration. Unfortunately, some group members' participation dwindled thereafter. Editing work became significantly uneven coupled with one missing member in Session 2 and two missing members in Session 3 (i.e., 0% contribution). In their post-collaboration reflection, only Person H, K, and P were acknowledged as the main contributors of the group product.

Table 3

Summary of Task Participation for Each Group

	High Productivity (Group F)			
Observed data		Session 1	Session 2	Session 3
Percentage of editing work in the shared online document	*Person R*	6%	8%	24%
	Person B:	21%	43%	38%
	Person J:	18%	32%	30%
	Person M:	55%	17%	8%

Score for active collaboration (out of 2)	*Group:*	1	2	2
Post-collaboration reflection	All four group members indicated that members contributed equally to the project, suggesting an overall satisfaction with group members' participation level.			
	Low Productivity (Group K)			
Observed data		Session 1	Session 2	Session 3
Percentage of editing work in the shared online document	*Person A:*	5%	9%	0%
	Person H:	17%	29%	67%
	Person K:	34%	55%	0%
	Person S:	8%	7%	4%
	Person P:	16%	0%	29%
Score for active collaboration (out of 2)	*Group*:	2	1	1
Post-collaboration reflection	Four out of five members singled out three individuals who were the main contributors to the project: Person H, Person K, and Person P.			

Motivation challenges triggered by self- versus group conditions. As shown in Table 4, the most prevalent motivation challenge in the high productivity group was cognitive-based (f = 9), but the most prevalent challenge in the low productivity group was behaviour-based (f = 18). Specifically, the high productivity group experienced challenges mostly originating from *self* conditions (personal motivational beliefs and interest in the task) whereas the low productivity group experienced challenges mostly arising from *group* conditions (inter-individual interactions or lack thereof). The high productivity group's motivation challenges included lacking confidence or task purpose and feeling less motivated to engage in the task because the task was viewed as cognitively challenging. Members of this group also expressed negative feelings in the form of defeat and lacking task enjoyment. Occasionally, the group was challenged with low participation from a couple of individuals due to the individuals' work demands in other courses. One group member summarized in her reflection:

> *Sometimes you get a group (like this one) that doesn't seem to have a lot of passion and motivation to learn about the project or to present it in a really meaningful way. This makes*

> *it hard to make improvements and enjoy yourself. We had one of these groups, it could be because the class wasn't the most important on our schedules (Person B, Individual reflection data).*

When asked to identify the group's salient motivation challenge, members in the high productivity group stated challenges relating to procrastinating on task completion (1 member), finding time to work together (2 members), and experiencing technological glitches (1 member). In addition, the group's average pre-task motivation showed a small score variation between members, suggesting individuals in the group were similar in terms of their willingness to engage in the task (*Mean* = 3.75, *SD* = 0.50). This similarity may be associated with the group's lower instances of encountering conflicts related to differences in inter-individual motivational goals.

In contrast, the low productivity group's motivation challenges included issues with conflicting opinions, priorities, and goals. At times, group members appeared to be working at cross-purposes, particularly when the group failed to reach an agreement with regards to what they should be doing. One group member described in her reflection:

> *It was very hard to contact members due to some just not replying/engaging in the group chat. Our infographics template had been changed three times due to conflict over which one best suit our topic (Person H, Individual reflection data).*

Also prevalent in the low productivity group were behaviour-based motivation challenges related to some individuals being off-task, not showing up to group meetings, and avoiding the task altogether. When individual judgments about the group's salient motivation challenge were examined, at least one member mentioned difficulties dealing with differences in opinions. Others noticed challenges related to getting members to complete the task and communicating with them in the online platform. Moreover, upon examining the group's pre-task motivation, individuals in this group were more variable in their responses. The group's mean motivation level was 3.20 (*SD* = 1.30). These differences may have increased the likelihood of experiencing conflicts in task goals

and priorities. Despite differences in the types of motivation challenges, both groups had a similar number of motivation challenges (*f* = 23 in the high productivity group and *f* = 25 in the low productivity group).

Table 4

Types and Frequencies of Motivation Challenges in Each Group

	High Productivity (Group F**)**			**Low Productivity** (Group K)		
	Self	Group	*Total*	Self	Group	*Total*
Behaviour: *Effort initiation, distribution, and maintenance difficulties*	2	5	*7*	3	15	*18*
Cognitive: *Cognitive difficulties about one's competence, task value, and goals*	8	1	*9*	1	2	*3*
Affective: *Social or task enjoyment difficulties*	3	0	*3*	0	0	*0*
External: *Difficulties in managing priorities and demands outside of the task*	4	0	*4*	4	0	*4*
Total	17	6	*23*	8	17	*25*

How Were Self- and Shared-Regulation Used in Relation to Co-Regulation?

Frequencies of self-, co-, and shared-regulation. The raw frequencies of self-, co-, and shared-regulation in each group were first calculated (Table 5). Based on the proportional frequencies, the high productivity group used self-regulation the most (44.1%) followed by co-regulation (38.2%) and shared-regulation (17.6%). The higher instances of self-regulation may be due to the nature of the motivation challenges reported which often originated from *self* conditions. In contrast, considering the low productivity group often experienced challenges mostly arising from group conditions, one would assume the group activated shared regulation most often; however, this was not the case. The low productivity group activated co-regulation the most

(51.3%) while their within-group proportions of self- and shared regulation were relatively equal (23.1% and 25.6% respectively). This group's co-regulation can be seen as an attempt to promote regulation at both the individual and the group level, which may be necessary when individual group members were not proactively regulating on their own.

Percent co-regulation that stimulated self- and shared-regulation. The percentage of co-regulation that (a) promoted self-regulation, (b) promoted shared-regulation, and (c) did not lead to any regulation was examined (italicized in Table 5). These percentages were calculated based on within-episode patterns shown on each group's CORDTRA diagram (Figure 5 and 6). On each diagram, circles refer to co-regulation that promoted self-regulation and rectangles refer to co-regulation that promoted shared-regulation. The findings indicate that more than half of the high productivity group's co-regulation stimulated the emergence of self-regulation (61.5%, circles in Figure 5). In the same group, the percentage of co-regulation that was ignored and that promoted the emergence of shared-regulation were relatively similar (23.1% and 15.4% respectively). In contrast, co-regulation in the low productivity group was followed equally by shared regulation (40%), self-regulation (30%), no regulation (30%). However, between the two groups, the proportion of co-regulation leading to no responses was fewer in the high productivity group than the low productivity group (23% vs 30%). These non-responses were found in Episode 7, 17, and 20 in the high productivity group diagram (Figure 5), and in Episode 2, 4, 7, 10, 21, and towards the end of 22 in the low productivity group diagram (Figure 6).

Table 5

Frequency (Percentage) of Regulation Modes in Each Group

	High Productivity (Group F)	**Low Productivity** (Group K)
Self-regulation	15 (44.1%)	9 (23.1%)
Shared-regulation	6 (17.6%)	10 (25.6%)
Co-regulation	13 (38.2%)	20 (51.3%)
Toward SRL	*8 (61.5%)*	*6 (30.0%)*
Toward SSRL	*2 (15.4%)*	*8 (40.0%)*
Ignored/No regulation	*3 (23.1%)*	*6 (30.0%)*
TOTAL	34	39

Note: Italicized numbers refer to the breakdown of co-regulation that followed self-regulation (SRL), shared-regulation (SSRL), or no regulation.

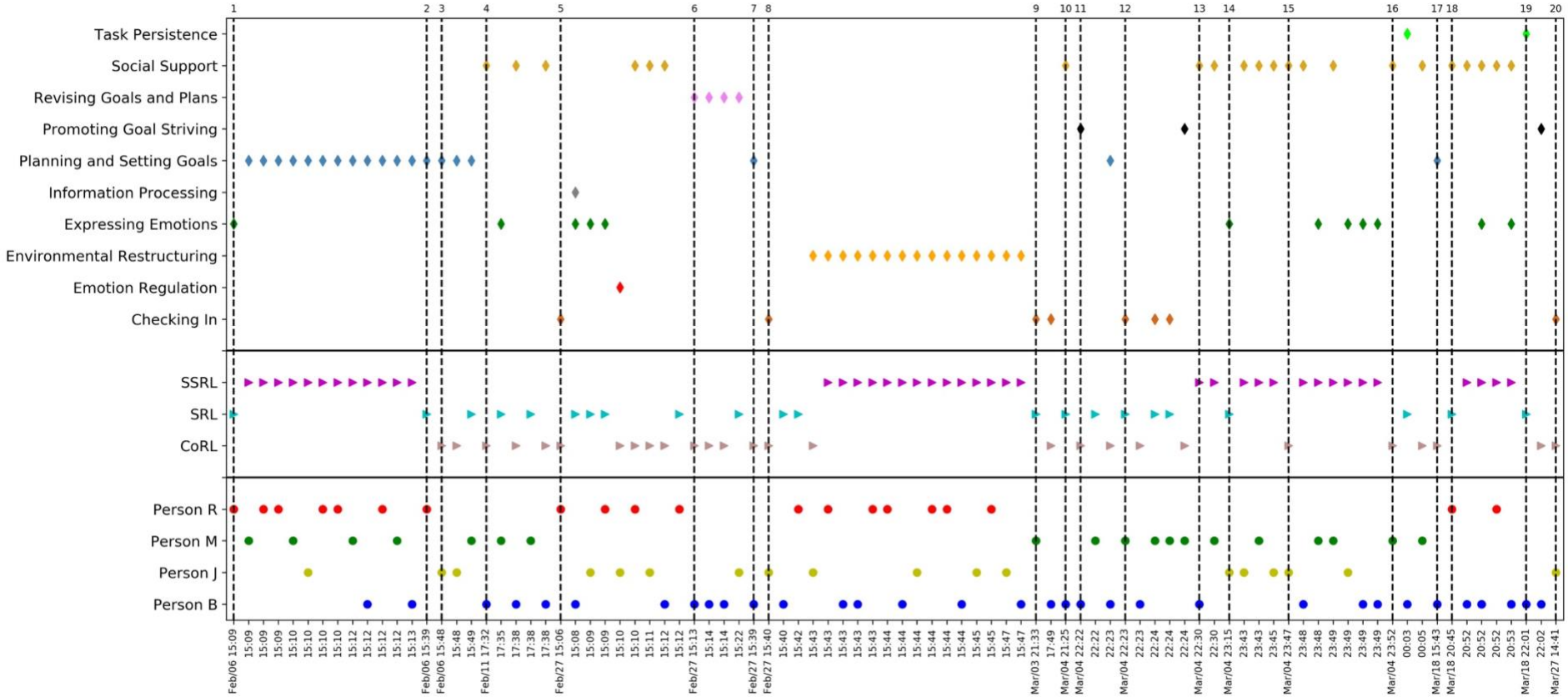


Figure 5. The high productivity group CORDTRA diagram. Coded utterances are chronologically ordered based on their conversation turns. Dotted lines represent the beginning of a motivation regulation episode and numbers on the x-axis represent the episode number. Circles refer to co-regulation that promoted self-regulation, and rectangles refer to co-regulation that promoted shared-regulation.

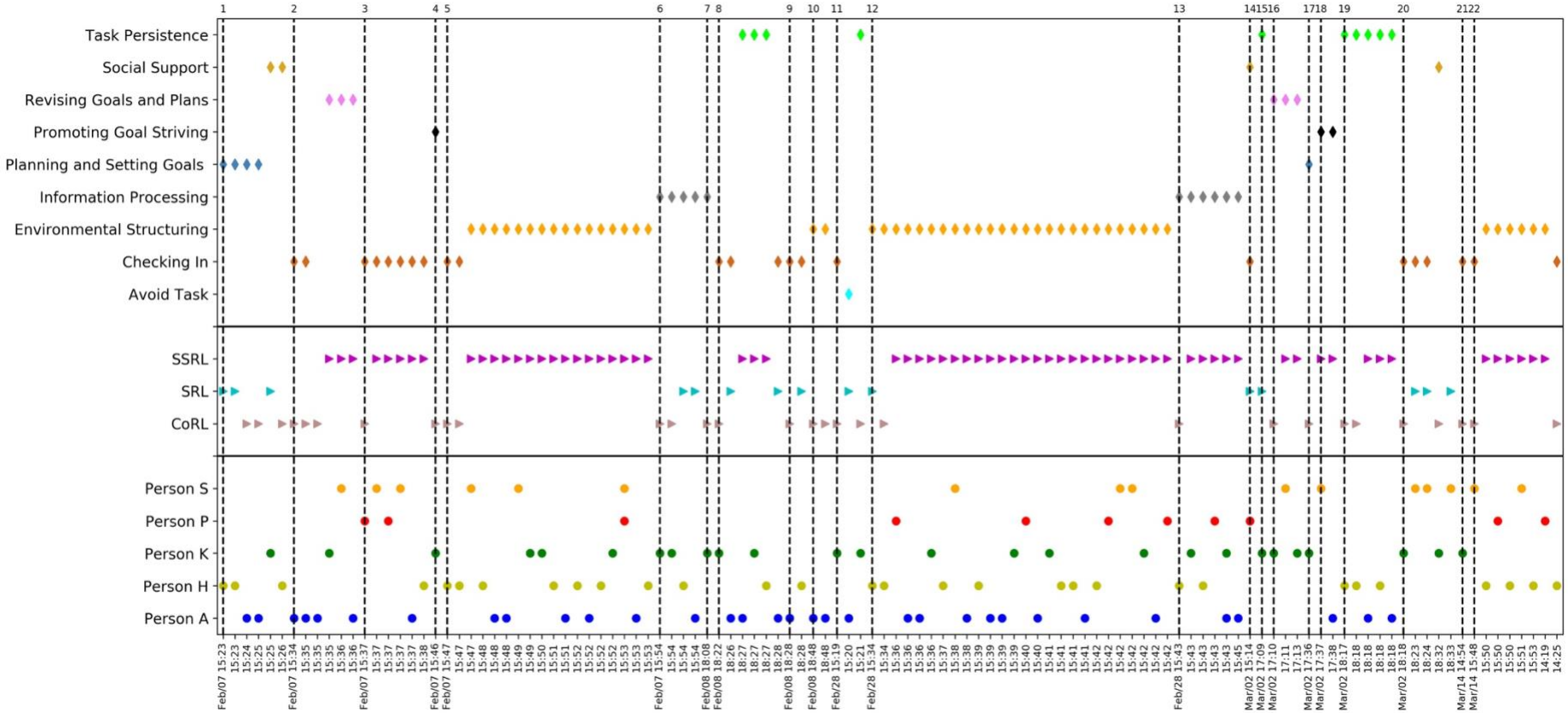


Figure 6. The low productivity group CORDTRA diagram. Coded utterances are chronologically ordered based on their conversation turns. Dotted lines represent the beginning of a motivation regulation episode and numbers on the x-axis represent the episode number. Circles refer to co-regulation that promoted self-regulation, and rectangles refer to co-regulation that promoted shared-regulation.

Qualitative differences in co-regulation of motivation between groups. Groups' CORDTRA diagram demonstrates the dynamic interactions between individuals involved in groups' episodes of co-regulation. When the overlap between co-regulation and each individual member was examined, one similarity between the groups was that they both had two dominant co-regulators taking turns in co-regulating their peers. These individuals were Person B and Person J in the high productivity group (Figure 5), and Person K and Person H in the low productivity group (Figure 6). However, when conversation data were cross-examined, the groups differed in the socioemotional tone accompanying the co-regulation.

Groups' conversation data showed that the high productivity group's co-regulation was often proactive and seemed to facilitate group members to work efficiently on the task. For example, when the group was tasked to read a long paper in preparation for the third collaborative session, Person A proactively checked on whether her group members have completed the task (see excerpt below). She began the conversations with an expression that indicates cohesion before prompting group members to check on their progress. In response, group members openly expressed their struggles with the task which was followed by some members attempting to help.

> *Person A: Hey gang! Has everyone looked at the reading?*
> *Person B: Hey! Yes I did, I jotted down some notes on the first 4 techniques too. It's a long paper UGH!*
> *Person J: very long LOL*
> *Person A: I was having difficulty finding it on the page. I forgot to look it over [emoticon]*
> *Person J: It's ok. did u manage to find it now?*
> *Person B: I think it is posted to part 3 description*

In contrast, the low productivity group's co-regulation was more directive and reactive to specific actions or inactions. The directive tone of their co-regulation might have thwarted appropriation of self- and shared regulation. For instance, in the except below, Person A co-

regulated the group to take on a specific approach to doing the task, which involved limiting one person to edit the group's Google Docs. This action may have been interpreted as Person A trying to avoid responsibility, as evident in the log data showing Person A's low to non-existent involvement in the project. Person A's co-regulation may have thwarted the emergence of shared regulation in his group; when some members attempted to edit the work as a group, Person A quickly brought them back to his original plan.

> *Person A: It's easier if we let one person does it (writing out answers). K did it last time, so he can do it again this time.*
> *Person K: Ok.*
> *[Person H attempted to help Person K expand his ideas in the Google Docs]*
> *Person A: Hey. Can we please stick to one person editing. It makes the computer slower for every extra person in there.*

Overall, between the two cases, findings suggest that the number of co-regulators may not matter as much as the affective tone accompanying the co-regulation, because tone can either promote or thwart self- and/or shared-regulation.

What Strategies Were Used During Episodes of Motivation Regulation?

The overlap between regulation modes and strategy types in groups' CORDTRA diagrams revealed some differences. Groups seemed to differ in terms of the variation in their strategy response and in terms of the types of strategies they enacted in a socially shared way. Table 6 summarizes each groups' motivation regulation strategies according to their associated modes of regulation.

Table 6

Frequency of Motivation Regulation Strategies in the Form of Self-, Co-, and Shared Regulation Between the High Productivity and Low Productivity Group

	High Productivity (Group F)				**Low Productivity** (Group K)			
	SRL	CoRL	SSRL	*Total*	SRL	CoRL	SSRL	*Total*
Behaviour control total	**6**	**8**	**4**	***18***	**7**	**14**	**3**	***24***
Avoided the task	0	0	0	*0*	1	0	0	*1*
Checking in	2	4	0	*6*	3	10	1	*14*
Social support	2	4	4	*10*	2	2	0	*4*
Task persistence	2	0	0	*2*	1	2	2	*5*
Emotion control total	**4**	**1**	**2**	***7***	**0**	**0**	**0**	***0***
Emotion regulation	0	1	0	*1*	0	0	0	*0*
Expressing emotions	4	0	2	*6*	0	0	0	*0*
Cognitive control total	**4**	**8**	**1**	***13***	**2**	**7**	**4**	***13***
Info. processing	1	0	0	*1*	1	3	1	*5*
Planning & setting goals	2	4	1	*7*	1	2	0	*3*
Promoting goal striving	0	3	0	*3*	0	1	1	*2*
Revising goals or plans	1	1	0	*2*	0	1	2	*3*
Environment control total	**0**	**1**	**1**	***2***	**1**	**2**	**3**	***6***
Environmental structuring	0	1	1	*2*	1	2	3	*6*
Total Regulation Mode	**14**	**18**	**8**	***40***	**10**	**23**	**10**	***43***

Note: One regulation episode mode may involve more than one type of strategy. Frequency calculation was performed by examining the overlap between each regulation mode and each strategy type in groups' CORDTRA diagrams.

The most common strategy in the high productivity group was behaviour control (f = 18), followed closely by the frequency of cognitive (f = 13) and emotion control (f = 7) strategies, $\chi^2(2) = 4.84$, $p = .09$. The group performed very few environment control strategies (f = 2) involving manipulation of physical task features such as the timing of the online session or the technology. When the micro-level strategies were examined, the high productivity group frequently engaged in social support behaviour (f = 10) encouraging or facilitating the participation of others by seeking and providing help, promoting openness, accommodating needs, and modelling specific tactics for completing the task. The most frequently observed shared regulation in this group was in the form of social support. Other micro-level strategies in the high productivity group included fundamental regulatory processes such as planning and goal setting (f = 7) and checking in or monitoring (f = 6). As it was defined in the coding scheme, the planning strategy involved constructing, negotiating, or aligning task perceptions and goals; it did not include planning logistics such as figuring out when to meet. Planning strategies in the high productivity group were mostly in the form of co-regulation where individuals were temporarily guided to think about task goals and purposes. There was only one shared planning strategy enacted in response to an expression of low task confidence and understanding. Similarly, the high productivity group's monitoring strategies mostly involved individuals temporarily guiding others to monitor task features or progress.

One stark difference between the groups' strategies related to the frequency of emotion control strategies: this type of strategy was quite frequent in the high productivity group but not evident at all in the low productivity group. Specifically, individual members in the high productivity group self-regulated their low motivation and lack of task enjoyment by openly expressing their emotions (f = 6). During one episode involving emotion expression, another

member in the group attempted to co-regulate that peer's feeling by reassuring her the group had it under control. Interestingly, two members in the high productivity group had planned to use emotion control strategies for motivation hurdles they anticipated at the beginning of the collaboration: Person R planned to *"keep a positive attitude,"* and Person J planned to *"make the task interesting."*

In comparison, the low productivity group activated behaviour control strategies (f = 24) most frequently compared to cognitive (f = 13) and environment control (f = 6) strategies, $\chi^2(2) = 11.61$, $p = .01$. The low productivity group's behaviour control strategies mostly involved checking-in or behaviour-monitoring strategies. Most of the check-ins were co-regulatory involving directing specific individuals to the task because of a lack of contribution from those individuals. Under the cognitive control category, the low productivity group's most common strategy was information processing that was activated using the co-regulation mode. The information processing strategy involved guiding others to engage with the learning materials to gain a better understanding of the domain knowledge necessary for completing the task efficiently. Person K who was dominant in performing the co-regulation stated in his planner that he planned to *"demonstrate to others how to work on the task and would like to work on his leadership skills."*

On other occasions when group members' engagement and attention derailed, the low productivity group focused on managing the environmental or logistical aspects of the task as a team (shared regulation) rather than addressing the task goals together. Planning and setting goals were not as frequent in the low productivity group (f = 3) compared to the high productivity group (f = 6), and none of the planning was performed in a shared way. Given the lack of joint involvement in constructing task goals and understanding, it was not surprising to find the low

productivity group revising their goals and plans more frequently (*f* = 3) compared to the high productivity group (*f* =7).

Overall, except for managing the external environment, the high productivity group tended to use more varied types of motivation regulation strategies focusing on managing behaviour, thoughts, and emotions. The high productivity group demonstrated social support in response to motivation challenges but also frequently engaged in fundamental regulatory processes such as planning and monitoring. In contrast, the low productivity group mostly focused on managing behaviour and thoughts. The behaviour control strategy the low productivity group used was highly related to conducting check-ins on others' behaviour. The same group engaged in less frequent strategic planning or goal setting but had to revise their previously unshared goals a couple of times along the way.

Discussion

This study aimed to examine the role co-regulation played in dynamically stimulating the emergence of self- and shared-regulation motivation in two groups with contrasting perceptions of their overall team learning productivity. This study demonstrated that the CORDTRA diagram was suitable for representing collaborative groups' regulatory actions because the intertwined processes between individuals and the group can be simultaneously considered. Findings also demonstrated that co-regulation of motivation may afford and thwart the emergence of group members' self- and shared-regulation of motivation, and these processes interacted with the group's situational challenges and the regulatory skills or strategies group members possessed. Specifically, case comparisons indicated that groups' motivation regulation should (a) match the demands of the challenges at hand, (b) be positively supported by group members through co-

regulation, and (b) involve a more varied strategic responses so that the group may continue to learn and co-construct knowledge effectively as a team.

Match Between Situational Demands (Conditions) and Modes of Regulation

Examining the context that triggered regulation matters. Rather than focusing on the frequency of self-, co-, and shared regulation, we examined the modes of regulation in tandem with the motivation challenges (conditions) that stimulated responses. If the conditions were ignored when groups' proportions of self- and shared-regulation were compared, we would have concluded that the low productivity group enacted more shared regulation than self-regulation and the high productivity group enacted more self-regulation than shared regulation. This conclusion would contradict previous research demonstrating an association between higher instances of shared regulation and better collaboration outcomes (see Panadero & Järvelä, 2015). However, when the types of motivation challenges that triggered regulation were examined, we found the high productivity group experienced more challenges originating from *self* conditions, such as personally lacking task enjoyment. Individuals within this group did not necessarily share the same motivation challenges. Hence, a high proportion of regulation in the high productivity group involved individuals self-regulating their own motivation and supporting or co-regulating the motivation of the struggling group members. In contrast, the low productivity group experienced more motivation challenges originating from *group* conditions relating to inter-individual conflicts and a lack of group interactions. The group, however, failed to activate higher instances of shared regulation despite some members' frequent attempts to promote regulation through co-regulation. Some instances of co-regulation thwarted the formation of shared-regulation, particularly when the co-regulator did not consider the other group members' perspectives. Also, rather than taking personal responsibility to proactively self-regulate in the

face of motivation challenges, a few group members in the low productivity group seemed to rely on others to regulate for them. This finding supports the theory that self-regulation is a necessary ingredient in collaboration; when individuals are not proactively self-regulating, co- and shared-regulation would be less relevant or effective.

The focus of shared motivation regulation in both groups also seemed to differ. Shared motivation regulation in the high productivity group targeted the wellbeing of the group, and group members focused on creating a supportive environment by exchanging feedback, negotiating needs, and jointly finding solutions to manage their challenges. In contrast, the low productivity group's shared motivation regulation tended to focus on environmental-based motivation challenges; the group focused on changing the physical conditions by finding a different meeting time where everyone could be more engaged. This finding parallels previous research that found low-performing groups often focused on controlling the external challenges such as difficulties navigating the online collaborative environment and using technologies (e.g., Malmberg et al., 2015). In contrast, the same study found that high-performing groups were more active in managing the cognitive, motivational, as well as social aspects of their collaboration—similar to findings related to the high productivity group in this study.

The differences in motivation challenges experienced in both groups call for a more refined conceptualization of motivation, especially as it is experienced in collaborative contexts. In this study, motivation challenges were conceptualized as circumstances in which individuals' or the group's level of willingness to engage in the task was compromised. Factors influencing motivation are diverse and not limited to traditionally discussed motivational beliefs such as self-efficacy. Motivation challenges may originate from behavioural (e.g., effort initiation and maintenance), cognitive (e.g., efficacy or task purpose), emotional (e.g., boredom), and

environmental (e.g., technological support) difficulties experienced before and during the task (Bakhtiar et al., 2019). Accordingly, the way learners respond to different challenges may also vary as not all motivation challenges require the same type of strategic response. We argue that understanding the nuances around groups' reactions to different challenges can help researchers and educators provide a more targeted support for students' motivation when learning in a team. More research needs to consider the contexts that triggered learners' regulation, rather than focusing on examining modes of regulation (frequency or sequence) in isolation from the situational demands that triggered it.

Supporting Group Members' Regulation through Co-regulation

Co-regulation, as conceptualized by Hadwin et al. (2017), refers to affordances and constraints stimulating appropriation of strategic planning, enactment, reflection, and adaptation by individuals or the group. Therefore, self- and shared-regulation should be examined with the co-regulatory affordances and constraints within the learning environment. Findings in this study demonstrate that co-regulation of motivation may mediate the productivity of self- and shared-regulation. Between the two groups, the low productivity group exhibited more co-regulation that was directive than facilitative (see also Bakhtiar et al., 2018; Rogat & Adam-Wiggins, 2015). Likely because of the directive regulation, group members were more reluctant to respond and productive self- or shared-regulation were less likely to transpire. This study's findings also suggest that whether the co-regulatory role is distributed amongst all members or dominant in specific team members had less of an effect on team learning. Instead, team learning seemed to be negatively influenced when the co-regulation was communicated in a directive and an undesirable way. Future research with a larger pool of participants is needed to examine which of these

factors (distribution of co-regulatory roles or socioemotional tone) have more influence on group learning and regulation.

Currently, there is a great interest in examining the extent to which groups' regulation is shared because “sharedness” is indicative of group cohesion and so may influence task performance (Iiskala, Vauras, Lehtinen, & Salonen, 2011). Panadero and Järvelä (2015) in their review also recommended future research to examine the best conditions that promote socially shared regulation in collaborative learning. Before pursuing such investigation, one missing link must be addressed: similar to the concept of group cohesion, limited research has attempted to articulate how a group transitions from a collection of individuals (SRL) to acting as a collective entity (SSRL). One suggested possibility is that active self-regulation across group members must simultaneously be observed. When all group members are metacognitively aware of the group’s needs and challenges and are invested in taking control of the situations, shared-regulation is more likely to emerge (Järvelä et al., 2015). Otherwise, shared-regulation is possible when some individuals activate co-regulation by bringing the group’s attention to the needs and challenges that needed to be regulated. Co-regulation may be a necessary metacognitive process for temporarily supporting (sometimes constraining) groups’ shared regulation. Hence, future research should investigate the types of co-regulation that afford or constrain the activation of shared regulation. Similarly, research is needed to examine the types of co-regulation that facilitate the development of self-regulatory competence for collaborative learning (e.g., DiDonato, 2013).

Variation in Motivation Regulation Strategies

Findings also indicate that the high productivity group exhibited more varied responses to motivation challenges, including behaviour-, cognitive-, and emotion-control strategies. The

variation in strategic responses observed in this group may point to the importance of groups (a) being more flexible to readily adapt when one strategy does not work, and (b) regulating across cognitive, behavioural, and affective dimensions of regulation rather than focusing on one aspect alone (see Rogat & Linnenbrink-Garcia, 2011). In contrast, the low productivity group demonstrated a limited strategy repertoire, which is a common finding in novice groups (Bakhtiar et al., 2019). The low productivity group tended to use strategies focused on correcting individual members' behaviour in the task; none of their strategies was related to improving the group's emotional experiences. The group tended to focus on increasing members' contributions and getting the task done without considering individual members' thoughts, beliefs, and feelings. The lack of emotion control strategies may have contributed to experiencing less productive team learning. Previous research demonstrated that emotion control strategies in the form of openly expressing negative and positive emotions could help build psychological trust amongst team members and that trust is a strong predictor of group members' ability to co-construct knowledge and ideas in the task (Van den Bossche et al., 2006).

Moreover, research argues that planning is critical in setting the stage for more effective learning (Hadwin et al., 2018). During planning, learners generate goals and standards, making it easier to monitor task progress. In response to motivation challenges, the groups in this study engaged in planning and goal setting at different frequencies. Planning (either done alone, for others or together as a team) was one of the most common strategies in the high productivity group. In contrast, the low productivity group engaged in planning at half the frequency of the other group and none of the planning related to developing shared task goals. Thus, it was not surprising to find the low productivity group working at cross-purposes and having to revise their goals and plans a couple of times during their collaboration. The link between group motivation

and planning in the form of figuring out task goals should be explicitly examined in future studies involving a larger sample size of collaborating groups.

Limitations

One limitation of this study is the possible underestimation of self-regulation of motivation. Some strategies may be internal to an individual and so may not have been observed during the group's interactions. Xu and Du (2013) found that a high proportion of the variation in students' motivation regulation strategies was at the individual level, suggesting minimal group influences. Strategies such as telling myself that I can successfully attain a set goal (i.e., promotion of goal striving or goal self-talk) are difficult if not impossible to observe unless the individuals themselves explicitly mention using the strategy. Unlike the strategies found in previous research (Bakhtiar et al., 2019; Xu & Du, 2013), several strategies were not observed in these two comparison groups including enhancing task interest, changing one's thought about the value or utility of the task, and administering rewards for accomplishing a goal. Such strategies may have been covertly enacted by individuals and so were not evident during groups' conversations. Similarly, data in this study might underestimate individual motivation challenges, particularly when these were not shared in conversations.

New to research in motivation regulation, groups' dynamic regulatory responses to motivation challenges were visually represented using CORDTRA diagrams. The diagrams allowed us to holistically examine how the strategic actions among group members go on and off, and how self- and shared-regulation of motivation were used in relation to co-regulation. As seen in the diagrams, we selected groups' motivation regulation episodes and ordered them chronologically while ignoring activities that were not considered an episode of motivation regulation. This approach may suggest that one episode of motivation regulation informs the next

one, but it may be possible that the activities in the motivation regulation episodes were influenced by the activities that were not considered motivational and so were not represented on the diagram. Future research may attempt to construct CORDTRA diagrams with a more continuous timeline, showing groups' regulation across different areas and with non-regulatory activities.

Implications

By analyzing the dynamic interplay between self- and shared-regulation as supported or thwarted by co-regulation, the current study contributes to uncovering how individual and group motivation regulation processes evolve in collaboration. Findings indicated that shared-regulation was limited and superficial when active self-regulation across group members was infrequently observed. Even when individuals attempted to co-regulate towards shared-regulation, such efforts were often unhelpful if the individuals themselves were not ready to play an active role in regulating and if the co-regulator ignored other group members' ideas and contributions in opposition to their own. Hence, supports for motivation in collaboration need to consider two elements. First, individual group members may need to be supported to engage their metacognition, beginning from the fundamental processes of constructing task perceptions and specific goals which are critical for directing and motivating individuals toward the task. When regulation at the individual level is productive, it will likely transfer to productive regulation at the group level. Second, group members may not necessarily know how to effectively co-regulate others without projecting directive statements, particularly when conversations occur in an online environment. Supports in the form of metacognitive sentence starters (e.g., Morris et al., 2010) geared toward supporting motivation in online collaborations should be explored to improve groups' motivation regulation processes.

Finally, this study is one of limited studies to identify motivation regulation strategies students conduct in the form of co- and socially shared regulation, particularly as they occur during online collaboration. Findings indicated that frequently adopted motivation co-regulation strategies included guiding individuals or the groups to check on their product and progress, responding to members' concerns and needs, and reminding others about a plan or a goal. Strategies that were performed in a shared way included collectively supporting each other's task engagement and modifying the environmental features of the task together. This set of findings provides a basis for re-operationalizing strategies relevant in collaborative contexts, rather than relying on motivation research that tended to focus on solo learning activities. As it was demonstrated, individual and social regulatory processes dynamically interact as groups move through a task, consequently, influence the expressions of motivation regulation strategies in such contexts.

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Appendix

Coding Schemes in All Four Waves

Wave 1 (Socioemotional vs. Task-Focused)[2]	
Code	**Descriptions**
Socio-emotional focused	Utterances about motivation (task engagement and participation) and emotions either related to individuals, a group of individuals, task features, progress or product.
Task focused	Utterances related to the details of the task, including domain related knowledge or items to include in the group's shared product.
Wave 2 (Motivation Challenges)[3]	
Code	**Descriptions**
Behaviour-based	Difficulties getting individuals to participate, getting the work done, or staying on task.
Cognitive-based	Lacking confidence or a sense of purpose or task goal; finding the task cognitively challenging.
Affective-based	Difficulties maintaining positive emotions about the task, the group, or the situation.
External-based	Difficulties managing other priorities or demands outside of the task.
Wave 3 (Modes of Regulation)[4]	
Code	**Descriptions**
Self-regulation	Individual deliberately plans, monitors, and/or regulates their own motivation and emotions in the joint task.
Co-regulation	Individual(s) temporarily supports or influences one or multiple members' self-regulation processes or the group's shared regulation processes. Co-regulation creates either affordances or constraints for productive self-regulated learning and/or shared regulation of learning.
Socially-shared regulation	Group members collectively negotiate and realign or adapt group regulation processes. Shared regulation is transactive in that multiple individuals (not necessarily all individuals in the group) contribute to the joint effort to regulate.
Wave 4 (Motivation Regulation Strategy)[5]	
Code	**Descriptions**
Behaviour control	

[2] Järvenoja, Järvelä, and Malmberg (2017)
[3] Bakhtiar, Hadwin, and Järvenoja (2019)
[4] Bakhtiar, Webster, and Hadwin (2018)
[5] Bakhtiar, Hadwin, and Järvenoja (2019)

Social Support	Encouraging or facilitating others' participation by seeking and providing feedback, promoting openness, accommodating needs, and demonstrating tactics/strategies.
Task Persistence	Focusing on completing the task by exerting more effort.
Checking In	Checking in with group members about the task, progress and/or product.
Reward	Provide some type of reward if the job gets done or if the goal is reached
Cognitive control	
Planning and Goal setting	Planning and setting goals to improve the clarity of individual or group goals.
Promote Goal Striving	Reminding individuals or the group about what they need to strive for and encouraging individuals to achieve a set goal.
Information Processing	Improving mastery and understanding of course concepts by seeking relevant resources
Utility and Value	Thinking about the benefits and value of engaging in the task.
Emotion control	
Expressing Emotion	Expressing or communicating emotions; Expressing concerns and/or challenges.
Emotion Regulation	Re-appraising the emotions by sorting out frustrations or becoming flexible with differences that may be the cause of the frustrations; Decreasing negative affect.
Interest and Enjoyment	Focusing on something about the task/experience that interests oneself or that is fun and enjoyable; Inducing positive affect.
Environment control	
Environmental/Task Structuring	Reducing work distractions; Finding a better workplace, condition, or time to work on the group project.