The Role of Social Emotions and Co-regulation of Learning During Complex Math Problem Solving

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Abstract

This study seeks to deepen the understanding of the social aspects of emotion in the classroom. Collaboration and conversation have the potential to generate positive emotions and foster motivation and support progressive communication and collaboration (Jones and Isroff, 2005). However, these same circumstances may bring about negative emotions and produce unique motivational barriers for students when personalities, objectives, and ideas clash (Järvelä, Lehtinen, & Salonen, 2000). As researchers (Muis et al., 2015) have shown, emotions may facilitate or constrain self-regulatory processes during learning but, to date, no research has explored how social emotions may similarly affect the co-regulation of learning (Järvelä & Hadwin, 2013), especially during learning of complex content. This study investigated the social emotions that arise during the collaborative process and explored the antecedents (control, value, and basic psychological needs) and consequences (co-regulatory processes and learning outcomes) of social emotions in the context of solving complex mathematics problems in a collaborative learning setting with elementary students. Twenty-nine, fifth grade students in the Montreal area were asked to solve a complex math problem in groups. Measures of task value, academic control for learning mathematics, and basic needs satisfaction in that group context were collected. Audio-recordings of the session were transcribed and coded to investigate co-regulatory processes. Results revealed that task value, control and basic needs were antecedents to the emotions that students experienced in the social context. Social emotions subsequently mediated relations between relatedness and functional co-regulatory strategies.

Keywords: social emotion, co-regulated learning, collaborative learning, mathematics problem-solving

Résumé

Cette étude cherche à approfondir la compréhension des aspects sociaux de l'émotion en salle de classe au primaire. La collaboration et la conversation génèrent possiblement des émotions positives qui favorisent leur soutien progressif ainsi que la motivation scolaire (Jones and Isroff, 2005). Toutefois, ces mêmes conditions peuvent entraîner des émotions négatives et faire obstacle à la motivation lorsque les personnalités, objectifs et idées s'entrechoquent (Järvelä, Lehtinen, & Salonen, 2000). S'il fut démontré que les émotions stimulent ou entravent les processus d'autorégulation pendant l'apprentissage (Muis et al., 2015), aucune étude n'a, à ce jour, cherché à expliquer comment les émotions sociales affectent la corégulation pendant l'apprentissage (Järvelä & Hadwin, 2013). Cette recherche cible les émotions sociales surgissant pendant le processus collaboratif lors de l'apprentissage de notions complexes. Elle examine les antécédents (contrôle, valeur et besoins psychologiques de base) et les conséquences (processus corégulateurs et résultats de l'apprentissage) des émotions sociales émergeant chez des élèves qui collaborent pour résoudre un problème mathématique complexe. Vingt-neuf élèves de cinquième année du primaire, provenant de Montréal, furent placés en petits groupes pour résoudre une situation problème. Des données cernant la valeur de tâche, le contrôle pédagogique pour l'apprentissage mathématique et les besoins fondamentaux de satisfaction furent collectées. Les enregistrements audio des périodes furent transcrits et codés afin d'analyser les processus corégulateurs. Les résultats montrent que la valeur de tâche, le contrôle pédagogique pour l'apprentissage mathématique et les besoins fondamentaux de satisfaction constituent des antécédents significatifs aux émotions ressenties par les élèves impliqués dans un environnement social. Les émotions sociales suscitent des sentiments d'interrelation et des stratégies fonctionnelles de corégulation.

Mots clés : émotions sociales, apprentissage corégulé, apprentissage collaboratif, mathématique, résolution de problèmes.

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CHAPTER 1

Introduction

Emotions can facilitate or constrain learning processes, and can increase or decrease student understanding, motivation to learn, and academic achievement (Efklides & Volet, 2005; Pekrun, 2006; Schutz & Pekrun, 2007). As a result of the far-reaching implications that emotions have on learning, Pekrun and Stephens (2012) urged researchers to consider emotions in classroom contexts. Although a proliferation of studies has recently emerged on the role of achievement emotions in learning, to date, social emotions have been largely overlooked (Pekrun & Stephens, 2012). Considering the achievement implications of emotions and their susceptibility to social influence (Pekrun & Stephens, 2012), it is imperative that researchers explore students' emotions as they occur in the socially dynamic and interactive environment of the classroom.

Collaborative learning is now a promoted staple of the classroom-learning environment and therefore requires special consideration of the way it is implemented and how students respond to its implementation (Slavin, 2015). The benefits of collaborative success abound; emotionally, Jones and Isroff (2005) noted that collaboration and conversation have the potential to generate positive emotions and foster motivation. This, in turn, helps to support communication and collaboration, and reinforces commitment to the co-construction of understanding (Jones & Isroff, 2005). Moreover, the satisfaction of an individual's basic needs of autonomy, relatedness, and competence via positive social relationships have been shown to lead to an increase in self-determined motivation for learning. This results in increased academic enjoyment, interest and effort (Ryan & Connell, 1989). It is also important to note that these same circumstances of collaborative learning may bring about negative emotions and produce unique motivational barriers for students when their personalities, objectives, and ideas clash (Järvelä, Lehtinen, & Salonen, 2000;

Kreijns, Kirchner, & Jochems, 2003). As Järvelä and Hadwin (2013) argued, for positive and beneficial collaboration to take place, emotional management at the individual and group level are necessary. That is, each participant must be cognizant and accountable for his/her own learning (self-regulation of learning), the support of other group members in their individual learning (co-regulation of learning) and collective representation of learning (socially shared regulation of learning) (Iiskala, Vauras, Lehtinen & Salonen, 2011; Järvelä & Hadwin, 2013; Panadero & Järvelä, 2015). To date, little research has taken into consideration the aforementioned aspects of collaborative learning in one study.

As such, the primary aim of this study is to explore the antecedents and consequences of social emotions, and to assess whether these emotions predict co-regulation strategies and learning outcomes in the context of solving complex mathematics problems in a collaborative learning environment with upper elementary school students. Prior to delineating the specific research questions and hypotheses, relevant theoretical and empirical work are reviewed. First, two prominent theoretical frameworks are presented: Pekrun's (2006) control-value theory of achievement emotions and Deci and Ryan's (2000) theory of self-determined motivation. Following this, research on social emotions in the collaborative learning context is included. Finally, conceptualizations of regulation of learning (i.e., self- and co-regulated learning) according to Muis (2007), Hadwin, Järvelä and Miller (2011) and Iiskala and colleagues (2011) are explored.

CHAPTER 2

Theoretical Frameworks

Control-Value Theory of Achievement Emotions

Emotions are defined as, "…sets of coordinated psychological processes including affective, cognitive, physiological, motivational and expressive components" (Pekrun & Stephens, 2012, p. 4). Thus, emotions make individuals act; they make them 'do something' in response to a situation by directing and synchronizing affective, cognitive and physiological responses. Emotions arise in relation to the appraisals an individual makes that emanate from experiences with the self, and/or a situation (Scherer, Schorr & Johnstone, 2001). In the context of learning, emotions affect a student's attentional resources, motivation to learn, the quality and effectiveness of learning strategies, and the regulation of learning (Pekrun & Stephens, 2012). For example, when students experience negative emotions such as anger, frustration, or anxiety in relation to a learning experience, they may begin to engage in off-task thinking where they worry about their ability to successfully complete an exam. These feelings of nervousness can reduce the dedication of attentional resources for the task, and ultimately undermine intrinsic motivation for learning (Pekrun & Stephens, 2012).

Indeed, given the negative effects that anxiety can have on learning processes and learning outcomes, a rich literature on test anxiety has dominated research on emotions in education over the past 50 years (see Zeidner, 1998). However, recent research suggests that a variety of emotions play an important role in learning. To take into consideration how other emotions might relate to learning in achievement situations, Pekrun and colleagues **(**Pekrun, 2000, 2006; Pekrun & Perry, 2014**)** proposed the control-value theory of achievement emotions. Achievement emotions are emotions that are tied to any achievement activity (i.e., playing chess, sports, and learning) or achievement outcome (e.g., the emotions one anticipates based on future and/or reflective emotions related to an achievement task) and

may occur in academic situations, but may also occur in other achievement settings, like sports- or work-related achievement outcomes. As such, achievement emotions are distinct from, but overlap with the broader category of academic emotions (Pekrun & Stephens, 2012). Achievement-related emotions can be connected to the achievement results (i.e., the grade on an exam), or activities associated with achievement (i.e., preparing/studying for an exam), which translate into two kinds of achievement emotion; outcome [prospective and retrospective] and activity-related emotions. Prospective outcome emotions occur as a result of a learner's perceived control over the achievement of success, and avoidance of failure, with regard to a specific achievement task, and the subsequent impact of that success or failure. Retrospective outcome emotions focus on the causes of success or failure and, subsequently, the cause of the successful or non-successful outcome (e.g., the self, others, the task, the environment/context). Activity-related emotions are the affective states that take place while individuals engage in an activity, without consideration or contemplation of possible outcomes (Pekrun, 2006; Pekrun & Stephens, 2012).

According to Pekrun (2006), achievement emotions may be categorized along two dimensions of valence (positive, negative) and two dimensions of activation (activating, deactivating): positive activating and deactivating, and negative activating and deactivating. These emotions are said to influence various facets involved in the learning process including learner motivation, use and availability of cognitive resources, learning strategies, self-regulated learning and academic achievement (Pekrun, Goetz, Titz and Perry (2002a). For example, positive activating emotions (e.g., enjoyment, pride, hope) have been found to increase learner readiness to perform an academic activity, strengthen perseverance, increase the use of creative and flexible learning strategies, and help focus attention (Perkun & Stephens, 2012). Additionally, positive activating emotions direct learners' cognitive resources and attention towards the task and help to foster effective self-regulation practices

(i.e., goal setting, planning, evaluating and monitoring). Considering the aforementioned assumptions associated with positive activating emotions, it can be implied that such emotions are generally beneficial in positively contributing to academic achievement (Pekrun, Goetz, Titz, & Perry, 2002b). However, some studies demonstrate that positive emotions have no effect (Trevors, Muis, Pekrun, Sinatra, & Winne, 2016), or even negative effects on academic achievement (Ellis, Seibert, & Varner, 1995), particularly when positive emotions draw attentional resources away from the task at hand (Meinhardt & Pekrun, 2003).

Positive deactivating emotions (e.g., relaxation, relief) have a more complicated effect on learning processes (Pekrun et al., 2002b). Positive deactivating emotions may momentarily disengage the learner's motivation and distract attention as may be the case when a learner experiences relief upon completion of a task. Such emotions may also produce more shallow learning strategies and information processing, but by the same token, creative thinking may be fostered because of a more relaxed learner state where there is space for a recombination of information. Achievement effects in relation to positive deactivating emotions are also complex in that the emotion may be undermined by the interaction between the nature of the task demands and mediating processes (Pekrun et al., 2002b).

Emotions that are negative activating (e.g., anger, frustration) are thought to consume cognitive resources, result in task-irrelevant thinking, and limit intrinsic motivation as is the case when an individual experiences worry in relation to anxiety over an upcoming exam. Conversely, these same emotions may boost extrinsic motivation in the hopes of avoiding failure. Therefore, it is important to consider the conditions of the task when assessing the impact of negative activating emotions on learning processes and performance (Pekrun & Stephens, 2012). Finally, negative deactivating emotions (e.g., hopelessness, boredom) decrease both intrinsic and extrinsic motivation, and result in shallow information-processing, rigid learning strategies and lower achievement (Pekrun, Goetz, Titz & Perry, 2002a; Pekrun,

2006; Pekrun & Stephens, 2012).

Pekrun (2006) further posited that the experience of achievement emotions is related to the perceived appraisals of control and value in relation to the learning task and other personal and environmental factors (i.e., beliefs, goals, cognition, motivation, and the cultural and social environment). Thus, control and value serve as antecedents to the kinds of achievement emotions one experiences in relation to a learning task. Control refers to the amount of controllability one perceives in relation to the achievement task whereas value refers to the amount of perceived importance and utility of the achievement activity itself along with the outcome of the activity. Both control and value are said to interact to predict the kinds of emotions individuals experience during learning. For example, high perceptions of control and high perceptions of value for a task interact to predict higher levels of enjoyment during task engagement. Conversely, perceptions of low control and low value may bring about frustration and anger. Anxiety may result from high perceived value but low control over the learning task. Lastly, boredom may result from overly challenging learning situations where control and value are perceived as being low.

Academic emotions, which include achievement emotions, can also be labeled according to their object focus (i.e., achievement emotions, epistemic emotions, topics emotions, and social emotions) (Pekrun & Stephens, 2012). For example, epistemic emotions arise as a result of the cognitive qualities of specific task information and the processing of information associated with the task (Pekrun & Linnenbrink-Garcia, 2012; Pekrun & Stephens, 2012). When an individual experiences cognitive incongruity regarding incoming information as when compared to prior knowledge, curiosity, surprise, or confusion may occur as a result. These emotions are epistemic in nature since they are tied to knowledge generation and the processes of knowing (Muis, Chevrier, & Singh, accepted). Topic emotions include the emotions that an individual experiences in relation to the content of the

learning material itself. Important to note is that topic emotions, unlike epistemic emotions, do not relate to learning directly, however, topic emotions do have the ability affect learning via their influence on engagement, motivation, and interest (Ainley, 2007).

Lastly, social emotions are brought about by the interactive quality of the learning environment. That is, social emotions are emotions directed at, or experienced in relation to interactions with teachers and peers, as well as emotions that are the result of socially constructed guidelines of the environment itself, the curriculum, and/or learning task (i.e., content and/or goals of the curriculum/learning task). At times, achievement emotions and social emotions may coincide, specifically when social emotions influence achievement (i.e., social achievement emotions), which include, envy, contempt, schadenfreude, gratitude, empathy, shame, pride, jealousy, embarrassment, and guilt (Hareli & Weiner, 2002; Immordino-Yang, McColl, Damasio, & Damasio, 2009: Pekrun & Stephens, 2012; Weiner, 2007).

To date, although research has not taken social emotions into consideration, peer relations and perceptions do play an important role in predicting students' emotions. For example, in relation to the impact that peers have on the kinds of emotions students experience within the learning environment, Frenzel, Pekrun, and Goetz (2007) examined students' perceptions about classroom environments and emotions in mathematics with 1623 students from fifth to tenth grade. They found that students' perceptions of their peers' self-esteem in mathematics predicted the activity- and outcome-emotions that they experienced in mathematics. Specifically, they found that when students believed that their peers valued mathematics, those students experienced less anxiety and greater enjoyment in mathematics. Thus, socially, students' consideration of their peers' perception of value appears to positively relate to students' own emotional experiences within the learning environment and during the learning task.

Additionally, Ahmed, Minnaert, van der Werf, and Kuyper (2010) conducted a study on the mediational role involved in perceptions of peer support and achievement, and the related effects on motivational beliefs and emotion with 238 seventh grade students. The researchers found that perceptions of feeling a high degree of support from peers positively affected motivational and emotional functioning. That is, peer support was associated with increased instances of personal competence and feelings of enjoyment and interest, which in turn predicted better math achievement. Therefore, from a social standpoint, peer perception of value for mathematics and supportive peer relations appear to translate into increased instances of positive affect during learning tasks and within the learning environment. Bearing in mind the emotional influence and impact of the peer group and larger social environment, it is worth extending the investigation to consider how these emotional experiences within peer interaction and collaboration affects how students collectively regulate (CoRL) their learning and, in turn, how this affects achievement outcomes.

Despite the fact that research has explored the role of achievement emotions in an academic setting (see Dettmers, Trautwein, Lüdtke, Goetz, Frenzel & Pekrun, 2011; Frenzel et al., 2007; Muis, Psaradellis, Lajoie, Di Leo, & Chevrier, 2015), few studies have taken into consideration social emotions in the social learning context (Hareli & Weiner, 2002). It is also noteworthy to consider that the degree to which our basic needs (i.e., feelings of autonomy, competency, relatedness) are satisfied within a social context (which will be discussed in the next section) affect our ability to self-regulate and perform (Deci & Ryan, 2000). Specifically, the perceived degree of acceptance an individual experiences in a group context has been shown to influence one's emotional state (Leary, 2001). In turn, it has been previously demonstrated that an individual's emotions, as a result of perceptions of value and control, have the ability to affect regulatory processes and achievement (Efklides & Volet, 2005; Pekrun, 2006; Schutz & Pekrun, 2007). Therefore, given the complex nature of the

interconnectivity between the self and others as noted in the research reviewed above, it is imperative that in order to better understand the academic emotions experienced in a learning environment, researchers must begin to consider the role of social emotions within a collaborative learning context (Hareli & Weiner, 2002).

The Role of Social Emotions in Learning

Given that collaborative group learning contexts are prevalent in classrooms, the role of social emotions must be taken into consideration. Following Pekrun's (2006) control-value theory of achievement emotions, I sought to identify the antecedents of social emotions and their subsequent impact on co-regulatory learning strategies that students use while engaged in a cooperative learning task. Additionally, Pekrun and Stephens (2012) posited that at times there may exist an overlay between achievement emotions and social emotions since the individual experiences various affective states related, and due to, learning within a social context. Therefore, for the purposes of this study, I took into consideration both social emotions (i.e., envy, shame, empathy, jealousy, guilt, pride, embarrassment) and the overlap of these social emotions with activity emotions (e.g., enjoyment, relaxation, frustration, relief, anger, anxiety, boredom, confusion, curiosity, hopelessness, and surprise) experienced within a cooperative group context.

Although perceived control and value are likely key antecedents to social emotions, the social environment, that is the quality and demands of instruction, amount of autonomy support, goal structures and expectations, and feedback and consequences in relation to achievement contribute to students' appraisals of control and value (Frenzel & Stephens, 2013). For instance, Ahmed et al. (2010) found that competence, as experienced within a supportive peer environment, had a significant mediating effect on math achievement. Therefore, the motivational effects of a supportive peer group may provide additional antecedents to the kinds of social emotions students experience within a collaborative

context.

As such, along with Pekrun's (2006) control-value theory of achievement emotions, Deci and Ryan's (2000) self-determination theory (SDT) was also used to situate the antecedents and consequences of social emotions. Deci and Ryan (2000) outlined the causes of intrinsic and extrinsic motivation and how they play a part in an individual's cognitive and social development. Specifically, SDT posits that human motivation is based on the fulfillment of three basic innate psychological needs (BPN), a sense of competency, autonomy and relatedness, to function at and grow towards a psychologically optimal level, as well as experience social and personal well-being. That is, within a social context, the degree to which individuals feel that they are in charge of their own behaviour (i.e., autonomy), are efficacious within their environment (i.e., competence), and are connected to others and being cared for (i.e., relatedness), determines the level of quality of an individual's motivation. The quality of motivation in turn directly impacts goals and outcomes and the regulatory processes involved in pursuing goals and outcomes. This, in turn, has an effect on how the individual performs within a given task (Deci & Ryan, 1985a, 2000; Ryan & Deci, 2000). For instance, within a collaborative context, if students feel that their behaviour is constrained, feel ineffective and/or disconnected to their peers, they may experience frustration or anger towards their group, which may negatively impact the quality of co-regulatory processes and ultimately impact task achievement. Conversely, students who feel valued, effective, and connected to their group may experience enjoyment and pride during the collaborative task, thus facilitating beneficial co-regulatory processes and ultimately result in higher achievement on the task.

Research in the area of SDT and BPN has demonstrated that self-determined motivation is related to task-related enjoyment and better performance (Miserandino, 1996). For example, Miserandino (1996) conducted a study with 77 third and fourth grade high

ability students to assess the impact of perceptions of autonomy and competence on their engagement and performance. She found that students who had perceptions of high competency reported that they were more curious, experienced enjoyment while learning, and persevered in school tasks more than those who felt low competency. Low perceived competency was related to higher reports of instances of anxiety, anger, and boredom and associated with avoidance behaviour in relation to task perseverance. Additionally, high levels of perceived competency significantly predicted achievement in math and social studies. In contrast, less self-determined motivation has been linked to higher instances of negative activating emotions such as anxiety (Ryan & Connell, 1989).

Hareli and Parkinson (2008) have also claimed that social emotions are connected with specific social behaviours. They put forth that social behaviours are those in which an 'other' is the either the focus of behaviour (i.e., experiencing anger or happiness in relation to another) and/or influences the nature of the interaction with the 'other' (i.e., inhibiting or extending help). For example, anger appears to be associated with the withdrawal or abstinence of helping behaviour (Weiner, 1985), whereas happiness appears to facilitate helping behaviour (Isen, 1987). As well, Ryan and Deci (2000) contended that social contexts, and the extent to which these contexts support members' psychological needs, provides an influential milieu through which an individual's commitment to a task, performance, and effort may be encouraged or constrained. De Dreu and Weingart (2003) conducted a meta-analysis of research on the connections between team relationships and satisfaction, and relationships and task conflict and found that in a social learning context, interpersonal conflict experienced within a group was more detrimental to team member satisfaction than conflict associated with the task. The researchers posited that because interpersonal disagreements are more emotional in nature (as compared to emotions related to a learning task), they tend to produce more intense instances of negative affect (De Dreu &

Weingart, 2003). Within the aforementioned dynamic, it is again important to note that emotion has the potential to encourage and provoke both learning *and* social behaviour (Pekrun, 2006; Schutz & Pekrun, 2007). As well, it appears that the social affect experienced between group members has a larger impact on the individual group member than do feelings associated with the actual learning task (De Dreu & Weingart, 2003). However, the details of this relationship as it relates to co-regulated learning have not been explored. Therefore, an individual's experienced affect and subsequent behaviour within a collaborative learning context not only has the ability to constrain or potentially bring about co-regulatory processes, but may also influence performance and achievement.

Given that positive social relations between collaborative group members have the potential to influence members' motivation and impact emotions related to the learning task, it is important to consider the role of satisfaction of basic psychological needs in the context of social and collaborative learning. In the same way that consequences of emotions serve to influence the regulation of learning at the individual level (Pekrun, 2006), it is important to consider the way in which social emotions may inhibit or bring about the co-regulation of learning at the cooperative level.

Regulation of Learning

Since the 1980s and 90s, theoretical and empirical work on regulation of learning has flourished. The majority of work has focused on individuals' self-regulated learning (SRL). From a socio-cognitive perspective, SRL is defined as the "… strategic and metacognitive behaviour, motivation, and cognition aimed toward a goal" (Hadwin & Oshige, 2011, p. 243). That is, individuals are active in their own learning processes in that they engage in the recursive processes of planning, goal setting, performing and evaluating in relation to their learning task (Muis, 2007). Theoretically, Pekrun (2006) posits that activity emotions, brought about by perceptions of the control and value, and shaped by the social environment,

serve as important influences on learning regulation, and the kinds of cognitive and metacognitive processes students employ in a learning context (i.e., shallow versus deep learning strategies). Empirically, Muis et al. (2015) found on an individual level, that emotions mediated appraisals, control and value, and specific learning regulation processes, as well as cognitive and metacognitive strategy use. Additionally, Hadwin and Oshige (2011) noted, the development of SRL is influenced by the learning context, the learning task itself, and the subject domain. Current theories have shifted to situate the social context as being at the center of SRL (Corno & Mandinach, 2004; Winne, 1989; 1997; Zimmerman,). Therefore, it is important that current studies on SRL take into account the social context.

Considering that at the core of SRL is the social context, theoretical models have been developed that place regulation along a continuum that spans from individual to social views of learning (Meyer & Turner, 2006). For example, Hadwin et al. (2011) delineate three regulatory situations that depend on the social context: self-regulated learning, co-regulated learning and socially shared regulation of learning. For the purposes and scope of this thesis, I focus on co-regulated learning but situate that work by first describing self-regulated learning.

Self-regulated Learning. SRL refers to an individual's ability to independently and effectively regulate the planning, monitoring, and regulating of behaviour, motivation and cognition in a given learning situation to complete an academic task (Hadwin et al., 2011; Hadwin & Oshige, 2011). While SRL is individual, it is socially influenced in that a learner's self-regulation may be influenced as a consequence of working within a social context, sometimes referred to as "self in social setting regulation" (Hadwin et al., 2011).

Muis (2007) outlines an integrated model of SRL that draws from the works of Winne and Hadwin (1998) and Pintrich (2000), which involves four recursive phases: task definition, planning and goal setting, enactment and evaluation. Within the task definition

phase, the learner builds a perception of the learning task. This perception is influenced by both external (i.e., task conditions) and internal conditions (i.e., cognitive and affective conditions). During the planning and goal setting phase, learners organize how they will approach the learning task and decide on appropriate strategies. Plans and goals are then assessed and compared to the definition of the task. Learners then enact their plans by employing the strategies and tactics chosen in the planning and goal setting phase. It is at this phase – enactment – where learners work through the task itself. Evaluation occurs as learners reflect on the perceptions related to the task, the self in relation to the task and/or the context, and whether or not they have been successful in each phase of learning.

As noted above, several studies have examined relations between emotions and the enactment phase of SRL. More recently, Muis et al. (2015) investigated the antecedents and consequences of epistemic and activity emotions experienced during complex math problem solving and extended previous research by examining whether emotions predicted the use of SRL processes at all four phases that Muis (2007) proposed (i.e., task definition, planning and goal setting, cognitive strategies in enactment, and metacognitive processes in monitoring and evaluation). Seventy-seven fifth grade students from two separate schools self-reported their perceptions of control and value for solving complex mathematics problems, and then worked on a complex math problem for 1.5 to 2 hours a day over the course of three to four days. To capture self-regulatory processes, students were recorded thinking out loud while solving a complex problem. Path analyses revealed that perceived control and value over a learning task predicted the kinds of achievement emotions experienced during problem solving, which predicted self-regulatory processes across the four phases of SRL. Self-regulatory processes then predicted mathematics problem solving achievement.

Within SRL, social interactions and influences may manifest during any phase within the aforementioned model, in the form of modeling, scaffolding and/or help-seeking, peer

assistance and tutoring (Hadwin et al., 2011). To illustrate, Kitsantas, Zimmerman, and Cleary's (2000) study examined how female high school students' exposure to three differing models (i.e., coping, mastery or absence of a model) and social feedback influenced their acquisition of dart-throwing skills. Within the coping condition, the students received instruction and subsequently observed an adult learning how to effectively throw a dart with instances of successful throws increasing as the demonstration progressed. The mastery condition had students receive instruction as well as watch a professional dart thrower engage in dart throwing, whereas the no-model condition students received instruction and then a practice phase. Feedback was given to half of the no-model condition group students, where the instructor would provide feedback as to whether their dart throwing technique was correct or faulty. Results showed that students assigned to the coping and mastery conditions had higher measures of self-efficacy, self-reactions and intrinsic interest compared to the no-condition group. Interestingly, in the coping condition, attributions of faulty throws were deemed to be due to lack of technique, whereas the mastery and no-condition groups attributed errors to lack of ability. Within the no-condition group, those who received social feedback increased their dart throwing skills and motivation. Therefore, social learning as well as the belief in oneself plays a role in SRL.

Co-regulated Learning. Co-regulation of learning (CoRL) is the ability of the self and other individual to coordinate self-regulatory learning processes (Hadwin et al., 2011; Hadwin & Oshige, 2011). Hadwin and Oshige (2011) refer to this coordination as transitional in that a *capable other* (i.e., a role filled by a more capable peer or teacher) shares in the regulation of a student's learning. Gradually, there is an appropriation of regulatory skills by the student. Accordingly, a given student's regulation of learning is mediated by the expertise of a more capable other (Hadwin et al., 2011). However, there is also the understanding that expertise is a relative term, and the role of the capable other can oscillate among group

members over the course of a single cooperative episode. Co-regulation is grounded in the Vygotskian understanding that psychological processes (i.e., regulation of learning) are intertwined and inseparable from the social context (Vygotsky, 1978) and considered a consequence of learning experienced within the zone of proximal development (McCaslin & Hickey, 2001).

To date, there are three categories of co-regulatory research that currently exist. In the traditional sense of co-regulation, research has focused on the mediation of regulation by a capable other to support and encourage another's SRL. Other areas of CoRL focus on the distribution of regulation of learning among learners in collaborative learning contexts (also known as "shared metacognition" [Iiskala, Vauras &Lehtinen 2004]). Lastly, CoRL research has investigated how the larger culture or social environment influences the co-regulation of learning (Hadwin et al., 2011). For the scope of this research study, the current investigation delves into the second area of CoRL research whereby members of a group look to accomplish a common goal (i.e., solving a complex problem) by which they distribute the regulation of learning among learners. I focus specifically on the function of CoRL as outlined by Iiskala et al. (2011).

Functions of CoRL fulfill one of two roles; that is, they facilitate CoRL processes or inhibit CoRL processes. Within these two functions exist two sub-functions. Facilitative CoRL functions can be delineated by whether they are activating (i.e., the activation of a new construct that is in line with the previous direction of understanding) or confirming (i.e., confirming whether the previous line of understanding is correct). Inhibitory CoRL functions can be delineated by whether they are slowing (i.e., attempts to slow down the processes of the previous direction) or changing (i.e., changing the direction of the previous activity) (Iiskala et al., 2011).

Factors involved in successful instances of CoRL in collaborative learning are

beginning to emerge. To assess whether CoRL influences individuals' ability to self-regulate their learning, Hadwin, Wozney, and Pontin (2005) investigated how scaffolding unfolds naturally between teachers and graduate students during instances of dialogue over students' research portfolios. Ten graduate students and three instructors were observed during two 20 to 60-minute student-teacher conferences during a year-long course where students were required to create a research portfolio. Qualitative discourse analysis revealed that there were observable changes in responsibility and ownership over learning from teacher to student over the course of a year. They interpreted that teachers directly regulated student learning through instances of explicit teacher-led regulation (i.e., telling students what to do next), and indirectly regulated student learning more subtly (i.e., through prompts and questioning). Students gradually took increased ownership over their regulation over time and this increase was mediated by indirect teacher and student regulation.

In another study, Iiskala et al. (2011) sought to assess whether instances of CoRL could be reliably assessed while eight fourth-grade children worked in groups of two on a complex mathematics problem. They argued that CoRL is best assessed during episodes of collaborative work and can be reliably identified by observers via discourse analysis. The researchers found that problem difficulty was shown to increase episodes – in instances and duration – of CoRL. That is, the more difficult the problem, the more episodes of CoRL occurred. Episodes were identified by increases in instances of function (e.g., facilitation or inhibition) and focus (e.g., situational model, operation, or incidental matter). CoRL also contributed to increased instances of metacognition and to the facilitation of problem solving. Lastly, metacognitive experiences (i.e., a feeling, a judgement or task-specific knowledge related to the assignment) were found to precede instances of CoRL. For example, instances of CoRL were preceded by remarks that related to an emotion regarding the task (e.g., confusion), a judgment regarding the ease or difficulty of the task (e.g., challenging

procedure), and/or similarity to previous problems presented (e.g., familiarity or resemblance).

Finally, Lee, Lajoie, Poitras, Nkangu, and Doleck (2016) investigated the way in which CoRL supports the collaborative construction of knowledge in the context of an on-line problem-based learning activity with four medical students. Using Iskala et al.'s (2011) amalgamated conceptualization of the function (Iskala et al., 2011) and focus (Cummins, Kintsch, Reusser & Weimer, 1988; van Dijk & Kintsch, 1983) of CoRL, the researchers coded discourse for the function of co-regulatory processes that facilitates or inhibits the collaborative process, along with the corresponding focus of the function (i.e., whether the situation model, the operation, or an incidental matter was the focus of the CoRL function). They found a strong relationship between instances of CoRL and metacognitive statements and episodes of overt inquiry or questioning. This research suggests that co-regulatory episodes foster individual metacognitive processes, aid group members, and facilitate monitoring of progression of the cooperative learning process. Taken together, research has shown important links between emotions and learning processes, but has not simultaneously taken into consideration antecedents and consequences of both individual and social emotions during collaborative learning. This research addresses this empirical gap in the literature.

The Current Study

Complex problem solving has the capacity to stimulate and evoke emotion. That is, the ill-structured nature of complex problems set the stage for a myriad of emotions to take place during learning (i.e., confusion, frustration, joy, boredom, anxiety) (Muis et al., 2015). Additionally, difficult problems produce more instances of CoRL (Iiskala et al., 2011). Complex problem solving within a collaborative setting also affords additional challenges in that the affective dynamics between group members can serve to bring about or inhibit motivation for learning (Järvelä, Lehtinen, & Salonen, 2000; Jones & Isroff, 2005; Kreijns,

Kirchner, & Jochems, 2003). Negative emotions (i.e., frustration and anger) experienced within the collaborative context may hinder effective collaborative communication and learning processes at the self- and co-regulatory level, progression towards task completion, or result in off-task behaviour among members of the collaborative group. These negative social emotions may then influence the kinds and quantity of co-regulatory processes amongst group members, thus resulting in lower performance and achievement on the learning task. Conversely, feeling supported by group members, a sense of capability with regard to the task, and that opinions and beliefs are of value may result in the experience of positive emotions, such as enjoyment, pride, and hope. These positive social emotions may facilitate the use of effective learning processes at the co-regulatory level and increase achievement on the learning task. As a result, it is essential that researchers investigate the antecedents and consequences of social emotions experienced in the collaborative learning environment.

As such, the purpose of this research was to explore the role of social emotions and co-regulation of learning within a collaborative learning context with elementary age students as they solved a complex mathematics problem. Emotional regulation during middle childhood matures as children continue to refine, and increasingly become more independent in their emotion coping strategies (Denham, 2007). Compared with preschool age children who are less independent in their ability to emotionally regulate (i.e., they tend to seek the external support in order to help regulate their emotions), older children are more independent, and self-sufficient in their emotional regulation abilities. Additionally, as children mature, they are better able to identify experiences of more complex emotions, such as embarrassment and pride (Griffin, 1995), and are better able to discriminate expressions of, in particular, social emotions (Olthof, Ferguson & Luiten, 1989). As well, students of the preadolescence years have the cognitive ability to better problem solve possible coping

strategies that affect emotional regulation (Saarni, 1999). Therefore, considering the increased independence, and influence of cognitive maturity on emotion regulation, and the more attuned ability to decipher and report specific emotions, upper elementary students (e.g., fifth graders) are a unique population with sufficient maturity in emotional regulation who have the potential to offer a more reliable depiction of the effects of social emotions on CoRL.

This study is grounded in Pekrun's (2006) control-value of achievement emotions, and modelled after Muis et al.'s (2015) study on the relationship between perceptions of control and value, emotions, and self-regulatory, cognitive and metacognitive strategies, and achievement. I explored whether control, value, and basic needs satisfaction served as antecedents to the social emotions students experienced, and whether emotions predicted the use of co-regulatory strategies during collaborative problem solving. Specifically, I examined whether social emotions predicted the functioning (i.e., the facilitation of action in order to build a shared representation of the learning task, or the inhibition of action in order to halt inappropriate conceptualizations of the problem (Iiskala et al., 2011)) and phases of co-regulatory learning: planning and goal setting, enactment of learning strategies, and evaluation and monitoring of the plan, strategies. Subsequently, I investigated whether these CoRL processes related to performance on the task. I also explored whether emotions mediated relations between the antecedents (i.e., control, value and three dimensions of basic needs satisfaction) and CoRL. Twenty-nine fifth grade students were grouped into collaborative teams comprised of two to four members of mixed ability, but gender consistent. Groups were given a complex mathematics problem to solve over a single 75-minute math period.

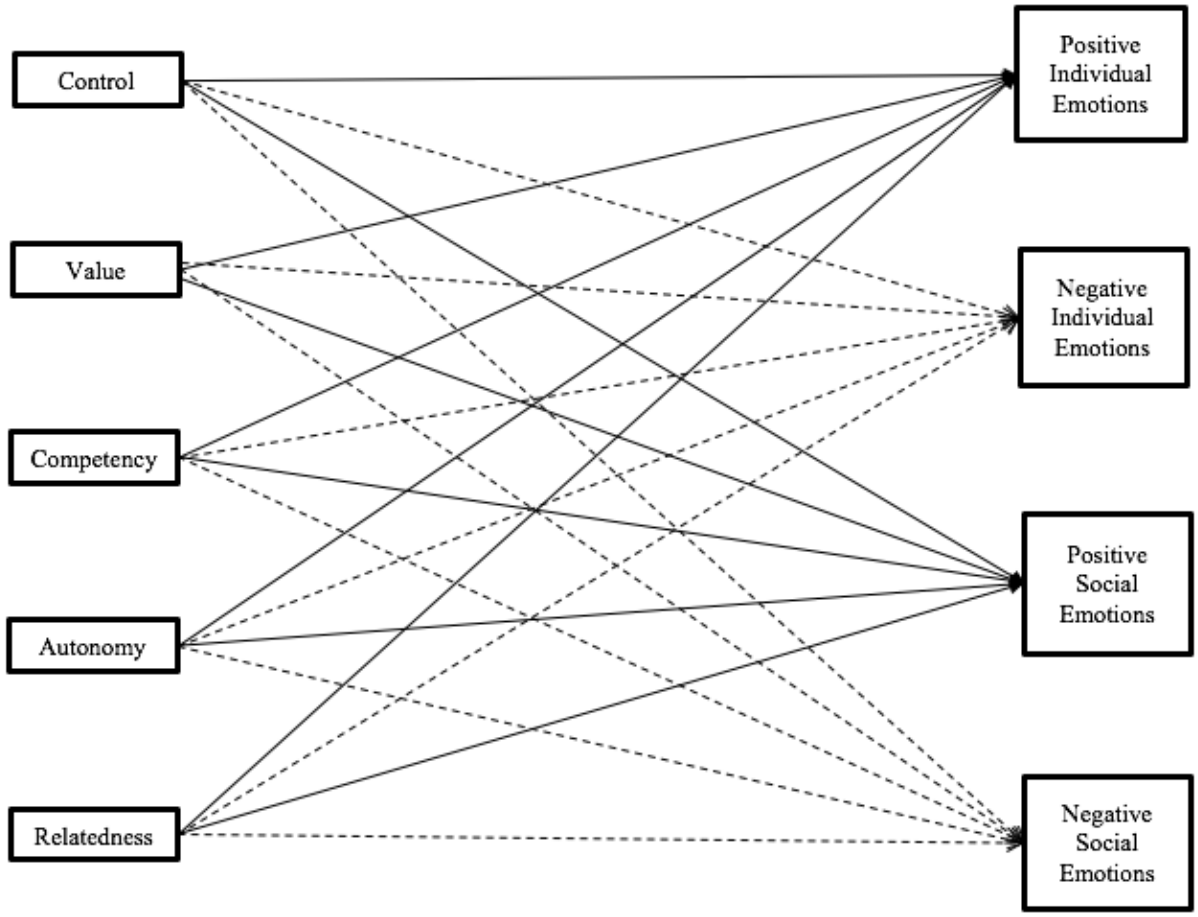
The following research questions were addressed: (1) Are students' perceptions of control, value and basic needs antecedents to the individual and social emotions they

experience within the collaborative context? (2) What are the relations between social emotions and learning processes across the two functions and four phases of regulation of learning during complex mathematics problem solving in a collaborative context? (3) Do learning processes experienced within the collaborative setting predict achievement in mathematics problem solving? (4) Do emotions mediate the relationship between perceptions of control, value and basic psychological needs, and CoRL learning processes?

Based on theoretical and empirical considerations (Muis et al., 2015; Pekrun, 2006), I hypothesize the following hypotheses, with each hypothesis presented in conjunction with a figure (see below).

Figure 1

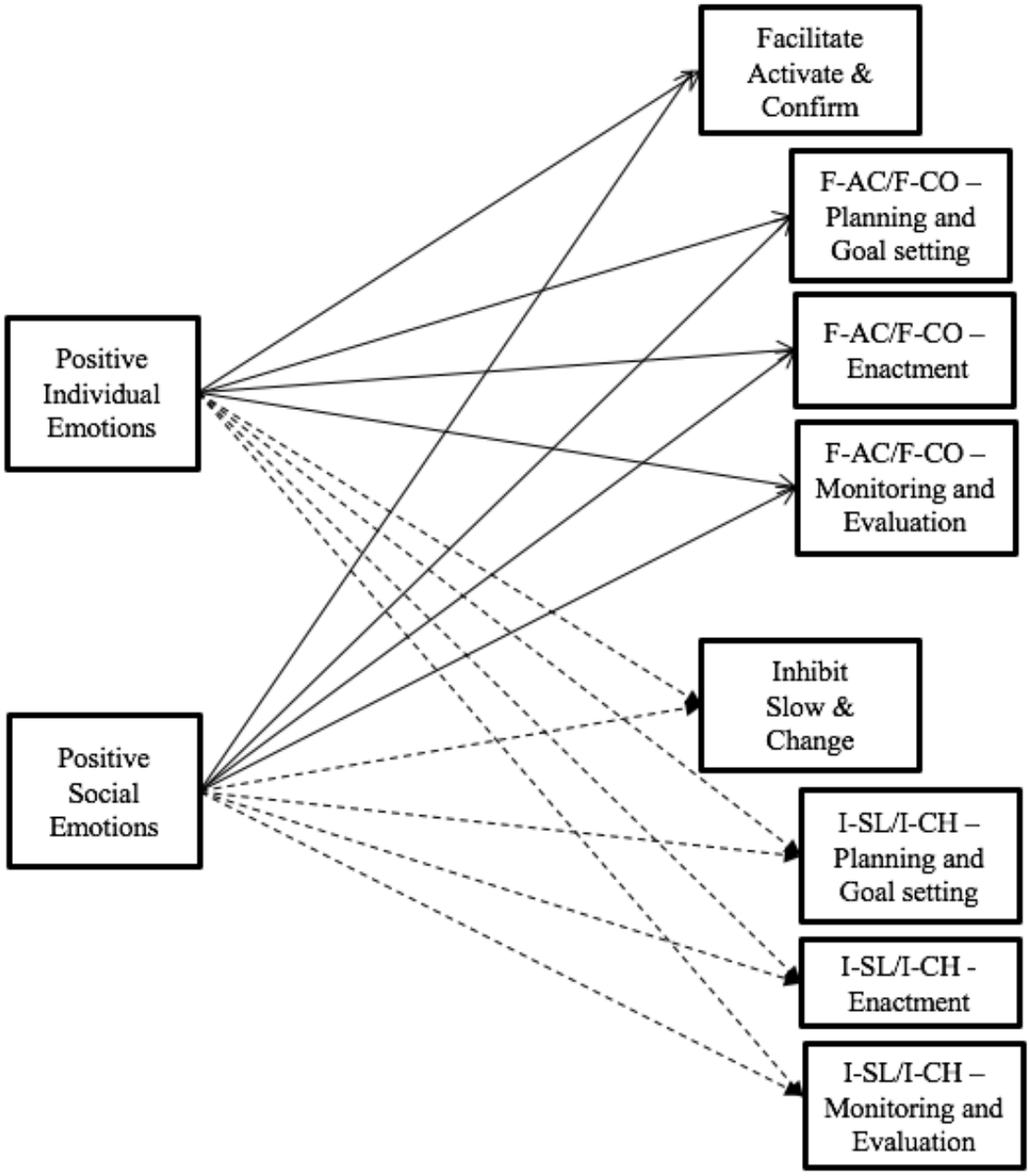
Hypothesized model for H1



(1) Higher perceptions of control, value, and the three dimensions of basic psychological needs (i.e., competence, autonomy, and relatedness) will positively predict students' positive individual emotions and positive social emotions (as represented by the solid lines), and will negatively predict negative individual and negative social emotions (as represented by the dashed lines).

Figure 2

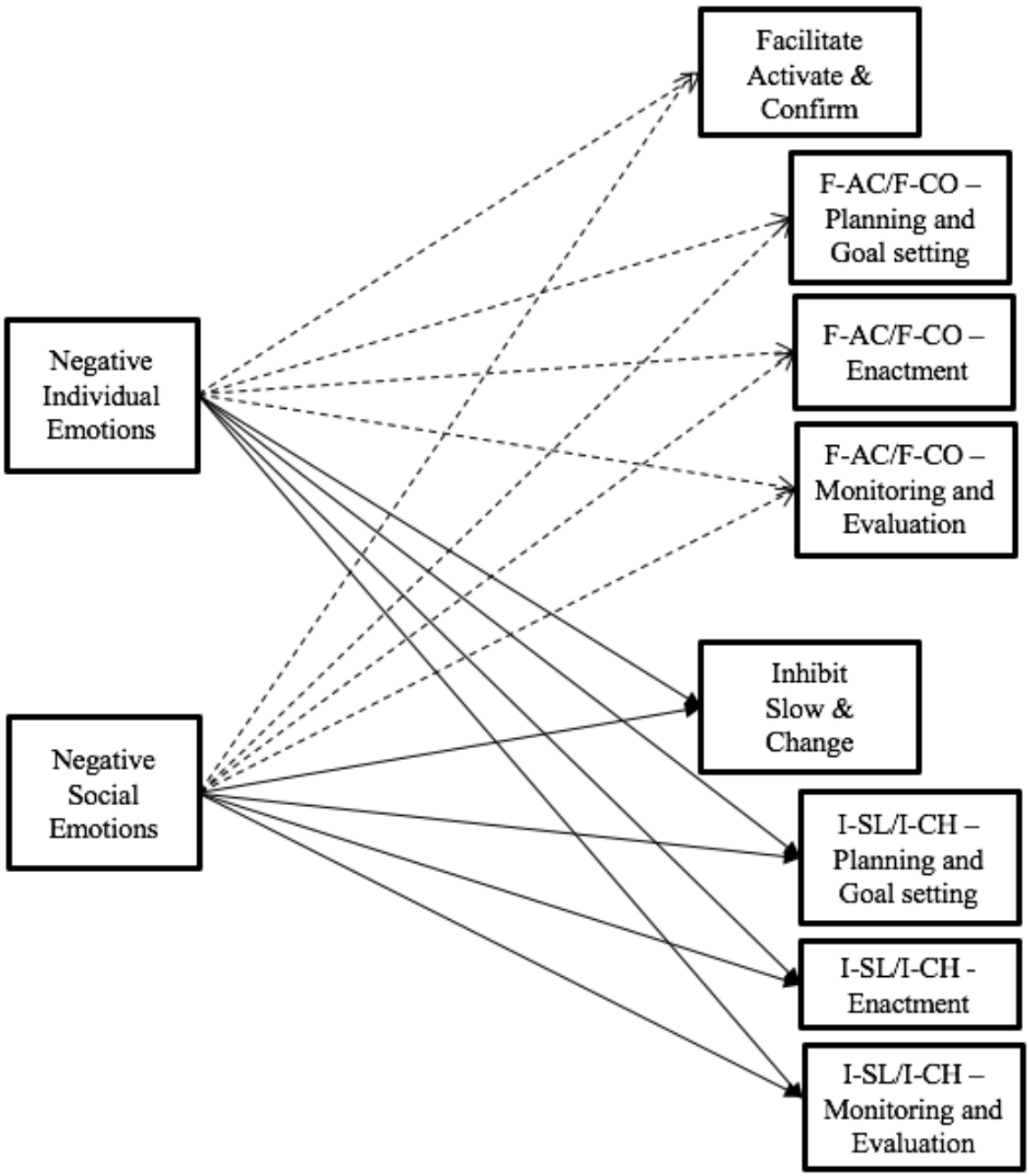
Hypothesized model for H2 – prediction of positive emotions



(2) Positive social emotions will positively predict planning and goal setting, effective strategy use, and metacognitive processes during the facilitative co-regulatory functions (i.e., activate and confirm) (as represented by the solid lines), but negatively predict inhibitory co-regulatory functions (i.e., slow and change) (as represented by the dashed lines).

Figure 3

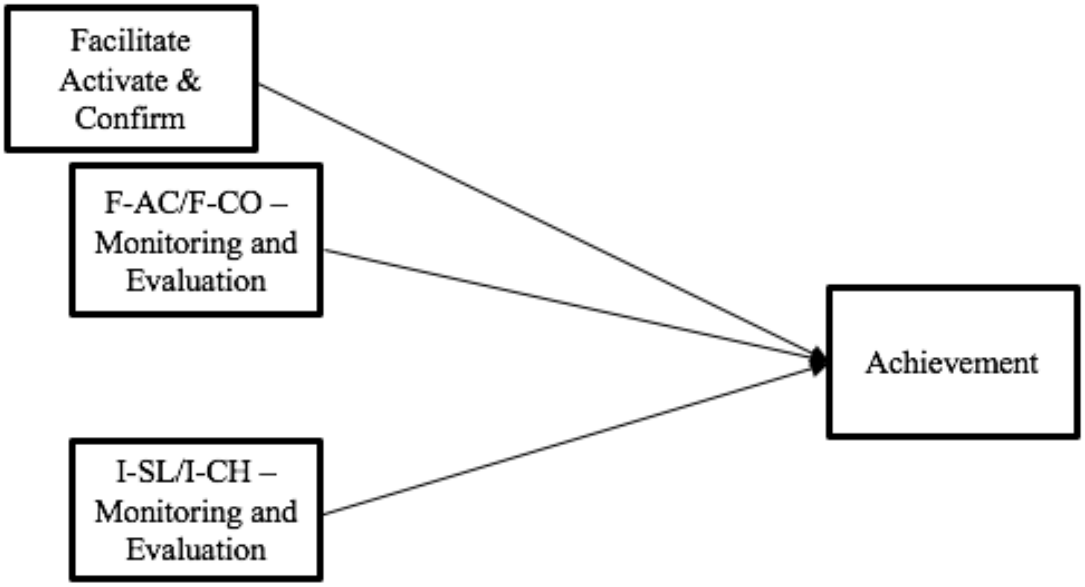
Hypothesized model for H2 – prediction of negative emotions



(3) Negative social emotions will negatively predict planning and goal setting, effective strategy use, and metacognitive processes during the facilitative co-regulatory functions (i.e., activate and confirm) (as represented by the dashed lines) but positively predict inhibitory co-regulatory functions (i.e., slow and change) (as represented by the solid lines).

Figure 4

Hypothesized model for H3



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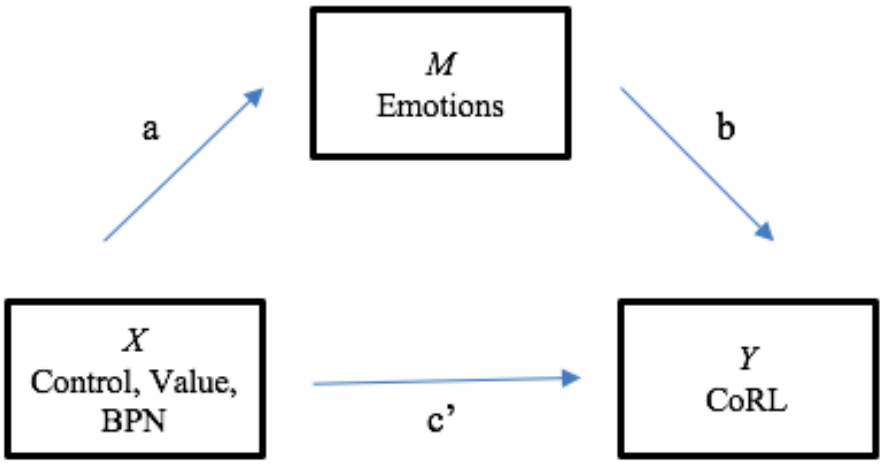
(4) Deep processing and metacognitive strategy use along with higher instances of facilitative co-regulatory functions will positively predict higher achievement in the problem solving task.

Figure 5

Hypothesized mediation



(5) Social and individual emotions will mediate the relationship between perceptions of control, value, and basic psychological needs satisfaction, and CoRL processes.

CHAPTER 3

Methodology

Participants

Thirty-one fifth grade students from an elementary school in the Montreal area (n = 17 girls) in a single classroom were invited to participate in this study. One of the students was on an individualized education program and followed a separate math program and was not able to participate in the study. A second student was absent on the day of the data collection. Consequently, twenty-nine fifth grade students (n = 17 girls) participated. The mean age of the sample was 11.38 years (SD = .45). Parental consent and student assent were attained prior to the study.

Materials

Prior knowledge. Students' mathematics grade on their most recent report card served as a measure of students' prior knowledge. Grades were based on complex situational problems, formal exams, teacher observation, project-based activities, mathematics homework, in-class worksheets, and mathematics warm-up activities. Considering the breadth and variety of assessment used to calculate students' math grades, reported mathematics grades served as a reliable estimate of prior mathematics knowledge.

Global emotions regarding mathematics. The Achievement Emotions Questionnaire – Elementary Version (AEQ) (Pekrun, Lichtenfeld, Killi, & Reiss, 2007) was used as a baseline measure to assess students' global emotions regarding mathematics. This questionnaire measures the degree of boredom, enjoyment, and anxiety that students experience during math homework (eight items, e.g., "*When I do math homework, I worry that I will ever understand it*"), completing a math exam (eight items, e.g., "*I get very nervous during math tests*"), and during math class (twelve items, e.g., "*I look forward to math class*"). Previous research has established the validity and reliability of the AEQ

(Pekrun, Goetz, Frenzel, Barchfeld & Perry, 2011). Reliability ratings for the scale ranged between fair and excellent given the small sample size for this study. Cronbach's alpha reliability estimates ranged from .65 to .93. (See Appendix A).

Academic control. Students' perceived control for learning mathematics content and engaging in the problem-solving activity was measured using Perry, Hladkyj, Pekrun, and Pelletier's (2001) Academic Control Scale, modified for elementary school students by Muis et al. (2015). The Academic Control Scale is an 8-item questionnaire that measures two dimensions of control (i.e., action and outcome) on a 5-point Likert scale ranging from "completely disagree" (rating of 1) to "completely agree" (rating of 5). Question examples include "*There is little I can do about my math grade*" and "*When I do poorly in math, it's usually because I haven't given it my best effort*". In line with previous research (see Muis et al., 2015; Muis, Pekrun, Sinatra, Azevedo, Trevors, Meier, & Heddy, 2015) all items were summed and averaged to obtain an overall control score. The greater the score, the greater the amount of perceived control for learning mathematics content. Cronbach's alpha reliability estimate was .66. Considering that this study was a replication of the study design by Muis et al. (2015), measures were kept the same despite a low reliability rating on this scale (See Appendix B).

Task value. Students' task value for learning and problem solving in mathematics was measured using Pekrun and Meier's (2011) Task Value Measure, which was adapted from a similar measure created by Eccles, Wigfield, Harold, & Blumenfeld (1993). The task value measure is a 7-item questionnaire that measures three dimensions of perceptions regarding mathematics learning (i.e., interest, utility, and importance) along a 5-point Likert scale ranging from "not at all true of me" (rating of 1) to "very true of me" (rating of 5). Question examples include "*In general, learning about math is useful*" (utility), "*In general, I find learning about math very interesting*" (interest), and "*I feel that, to me, learning more*

about math is very important" (importance). All seven questionnaire items were summed and averaged to obtain a global value score for each student, with higher scores representing greater the perceived task value. Previous research using the task value scale has summed and averaged all scale items (see Muis et al., 2015) since it has been established that younger students do not necessarily differentiate between the three types of value (i.e., interest, utility, and importance) (see Wigfield, 1994). Cronbach's alpha reliability estimate was .87. (See Appendix C).

Activity emotions. The Epistemically-Related Emotions Scale (EES) (Pekrun, Vogl, Muis & Sinatra, 2016), modified for elementary students (see Muis et al., 2015) was used to measure the emotions students experienced during the problem solving session (i.e., surprise, curiosity, joy, confusion, anxiety, frustration, boredom). The EES is a single-item adjective questionnaire (e.g., "curious") that includes a 5-point Likert scale wherein participants are instructed to indicate the extent to which they experienced each of the emotions. Response options ranged from "Not at all" (a rating of 1) to "Very strong" (a rating of 5). Social emotions were also added to the EES (i.e., embarrassment, guilt, shame, envy, jealousy, empathy and pride). Because both activity emotions and more traditional social emotions could be experienced during problem solving, students were also asked to indicate the object focus of the emotion (i.e., whether the emotion was directed at themselves, members of their group, or both) (see Appendix D).

Basic needs satisfaction. To assess the degree to which participants' needs were met in the group context, an adaptation of La Guardia, Ryan, Couchman, and Deci's (2000) Basic Psychological Needs Scale – Relationship Domain (BPNS-R) was administered subsequent to the problem solving activity. The BPNS-R assesses an individual's needs related to the group experience along three dimensions: the degree to which an individual felt a sense belonging, relatedness, and perceived competency within the group. This particular

questionnaire was adapted to reflect language and vocabulary appropriateness given the age of the participants, and to make it specific to the learning task. The BPNS-R is measured along a 7-point Likert scale ranging from "not at all true" (rating of 1) to "very true" (rating of 7). Examples include, "*When I was solving the math problems with my group, I felt like I could be myself*" (autonomy), "*When I was solving the math problems with my group, I often felt like I didn't know how to do the work or can't do the work*" (competence), and *"When I was solving the math problems with my group, I felt a lot of closeness and kindness"* (relatedness). Previous research has established the validity and reliability of the BPNS (Vlachopoulos & Michailidou, 2006). Cronbach's alpha reliability estimate was .62 for autonomy, .58 for competence and .72 for relatedness, with an overall scale reliability of .79. (see Appendix E).

Complex problem. The complex problem, *The Dragon's Desserts,* required the students to collaboratively calculate the bill totals of four families' orders at an ice cream store. Each family member's order was described and, using a price list, students were required to tally each individual's order, and subsequently each family's total bill. A 15% tax rate was also calculated where students were required to convert percentages to decimals and calculate the tax rate accordingly for each bill total. Lastly, an end of the day cash-out was required so as to provide the total sales for the day, before and after taxes (see Appendix F).

The complexity of the problem stems from the fact that there was no clear pathway to a solution. Students had to rely on previously learned concepts and apply various strategies to solve the problem. Complex mathematics problem solving was a staple of the current classroom curriculum, therefore, the students in this study had previous experience working through similar problems to the one presented for the purposes of this study. The classroom teacher and primary investigator worked collaboratively to develop the complex problem to ensure that the mathematical concepts needed to solve the problem had been previously

reviewed in class. Additionally, the complex problem was reviewed for level of difficulty to ensure that the problem would be challenging, but achievable. A rubric was developed to assess the achievement score on the task (see Appendix G).

Procedure

Prior to the study, parental consent and participant assent were collected, along with basic student demographic information (i.e., age, sex, first language spoken). The study was conducted over a period of two sessions. In the first session, students responded to questionnaires used to measure their global emotions about mathematics (*AEQ*), academic control for learning mathematics (*Academic Control Scale*), and their task value for mathematics (*Task Value Measure*). This portion of the study took approximately 20 minutes. During the same session, students also received thinking-aloud training where the primary investigator modelled examples of how to think out loud. Specifically, I explained to students that I want them to verbalize everything that they would normally say to group members while solving the problem, just like they would normally solve a problem as a group. I also advised students that if they were silent for too long then I would prompt them to keep talking out loud. Subsequently, in groups of three, students were asked to solve a simple mathematics problem (i.e., *Kim can walk 3 kilometers in one hour, how many kilometers can Kim walk in 2.5 hours?*) while being audio recorded using the Simple Recorder application to practice verbalizing and externalizing their thought-processes. The practice session also lasted approximately 20 minutes.

In the second session, which occurred on a separate day from session one, the class was divided up into groups of two, three or four students. Groups were comprised of students of the same gender for control purposes, but of mixed ability. Student ability was determined by the classroom teacher (based on students' achievement to date) and, as such, the classroom teacher was also responsible for devising the groups so that ability was varied. Groups were

then given one iPad per group (for audio-recording purposes) as well as the complex mathematics problem, *The Dragon's Desserts*, to solve collaboratively. Students were told that the activity was comparable to, and should be considered with the same importance as, any other mathematics activity that they do during their mathematics class. Students were instructed to place their group's iPad face-up in the middle of their table and press the "record" button once they were ready to begin. During this time CoRL was measured during task engagement via audio-recording.

Students worked on the problem for the entire duration of their 75-minute mathematics class, and all groups completed the problem within that timeframe. To ensure that students were continuously thinking aloud, the primary investigator along with one research assistant and the classroom teacher prompted groups if they were silent for more than 10 seconds. Once students completed the problem, they were asked to individually complete the EES, and the Basic Psychological Needs Satisfaction in Relationships Scale (BPNS–R). Upon completion of the study, the class was given a $100 cash gift.

Coding and Scoring

Co-regulatory processes. A Type 1, concurrent, think aloud protocol was used (i.e., thinking out loud while completing a task; see Ericsson and Simon, 1998; Kuusela, & Pallab, 2000) to capture students' co-regulatory processes as they collaboratively solved the complex mathematics problem. A concurrent protocol, as opposed to a retrospective (or Type 2) protocol, was used to capture the in-the-moment, real-time regulatory processes of the group as they were engaged in the problem solving activity. Each group was given an Apple iPad and asked to record their problem solving session using the Simple Recorder application. Students were instructed to converse aloud, explaining their thought processes, calculations and any suppositions. Considering that a concurrent Type 1 think-aloud protocol allows for fluidity of thoughts or achievement without constrain or interruption, this protocol offers an

accurate evaluation of students' co-regulatory processes as they occur during problem solving when compared to self-report questionnaires that are reflective in nature (see Winne, Jamieson-Noel, & Muis, 2002). Think alouds were then transcribed verbatim by two research assistants and the primary investigator. The transcribed think alouds ranged in time from 25 minutes and 2 seconds to 55 minutes and 47 seconds, and generated 316 double-spaced pages of transcriptions (38 885 words).

An amalgamation of Iiskala et al.'s (2011) think aloud coding scheme for identifying the function (i.e., facilitative or inhibitory) of episodes of CoRL was used, along with Muis et al.'s (2015) coding scheme for identifying the phase during which the functional CoRL episodes took place. Muis' (2007) theoretical model of self-regulated learning was used as a framework for coding the transcriptions along four macro-level dimensions of SRL: task definition (e.g., *recognizing critical information*), planning and goal setting (e.g., *making a plan*), enactment (e.g., *summarizing or rereading*), and monitoring/evaluation (e.g., *questioning oneself*). Instances of co-regulated learning were organized within the same dimensions as outlined above, but were evident through cooperative instances that represent evolving interactions between group members, the adjustment of support for peers for self-regulatory purposes, mediation techniques that guide or support self-regulation or the group process, and encouraging and prompting group members to self-regulate their learning (Hadwin et al., 2011). The primary investigator spent eight weeks examining the transcripts to identify instances of CoRL episodes, which were then categorized into sixteen function-phase processes: facilitation-activate (during task definition, planning and goal setting, enactment, and monitoring and evaluation), facilitation-confirm (during task definition, planning and goal setting, enactment, and monitoring and evaluation), inhibit-slow (during task definition, planning and goal setting, enactment, and monitoring and evaluation), and inhibit-change (during task definition, planning and goal setting, enactment, and monitoring

and evaluation). See Table 1 below for the coding scheme and associated examples.

Table 1

Function and phases of CoRL: Definitions, codes, and examples

Function (phase)	Definition	Code	Example
Facilitate	The direction of the activity continues the same as previously and strengthens during the episode.	F	
Activate	Activating a new construct in line with previous direction.	AC	
Task Definition	The group generates a perception about the task, context, and the group in relation to the task. External and internal conditions play a major role.	F-AC-TD	S1: "So, first we have to figure out what 15% is." S2: "15% for taxes is like every dollar you have…" S1: "You add fifteen cents." S3: "…You add 15 cents." S1: "Oh."
Planning and Goal Setting	The group begins to devise a plan to solve the problem and sets goals.	F-AC-PGS	S1: "So how about we add, what was the answer for that …" S2: "That if we add them all up its $11.90." S1: "Then we have to get the percentage for that." S2: "For that whichhhh…" S1: "'Cause then we have to add 15% of $11.90." S2: "So, what we do is 11 point 90 divided by 15."
Enactment	Enactment occurs when the group begins to work on the task by applying tactics or strategies chosen for the task.	F-AC-EN	S1: "So the first order is one kiddie scoop in a regular cone, with sprinkles." S2: "Okay so kiddie scoop." S1 & S2: "Okay, so…" S1 & S2 & S3: "$1.25" S1: "Regular cone…" S2: "Zero point 45. Umm yes is…" S1: "With whipped cream!" S2: "So, zero." S3 (interrupted): "…not with

			whipped cream, with sprinkles." S2: "35."
Monitoring and Evaluation	Various types of reactions and reflections are carried out to evaluate the successes or failures of each phase or products created for the task, or perceptions about the self or context. Reaction and reflection also includes judgments and evaluations of performance on a task as well as the attributions for success or failure.	F-AC-MEV	S1: "Okay so now we do…" S2: "Do we continue? I don't think we have to continue." S1: "So we just have to add on sixty-five cents…." S3: "Ya." S1: "…So nine dollars and eighty cents plus sixty-five." (writing) "…Ten dollars and forty-five cents."
Confirm	Confirming that the previous direction is correct.	CO	
Task Definition	The group confirms the generated perception about the task, context, and the group in relation to the task. External and internal conditions play a major role.	F-CO-TD	S1: "What's 15% off?" S2: "15% off?" S1: "15% off of 11.90" S2: "15% off… 15 cents off?" S1: "No, 15%". S2: "Oh, 15%!"
Planning and Goal Setting	The group confirms the plan to solve the problem and sets goals.	F-CO-PGS	S1: "I got one regular scoop in waffle… in waffle cone." S2: "Ya, you do one regular scoop in a waffle cone. S3, you do one kiddie scoop in a regular cone. Okay? Kiddie scoop, regular cone, okay you got it? …S3, do one kiddie scoop in a regular cone." S1: "One regular scoop in a waffle cone is what I've got,

			okay?" S2: "One regular scoop in a waffle cone is what you have, good! I have two regular scoops in a cup with sprinkles."
Enactment	Tactics or strategies chosen for the task are confirmed by group members.	F-CO-EN	S1: "So in the cup…" S1 & S2: "…with sprinkles, in the cup." S3: "So that's a cup times 2." S1: "Yes." S3: "Or 1 cup. So that's … zero… one point thirty... in a cup…" S2: "Zero point three five." S3: "Zero point three five for the sprinkles." S2: "Ya! For the sprinkles."
Monitoring and Evaluation	Various types of reactions and reflections are confirmed by group members to evaluate the successes or failures of each phase or products created for the task, or perceptions about the self or context. Reaction and reflection also includes judgments and evaluations of performance on a task as well as the attributions for success or failure.	F-CO-MEV	S1: "How's it 145?" S2: "It's 15." S3: "It's 15 times 9..." S2: "So 120..." S3: "5 times 9 is 45, 9 times 1 is 9, times 4 is ..." S1: "Wouldn't it be, ummm, 135? 'Cause ..." S3: "We'll use that yes, sorry." S2: "So 9, then 135." S1: "Yes."
Inhibit	The direction of the previous activity is interrupted during the episode.	I	

Slow	Slowing down a continuation of the previous direction.	SL	
Task Definition	The group slows the generated perception about the task, context, and the group in relation to the task. External and internal conditions play a major role.	I-SL-TD	S1: "Wait what do they mean 'costs'? What's the 'subtotal'?" S2: "'Subtotal' is the total before the tax." S1: "Okay so then what's costs?!" S2: "Its costs."
Planning and Goal Setting	The group slows act of devising a plan to solve the problem and sets goals.	I-SL-PGS	S1: "Wait. Wait, wait, wait… we should write the goal." S2: "You guys, guys… write the goal at the bottom." S3: "Goal is to…" S1: "Find out how much money we've earned at the end of the day."
Enactment	Carrying out of tactics or strategies chosen for the task are slowed by group members.	I-SL-EN	S1: "Wait so let's do…" S2: "…wait, wait, wait, wait! 15…" S1: "…let's do 30% then." S2: "15…" S3: "S1, let's do…! S1, come on you're rushing ahead of the group! S1 we're a group here you're not by yourself. S1, you're not by yourself!" S2: "No you're not by yourself!" S1: "So 15 times 11.90."
Monitoring and Evaluation	Various types of reactions and reflections are slowed down by group members to evaluate the successes or failures of each phase or products created for the task, or perceptions about the self or context. Reaction and	I-SL-MEV	S1: "Okay, hold on, I didn't write this like properly." S2: "Okay sure." S3: "Are you done?" S1: "Ok…Sorry." S3: "No its okay, it's fine."

	reflection also includes judgments and evaluations of performance on a task as well as the attributions for success or failure.		
Change	Changing the direction of previous activity.	CH	
Task Definition	The group changes the generated perception about the task, context, and the group in relation to the task. External and internal conditions play a major role.	I-CH-TD	S1: "So now we have to add the 15…" S2: "Percent." S3: "So we do a divided by. (inaudible)" S1: "Divide by what though? (laughing)" S3: "Divided by 15! Divide 11 point 90 by 15." S2: "No. No, not (inaudible)" S1: "Wait, to do percent we need a fractions…"
Planning and Goal Setting	The group changes the plan to solve the problem and sets goals.	I-CH-PGS	S1: "What did I miss? I say we all do it just to make sure." S2: "…1.20...No let's not all do it then otherwise it's a waste of time." S3: "Sprinkles, uh okay." S1: "Wait, so..." S2: "Brownstone (Branston) family…" S1: "You don't have to do that." S2: "I know but we might as well all do it in case we take them …" S1 (interrupts): "Ya but then we're wasting time 'cause we could do another part of it." S2: "Okay, true."

Enactment	Tactics or strategies chosen for the task are changed by group members.	I-CH-EN	S1: "So fifteen goes into a hundred and forty… so let's do it… fifteen times six…" (writing) S2: "Stop, we know that it's probably nine." S3: "Times nine, it's times nine, ya we said nine." S2: "Because we know…" S1: "You do nine, I'll do ten."
Monitoring and Evaluation	Various types of reactions and reflections are changed by group members to evaluate the successes or failures of each phase or products created for the task, or perceptions about the self or context. Reaction and reflection also includes judgments and evaluations of performance on a task as well as the attributions for success or failure.	I-CH-MEV	S1: "Wait, S2, can you double check this fast?" S2: "Wait so that's… Eleven dollars and ninety cents plus nine dollars and eighty cents". S1: "No it's (inaudible). Eleven dollars… wait what are you doing?" S2: "No, I'm going down… I'm going… look. We're adding up totals..." S1: "No, add eleven dollars and ninety cents plus nine dollars and eighty cents plus seven dollars and…" S2: "No you have to add the total amounts." S1: "Ya, we do that next."

With the function-phase code established, the primary investigator then spent the next ten weeks coding nine of the ten transcripts. The tenth transcript, which was generated by the think aloud of a two-person group, was omitted since they received an abundance of external support which rendered their think aloud non-valid for the purposes of this research study, and ultimately inadmissible. The remaining nine transcripts contained the think alouds of nine separate groups totaling 27 students. Inter-rater reliability was achieved by comparing agreement ratings of one randomly selected, re-coded (blind) transcript which was completed by a research assistant. The research assistant was trained on the coding scheme prior to re-coding. Inter-rater agreement was 90% for the 49-page (4952 words) transcript.

Achievement scoring. To determine each group's achievement score on the mathematics problem, a rubric was developed by the primary investigator. Five criteria were assessed (i.e., evidence of mathematical concept use, evidence of mathematical reasoning, strategy use, percentage of mathematical errors, problem completion) on a 4-degree scale that ranged from 1 (low demonstration) to 4 (full demonstration). The total number of points possible was 20, with zero points given for no evidence of the criteria, to partial points awarded for some evidence of the criteria, to full points awarded for complete demonstration of the criteria. The primary investigator and a research assistant scored one group's solution together. Agreement was 100%. The primary investigator then scored the remaining solutions. The research assistant blindly re-scored two solutions to establish inter-rater agreement. Agreement was 93%, with the 7% discrepancy resolved through discussion. (see Appendix G).

CHAPTER 4

Results

Preliminary Analyses

A summary of the descriptive statistics is depicted in Table 2. Values of skewness and kurtosis were examined for normality prior to carrying out a full analysis, using Gravetter and Wallnau's (2014) limits +/-2 for skewness and kurtosis. Normality was not expected for CoRL frequencies and social emotions; normalization is not needed for the path analyses since the analyses were done on bootstrapped samples, which are not expected to be normal (Hayes & Preacher, 2013). Skewness results showed that achievement on the complex problem was within range (-.64). All antecedents were also within the normal range, but negatively skewed; control (-.56), value (-.85), along with the three dimensions of BPN, competence (-.60), autonomy (-.57), and relatedness (-.07). For the social emotions and EES scale, shame (5.39), jealousy (4.20), embarrassment (2.70), guilt (4.20), and envy (3.43), as expected, were all outside of the normal range. However, global negative social emotions (i.e., taken together, shame, jealousy, embarrassment, guilt, and envy) was just slightly above normal range (2.16). All other reported emotions were within normal skewness range; global positive social emotions (i.e., taken together, empathy and pride) was within normal skewness range (.81), as was separate skewness analysis of empathy (.89) and pride (-.72). Confusion (.67), hopelessness (1.27), surprise (.64), boredom (1.49), curiosity (-.01), frustration (2.08), enjoyment (-.54), and anxiety (.84) were also within the normal range. Global positive individual emotions (-.42) and global negative individual emotions (.78) were also acceptable. For the episodes of CoRL, all were within the normal range for skewness except for inhibition-change during the enactment phase of learning (2.62).

Table 2

Means and standard deviations for variables

Variables	Mean	Std. Deviation
Problem Achievement	72.17%	15.911
Value	3.4236	0.79744
Control	4.1767	0.51242
Competence	5.8103	1.0096
Autonomy	5.4655	1.3058
Relatedness	5.523	1.17996
Shame	1.03	0.186
Empathy	2.07	1.307
Hopelessness	1.48	0.829
Surprise	2.04	1.105
Jealous	1.1	0.409
Embarrassment	1.21	0.559
Guilt	1.1	0.409
Envy	1.14	0.441
Pride	3.59	1.476
Curiosity	2.9286	1.04274
Frustration	1.6379	0.98104
Anxiety	1.4713	0.55289
Enjoyment	3.4643	1.41375
Positive individual emotions	3.1964	1.16539
Negative individual emotions	1.8011	0.59692
Positive social emotions	2.8276	1.1747
Negative social emotions	1.0948	0.19381
Total episodes of CoRL	54.74	18.826
F-AC-TD	0.44	0.698
F-AC-PGS	8.26	3.008
F-AC-EN	10.63	7.276
F-AC-MEV	0.56	0.847
F-CO-TD	0.48	0.7
F-CO-PGS	2.15	1.35
F-CO-EN	1.96	2.066
F-CO-MEV	13.33	7.238
I-SL-TD	0.44	0.506
I-SL-PGS	1.3	1.137
I-SL-EN	5	3.076
I-SL-MEV	6.44	3.598
I-CH-TD	0.63	0.742
I-CH-PGS	0.96	1.315
I-CH-EN	0.22	0.641
I-CH-MEV	1.93	2.074

For measures of kurtosis, achievement on the complex problem was within range (.86). All antecedents were also within the normal range; control (-.28), value (1.05), and the three dimensions of BPN, competence (-.28), autonomy (-.69), and relatedness (-1.59). For the social emotions and EES scale, once again shame (29.00), jealousy (18.09), embarrassment (6.38), guilt (18.09), and envy (12.01), were all outside of the normal range for kurtosis. Global negative social emotions (i.e., taken together, shame, jealousy, embarrassment, guilt, and envy) were also above normal range (4.25), as was frustration (4.58). All other reported emotions were within normal range for kurtosis; global positive social emotions (i.e., taken together, empathy and pride) (-.70), as was separate analysis of empathy (-.32) and pride (-.79). Confusion (-.16), hopelessness (-.25), surprise (-.95), boredom (1.34), curiosity (-.95), enjoyment (-1.10), and anxiety (-.45) were also within the normal range. Global positive individual emotions (-.79) and global negative individual emotions (.-.08) were acceptable. Episodes of CoRL, all were within the normal range for kurtosis except for facilitation-confirm during the monitoring and evaluation phase (3.33), inhibition-slow during the task definition phase (-2.11), and inhibition-change during the enactment phase of learning (5.27).

Table 3

Correlations between problem achievement, antecedents, emotions, and CoRL functions and phases

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1. Problem achievement		-.03	-.03	.01	.05	.13	.02	.28	.12	-.07	-.39*	-.22	.04	-.15	-.10	.21	.10	-.26	.19	.02	.27	.82**	-.18	.33*	.15	.43*	.50**
2. Control			.42*	.11	.20	.36*	.27	.35*	-.45**	.17	-.04	-.34*	-.07	-.33*	-.24	.25	.32*	-.34*	.38*	-.16	.06	-.07	.01	.07	.02	-.08	-.12
3. Value				.13	.00	.08	.09	.25	.08	.13	-.10	-.39*	.01	.16	.21	.43*	.40*	-.10	.21	.14	-.31	-.21	-.20	-.42*	-.25	-.16	-.16
4. Competence					.50**	.42*	-.07	.36*	-.18	-.09	-.37*	-.14	-.52**	-.22	-.45**	.44**	.40*	-.53**	.19	-.09	.02	.11	-.03	.15	.02	.16	-.12
5. Autonomy						.51**	.03	.44**	-.16	.15	-.37*	-.15	-.51**	-.68**	-.65**	.52**	.55**	-.72**	.29	.04	.20	.22	-.13	.16	.07	.08	-.05
6. Related							.07	.47**	-.34*	-.26	-.26	-.54**	-.11	-.44**	-.50**	.53**	.58**	-.59**	.34*	-.32*	.40*	.43*	.13	.39*	.01	.18	.23
7. Empathy								.42*	-.21	.19	.20	-.16	.07	-.19	.02	.32*	.40*	-.05	.82**	.22	.32	-.28	.34*	.19	.41*	-.03	-.16
8. Pride									-.34*	.01	-.36*	-.42*	-.10	-.54**	-.41*	.75**	.78**	-.57**	.86**	-.23	.09	.11	.03	.06	-.02	.03	.06
9. Jealous										-.07	-.15	.49**	-.04	.45**	.41*	-.31	-.35*	.38*	-.33*	.66**	-.13	-.18	-.19	-.21	.01	-.15	-.11
10. Guilt											.06	.09	-.04	-.17	-.01	.04	-.03	-.02	.11	.43**	-.09	-.13	-.14	-.19	-.01	-.23	-.14
11. Hopeless												.08	.42*	.33*	.32*	-.34*	-.25	.65**	-.11	.04	-.04	-.21	.22	.06	.15	-.11	-.15
12. Bored													-.35*	.07	.02	-.60**	-.59**	.34*	-.35*	.33*	-.06	-.12	.02	.03	.26	.01	-.29
13. Confused														.52**	.53**	-.12	-.13	.64**	-.02	-.18	-.20	-.17	-.01	-.38*	-.39*	-.32	.15
14. Frustration															.84**	-.44**	-.48**	.82**	-.44**	.23	-.35*	-.42*	-.02	-.42*	-.22	-.27	-.27
15. Anxiety																-.28	-.31	.77**	-.25	.29	-.14	-.48**	.21	-.37*	-.03	-.16	-.21
16. Enjoyment																	.96**	-.60**	.65**	-.14	.09	.17	.02	.04	.00	.21	.06
17. Global positive individual emotions																		-.59**	.72**	-.15	.17	.09	.12	.10	.07	.13	.00
18. Global negative individual emotions																			-.39*	.21	-.26	-.41*	.09	-.34*	-.09	-.27	-.23
19. Global positive social emotions																				-.02	.24	-.09	.21	.14	.22	.00	-.05
20. Global positive social emotions																					-.08	-.26	-.20	-.09	.13	-.25	-.30
21. Total episodes of CoRL																						.31	.78**	.70**	.78**	.55**	.48**
22. F-AC-ME																							-.08	.54**	.14	.54**	.52**
23. F-CO-TD																								.44*	.72**	.44*	.16
24. F-CO-EN																									.73**	.45**	.28
25. F-CO-MEV																										.55**	.07
26. I-SL-PG																											.44*
27. I-SL-MEV																											

* Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

Correlational and Path Analyses

Zero order correlations for significant variables are reported in Table 3 (a zero order correlations for all variables are reported in Table 4, see Appendix H). Due to the small sample size, correlational analysis was performed using SPSS (v. 24) to assess relations between each of the variables to supplement the main analyses, path modeling. To model the antecedents and consequences of emotions during complex mathematics problem solving, Hayes and Preacher (2013) PROCESS SPSS macro (v 2.16) was used to test the mediation model presented in figure 5. The PROCESS macro, a computational procedure for SPSS, is recommended as it uses a path analysis framework that allows for more complex modelling appropriate for smaller sample sizes using a single command feature (Hayes & Preacher, 2013). A bootstrapping technique was used given the small sample size (n = 29) and associated low power to detect statistically significant paths in the model (Hayes & Preacher, 2013). The random resampling of the bootstrapping technique (i.e., 10 000 times) allows for an increase in the amount of power and enables for more precision in translating the estimates of the effects. However, important to note is that these analyses were carried out for illustrative purposes to assess plausible relations between variables. Due to low power, results must be interpreted with caution. Statistically significant standardized estimates are depicted in Fig. 6-9.

RQ 1. Do students' perceptions of control, value and basic needs predict the social emotions they experience within the collaborative context?

To answer the first research question as to whether students' perceptions of control, task value and basic psychological needs predict the kinds of social emotions students experience with the collaborative learning context, a correlation analysis was performed. Control positively significantly correlated to global individual positive emotions (r = .32, p < .05)., negatively correlated to global individual negative emotions (r = -.34, p < .05)., and

positively correlated to global positive social emotions ($r = .38$, $p < .05$). Control was also found to negatively relate to feelings of jealousy ($r = -.45$, $p < .01$), and boredom ($r = -.34$, $p < .05$). Additionally, value and positive individual emotions were significantly correlated ($r = .41$, $p < .05$). As well, value negatively associated with feelings of boredom ($r = -.39$, $p < .05$).

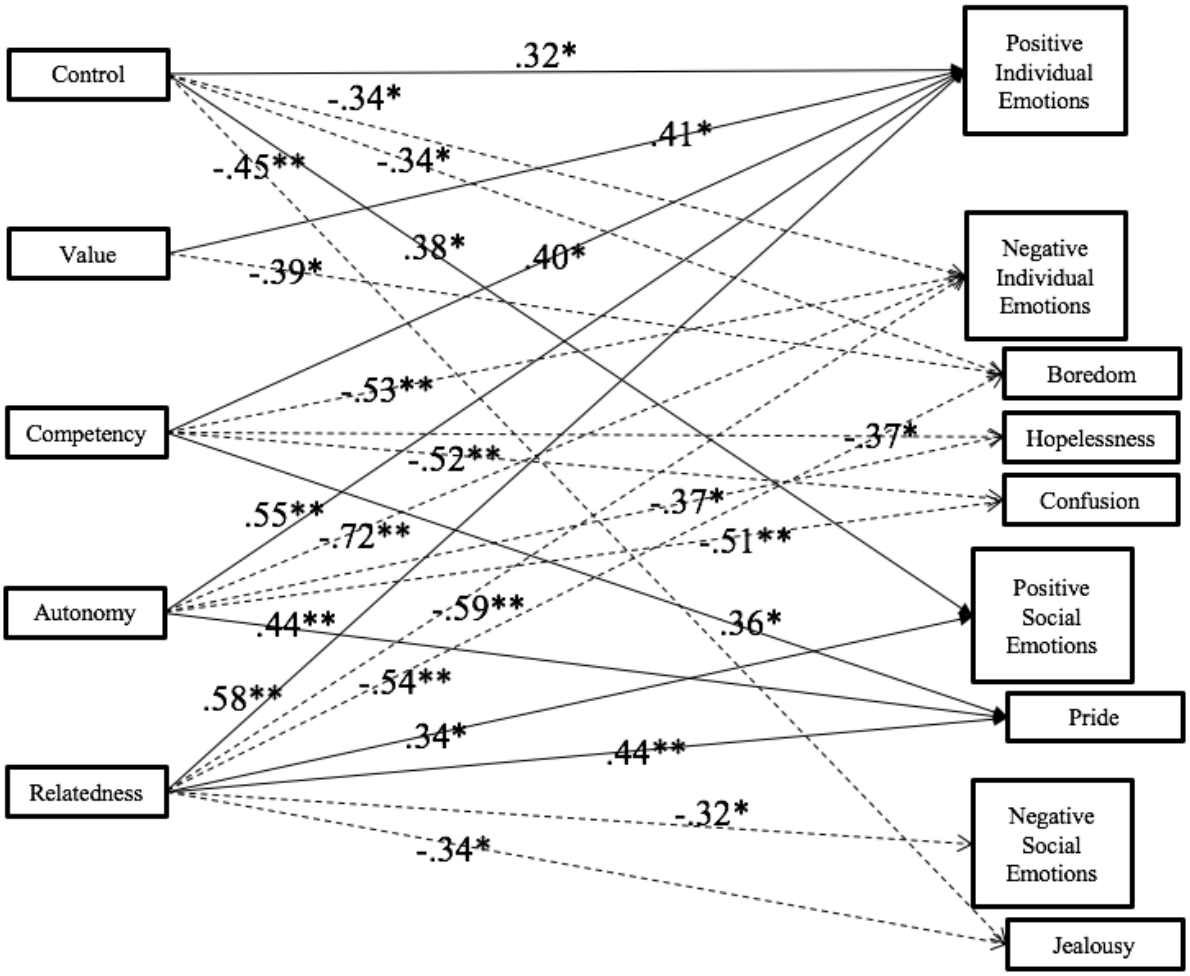
Reports of competency in the group positively correlated with global individual positive emotions ($r = .40$, $p < .05$) and negatively correlated with global individual negative emotions ($r = -.53$, $p < .01$). Additionally, competency and hopelessness were negatively correlated ($r = -.37$, $p < .05$), as were competency and confusion ($r = -.52$, $p < .01$). Competency did not correlate to global positive or negative social emotions, but significantly correlated with feelings of pride ($r = .36$, $p < .05$).

Similarly, reported reports of autonomy in the group positively correlated with global positive individual emotions ($r = .55$, $p < .01$) and negatively correlated with global negative individual emotions ($r = -.72$, $p < .01$). Reports of perceived autonomy and hopelessness were negatively correlated ($r = -.37$, $p < .05$), as were autonomy and confusion ($r = -.51$, $p < .01$). Autonomy, like competency, did not correlate to global positive or negative social emotions, but significantly correlated with feelings of pride ($r = .44$, $p < .01$).

Lastly, perceptions of relatedness within the group were positively correlated to both global positive individual ($r = .58$, $p < .01$) and social emotions ($r = .34$, $p < .05$), and negatively correlated to both global negative individual ($r = -.59$, $p < .01$) and social emotions ($r = -.32$, $p < .05$). Specifically, perceptions of relatedness positively correlated with pride ($r = .47$, $p < .01$), but were negatively related to both jealousy ($r = -.34$, $p < .05$), and boredom ($r = -.54$, $p < .01$).

Figure 6

Statistically significant standardized estimates for RQ1



RQ 2. What are the relations between social emotions and learning processes across the two functions and four phases of regulation of learning during complex mathematics problem solving in a collaborative context?

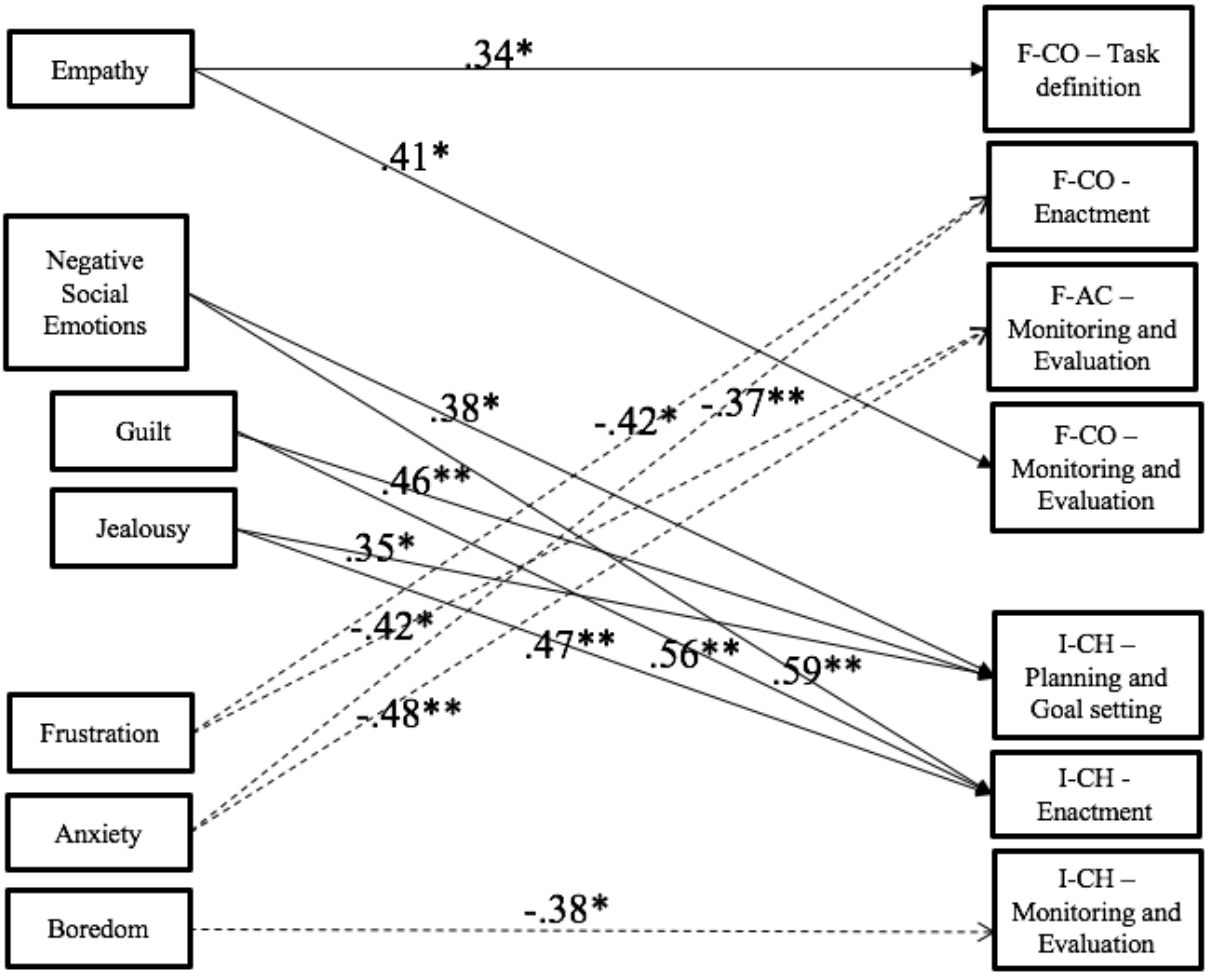
With regard to the second research question concerning the relationship between social emotions and specific learning processes, power was too low from the path analysis. As such, results from the correlational analysis are reported. Results revealed that overall global positive social emotions did not correlate to either of the CoRL functions across the four phases of learning regulation. However, at the micro-level, empathy positively correlated with the facilitative-confirmation function during the task definition (r = .34, p < .05)., and

monitoring and evaluation phase of learning ($r = .41$, $p < .05$). Global negative social emotions positively correlated with the inhibition-change function of CoRL during the planning and goal setting ($r = .38$, $p < .05$), and enactment ($r = .59$, $p < .01$) phases of learning regulation. Specifically, reported feelings of guilt positively correlated with the inhibition-change function of CoRL during the planning and goal setting ($r = .46$, $p < .01$), and enactment ($r = .56$, $p < .01$) phases, and jealously positively correlated with the inhibition-change function of CoRL during the planning and goal setting phase ($r = .35$, $p < .05$), and enactment phase ($r = .47$, $p < .01$).

Individual emotions reported in the social context revealed that both frustration and anxiety were negatively correlated with the facilitation-activation function during the monitoring and evaluation phase ($r = -.42$, $p < .05$, and $r = -.48$, $p < .01$, respectively) phase of learning regulation. Additionally, frustration and anxiety negatively correlated with the facilitation-confirmation function during the enactment phase ($r = -.42$, $p < .05$, and $r = -.37$, $p < .05$, respectively). Lastly, boredom negatively correlated with the inhibition-change function during the monitoring and evaluation phase ($r = -.38$, $p < .05$).

Figure 7

Statistically significant standardized estimates for RQ2



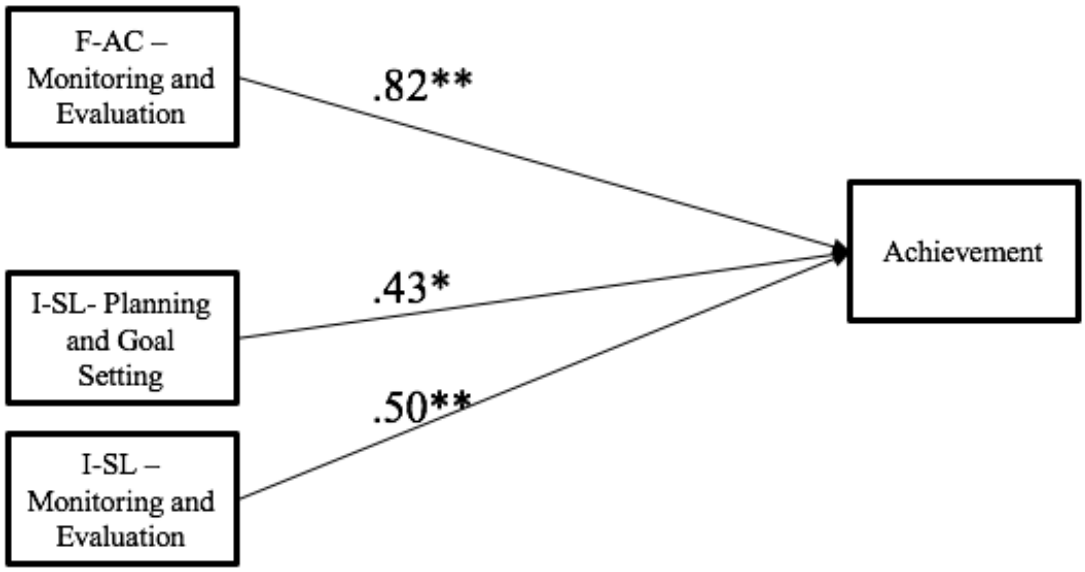
RQ 3. Do learning processes experienced within the collaborative setting correlate to achievement in mathematics problem solving?

In relation to the third research question as to whether learning processes facilitate achievement on the complex problem, power was too low for the path analysis. As such, correlational analysis found that the inhibition-slow function during the planning and goal setting phase was positively correlated with achievement ($r = .43$, $p < .05$) Additionally, facilitation-activation and inhibition-slow functions at the monitoring and evaluation phases were positively correlated with achievement on the complex problem ($r = .82$, $p < .01$, and r

= .50, $p < .01$, respectively).

Figure 8

Statistically significant standardized estimates for RQ3



RQ 4. Do social emotions mediate the relationship between task value, control, and BPN, and the functions of CoRL?

To investigate whether global individual positive emotions, global individual negative emotions and global social positive emotions (i.e., empathy and pride) and global social negative emotions (i.e., envy, jealousy, shame, embarrassment and guilt) mediated the relationship between control, value, and the three basic psychological needs (i.e., competence, autonomy, and relatedness) and the two functions of CoRL at all four phases of learning regulation, a mediation analysis (model 4) was conducted. Results indicated that emotions, specifically global individual positive emotions (B = 4.15, 90% CI = -10.71 to -2.73), global positive social emotions (B = 2.70, 90% CI = -.70 to -8.43), global negative individual emotions (B = 3.73, 90% CI = -3.68 – 8.35) and global negative social emotions (B = 1.63, 90% CI = -2.87 – 2.34) mediated the relationship between relatedness and CoRL. Specifically, relatedness was no longer a significant predictor of CoRL after controlling for

the mediators of positive and negative individual emotions and positive and negative social emotions, consistent with full mediation analysis.

Summary of results. In summary, for the first research question, results partially supported the hypothesis. Perceptions of control over the learning task were found to positively correlate with reported global positive individual emotions, global positive social emotions, and negatively correlate with global negative individual emotions, in particular boredom. Although control did not correlate with global negative social emotions, it was found to negatively correlate to feelings of jealousy. Value was found to positively relate to global positive individual emotions, and like control, negatively correlate to feelings of boredom. With regards to the three dimensions of basic psychological needs, reports of competency and autonomy both positively related to global positive individual emotions, and negatively correlated with global negative individual emotions, namely confusion and feelings of hopelessness. Perceptions of feeling related to within the group were found to be positively correlated to global positive individual and social emotions, and negatively correlated to global negative individual and social emotions, namely boredom and jealousy. Perceptions of relatedness was the only dimension to negatively correlate to global negative social emotions, and interestingly, all three dimensions (i.e. competency, autonomy, and relatedness) were found to be positively related to the social emotion, pride.

With regard to the second research question, results indicated that global positive individual emotions did not correlate to any of the functions of CoRL across all four phases of learning regulation. Conversely, global negative social emotions positively correlated with the inhibitory change function of CoRL during the planning and goal setting phases of learning regulation. Specifically, empathy, a positive social emotion, positively correlated with the facilitative-confirmation function during the monitoring and evaluation phase of learning. Guilt positively correlated with the inhibition-change function of CoRL during

planning and goal setting, and enactment. Jealously positively correlated with the inhibition-change function of CoRL during the enactment phase. Of the individual emotions reported, both frustration and anxiety were negatively correlated with the facilitation-activation function during the monitoring and evaluation phases of learning regulation. Frustration additionally negatively correlated with the facilitation-confirmation function during the enactment phase. And finally, boredom negatively correlated with the inhibition-change function during the monitoring and evaluation phase.

The third research question addressed if CoRL processes predicted achievement on the math problem solving activity. It was found that facilitation-activation and inhibition-slow functions at the monitoring and evaluation phases positively correlated with achievement on the complex problem. Additionally, the inhibition-slow function during the planning and goal setting phase was positively correlated with achievement. Lastly, results from the mediation analysis revealed that positive and negative individual, and positive and negative social emotions, mediated the relationship between feelings of relatedness and total instances of CoRL at the two functions and all four levels of learning regulation.

CHAPTER 5

Discussion

This study responded to calls for research made by Muis et. al (2015) to explore the role of social emotions and co-regulation of learning within a collaborative learning context during complex mathematics problem solving. The aim of the study was to investigate the antecedents of social emotions (i.e. control, value, and the three dimensions of basic psychological needs), and whether social emotions predicted the functions of CoRL across the two functions and four phases of learning regulation: planning and goal setting, enactment, and evaluation and monitoring. Consequently, I explored whether specific CoRL processes related to achievement on the complex problem. Lastly, I examined whether emotions mediated relations between the antecedents, and learning processes inherent in CoRL.

The study yielded some interesting and noteworthy results. The remainder of this chapter will focus on presenting an in-depth discussion of each of the results in relation to their respective research question. Theoretical and research implications in consideration of the results are offered. Subsequently, educational implications with regards to this research study's findings will be presented. To conclude, limitations of the present study are discussed, and directions for future research are explored.

Control, Value and Basic Psychological Needs as Antecedents of Social Emotions

The first research question addressed whether or not higher perceptions of control, value, and the three dimensions of basic psychological needs (i.e., competence, autonomy, and relatedness) positively predicted students' positive individual emotions and positive social emotions, and negatively predicted negative individual and negative social emotions. The findings presented help to support Pekrun's (2006) control-value theory and extend the implications of perceptions of control beyond achievement emotions to social emotions.

Pertaining to the study's focus on social emotion, the findings echo Muis et al.'s (2015) results that perceptions of control and value serve as important antecedents to the kinds of epistemic and activity emotions students experienced during mathematics problem solving. Specifically, it was found that control, value, and the three dimensions all related to group members' positive individual emotions. Firstly, the more one feels control over their learning, and the outcome of the learning activity, and the more they are interested in, see the utility of, and importance in the learning task, the more likely they are to experience positive individual emotions within the collaborative context. Additionally, higher perceptions of control over the learning task, and value for what is being learned, related to lower reports of experienced boredom in relation to the group problem solving task. In this way, control and value served as important buffers against disengagement, or avoidance motivation (i.e., trying to flee a given situation) (Pekrun, Hall, Goetz & Perry, 2014).

As well, students' reported feelings of control over learning, and the outcome of learning, were negatively associated with feelings of jealousy within the collaborative setting. Jealousy is an emotion thought to be experienced by an individual when they conclude a gap between a social comparison and their self-perception (Salovey & Rodin, 1984). Social comparisons have been found to take place during instances of self-doubt, and with the hopes of reaffirming or boosting one's sense of competence. It follows then, that when individual's hold high self-perceptions of competence (a control-related appraisal (Frenzel et al., 2007)), there is little practice of social comparisons that could result in feelings of jealousy, thus corroborating the finding in this study.

It is also evident from the outcomes of this research study that social emotions, and the individual emotions experienced within a group context, are preceded by specific social appraisals above and beyond control and task value. Consequently, as will be explored later, these appraisals were shown to affect the kinds of regulatory processes that group members

used while engaged in a collaborative learning situation. Pekrun (2006) explains that the influence of emotions associated with functioning within a social setting are mediated by control and value appraisals. However, as demonstrated by the findings of this study, the impact on affect as a result of the social environment is also related to social appraisals, such as the degree to which an individual feels competent, autonomous, and related to within the social context. Findings from this study demonstrate that feelings of competency, autonomy, and relatedness within the group were positively associated with positive individual emotions, and negatively associated with negative individual emotions, within the collaborative context. These findings are consistent with studies conducted by Miserandino (1996), and Ryan and Connell (1989) who found that higher instances of perceived competency and autonomy led to more enjoyment when engaged in a learning task, while lower reports of competency and autonomy were associated with higher reports of anger and anxiety. Additionally, this study found that, in particular, feelings of relatedness correlated with all four global emotion categories (i.e. positive and negative individual, and positive and negative social). This is in line with theoretical suppositions by Leary (2001), who explained that in a social context, positive social emotions arise when people experience feelings of being valued in relation to a social situation. Additionally, negative social emotions arise as a consequence of *relational devaluation*, or when an individual feels as if a social relationship with another is not important, of value, or close.

Consistent with research by Hareli and Weiner's (2002) who found that hopelessness is the result of a learner's perception of low ability, our findings did demonstrate that reports of competency and autonomy negatively related to feelings of hopelessness and confusion. That is, when the collaborative context contributed to an individual's perception of personal ability and increased feelings of self-governance in relation to the learning activity, the less group members experienced hopelessness. The same relationship was also found between

competency and autonomy in relation to confusion. Confusion, according to D'Mello and Graesser (2012) is the result of a learner's inability to dissolve cognitive incongruity, with the dissolution of confusion requiring strategic regulation on the part of the learner. As previously mentioned, satisfaction of the dimensions of BPN relates to the quality of motivation, and consequentially, motivation is found to directly impact the goals and outcomes, and the regulatory processes involved in pursuing those goals and outcomes. It may then be the case that the satisfaction of the two dimensions of BPN, as seen in this study, provide group members with the motivation, and in turn, the appropriate regulatory processes required to resolve the cognitive impasses, and refocus on the goal of the activity.

Interestingly with regards to this study, all three dimensions of BPN were found to positively correlate to pride. Fischer and Tangney (1995) describe pride as being an emotion that is experienced in relation to the evaluations made by others and/or social standards. Hareli and Weiner (2002) consider that peers express pride for others when an individual experiences success because of high ability and/or experiences success due to high effort. In addition, the experience of pride is an ego enhancement in that an individual seeks to maintain pride by either showcasing effort/ability and/or attempting to sustain feelings of worth (Ryan & Deci, 2000). Although analysis of the object focus of the experience of pride (i.e. pride towards an individual, or pride towards oneself) was beyond the scope of this study, theoretically, experiencing pride in relation to feeling that the self or other group member are able, in charge, and valued within a group context is supported by the results of this study.

As demonstrated by the findings of this study, the impact on affect as a result of the social environment and collaborative learning context is also associated with social appraisals (i.e., the degree to which an individual feels competent, autonomous, and related to within the social context) above and beyond appraisals of control and value. As such, theorists should

consider the social antecedents when studying activity emotions in general in that it may expand on the interplay between antecedents, emotions, and resulting consequences. As well, it would be a worthwhile endeavor to contemplate how socially experienced feelings of competence potentially boost perceptions of control considering that competence is a control-related appraisal (Frenzelet al., 2007) and was found to be negatively related to feelings of jealousy. Findings from this study regarding competency and autonomy negatively relating to confusion, also set the stage for the plausible foundation of theorization with regards to the relationship and dynamics between social perceptions of autonomy and competency and feelings of confusion. How do dimensions of BPN interact with D'Mello and Graesser's (2012) affective dynamics of confusion? Lastly, in relation to the dimensions of BPN experienced in the collaborative context and the resulting social emotions, research focusing on competence, autonomy, and relatedness in relation to social emotions that are based on social comparisons (i.e., jealousy, pride, etc.) would prove to be in interesting line of inquiry. Of particular relevance to the current study, would be an exploration of the social dynamics involved in the interplay between collaboration, self-perception, and affect, and possibly the emotion-to-emotion temporal dynamics of socially experienced affect as a result of social comparisons.

Relations Between Social Emotions and Learning Processes

The second research question addressed the relations between social emotions and learning processes across the two functions and four phases of regulation of learning during complex mathematics problem solving in a collaborative context. Results partially supported the hypothesis. In relation to CoRL, Furrer and Skinner (2003) found that students may experience enthusiasm when working with peers who they like, and who in turn express a like for them. This resulting positive affect may spur interest and motivation to learn and persevere, but may also lead to lengthier episodes of high-level collaborative functioning

(Volet et al., 2009). Additionally, feelings of relatedness within a social context are hypothesized to be a potential buffer for negative emotions (Furrer & Skinner, 2003). Pekrun (2006) also explains that feedback from the social environment serves to provide the learner with information that in turn shapes their appraisals of control and task value, both of which as earlier explained, influence emotions and in turn learning regulation, and as theorized by Pekrun, achievement. Findings from this study support the aforementioned theorizations in that results suggest that the degree to which learners' basic psychological needs are satisfied in a collaborative context is an important antecedent to the kinds of social emotions they experienced (see RQ1) and the consequences of those emotions, namely CoRL processes.

In the present study, it was found that empathy, or the capability of sharing someone else's feelings in a given situation, positively predicted the facilitative-confirmation function of CoRL at the monitoring and evaluation phase of learning regulation. Essentially, when one student understands another individual's feelings, the more likely students are to engage in more instances of confirming and reviewing the appropriateness of the goals, plans, and strategies that they collaboratively decided upon. A reason for this occurrence may be due to the desire of group members to alleviate the negative individual feelings (e.g., confusion) of a fellow group member by confirming that the plan or strategy employed to solve a section of the problem was indeed effective. Another reason for this occurrence may lie in the relationship between positive social emotions and instances of *high-level collaborative processes*, which are a kind of deep level processing in the collaborative context where group members share inferences, justifications, elaborations, thought-provoking inquiry, and point out relationships, which all serve to contribute to the co-construction of knowledge (Volet, Summers & Thurman, 2009). Conversely, *low-level collaborative processes* are shallower in nature and involve practices such as sharing information, reciting definitions, exchanges of ideas, and understanding without the occurrence of transformation of the information at hand

(Volet et al., 2009). Volet et al. (2009) explained that the maintenance of high-level collaborative processes, which are processes akin to what group members experienced during the facilitative-confirmation function of CoRL during the monitoring and evaluation phase, may be in part sustained due to the experiencing of positive social emotions, like empathy.

As partially hypothesized, global negative social emotions positively correlated with inhibition-change functions of CoRL specifically during the planning and goal setting, and enactment phases. Taken together, when feelings of shame, jealousy, embarrassment, guilt, and/or envy were experienced in the group context, the co-regulation that occurred was defined by greater instances of changing the goals of the problem and/or plan to solve the problem, as well as increased episodes of changing the enactment, or the carrying-out of strategies needed in order to solve the problem. Muis (2007) explains that phases can be reciprocal in nature and therefore, as it pertains specifically to the second and third phase of learning regulation, changes in enactment could call for changes in the kinds of goals or plans decided upon and vice versa. Therefore, greater instances of negative social emotions experienced by group members are associated with an increase in changing the plans, goals, and strategy enactment while solving the mathematics problem.

At the micro level, guilt positively correlated with the inhibition-change function of CoRL during the planning and goal setting and enactment phases, and jealously positively correlated with the inhibition-change function of CoRL during the enactment phase. Thus, it appears that reported experiences of guilt and jealousy are the most influential contributors of the negative social emotions that relate to higher instances of the inhibition-change function of CoRL during the second and third phase of learning regulation. Hareli and Weiner (2002) explain that guilt occurs when an individual recognizes that an *other* in the social group performs an admirable behaviour that was not, but could have been performed by the individual themselves. As well, feelings of guilt stimulate behaviour that serve to make up for

the wrongdoing (see Weiner, 1986) As previously mentioned, jealousy occurs when an individual determines a gap between a social comparison and their self-perception (Salovey & Rodin, 1984). Social comparisons occur during moments of self-doubt with the intention of reaffirming one's sense of competence (Salovey & Rodin, 1984). From these definitions, it can be concluded that both emotions are initiated by episodes of social comparison. Theoretically, it follows then that the increased and overt changing of plans and strategies could in part be due to individuals noticing a gap between potential for their own demonstration of understanding, and/or needing to reaffirm a sense of competence by attempting to close the gap between self-doubt and the social comparison.

In the social context, reported feelings of frustration and anxiety were associated with lower instances of facilitating the activation of metacognitive monitoring and evaluation (i.e., the initiation of reflection or evaluation of the effectiveness of cognitive strategies). Additionally, frustration negatively correlated with the facilitation-confirmation function during the enactment phase, meaning that when group members experienced frustration, the less likely they were to confirm that the strategies they were using were appropriate. According to Pekrun (2006) both frustration and anxiety result in the use of shallow cognitive strategies. Additionally, Pekrun and Perry (2014), explain that anxiety in particular carries the consequence of task-irrelevant thinking, which in turn, undermines cognitive resources required for the task at hand. It may be the case then that these emotions experienced in a collaborative context serve to distract the group members from the task, and additionally, undermine intrinsic motivation to complete the task successfully and with care, and instead boosts extrinsic motivation to escape the learning situation (Pekrun et al., 2011; Pekrun & Stephens, 2012).

Lastly, boredom negatively correlated with the inhibition-change function during the monitoring and evaluation phase. It appears then, that boredom experienced in the

collaborative context decreases instances of metacognitive processes embedded in the fourth phase of learning regulation. Interestingly, this lack of metacognitive monitoring occurs specifically when in the inhibition-change function of CoRL. Inhibitory functions (i.e., slow and change) are mainly used by group members in order to control for inappropriate conceptualizations of the problem and offer possible alternatives to the problem representation. Therefore, boredom appears to be negatively associated with the metacognitive event of group members slowing or changing group function in order to rectify an individual's incorrect conceptualizations of the problem. A possible reason for this is that boredom is a negative deactivating emotion that negatively affects the learner(s) motivation to solve the problem and leads to the occurrence of shallow or superficial strategy use (Pekrun, 2006), and may in CoRL terms, lead to low-level collaborative processes.

Results from this study, specifically RQ1 and RQ2, suggest that the degree to which learners' basic psychological needs are satisfied in a collaborative context is an important antecedent to the kinds of social emotions they experienced and the consequences of those emotions, namely CoRL processes. For SDT theorists, this interaction between social emotions and a sense of personal value via feelings of belonging may be an interesting line of theoretical inquiry considering that, "the extent to which relatedness to peers has a direct effect on academic outcomes is still an open question" (Furrer & Skinner, 2003, p. 150). Specific to the second research question, Malmberg, Järvela, and Järvenoja (2017) recently explored the moment to moment and sequencing of SRL, CoRL, and SSRL (socially shared regulation of learning) during different stages of collaborative learning. It would be of interest to theoretically suppose, and empirically test, the additional variable of social emotion within this temporal and sequential dynamic. What learning processes, specifically CoRL processes, result as a consequence of empathy/boredom/jealousy/pride? How do socially experienced emotions such as empathy/boredom/jealousy/pride influence

participation, and in turn, CoRL processes?

Learning Processes and Achievement

The third research question addressed whether learning processes experienced within the collaborative setting predict achievement in mathematics problem solving. Theoretically, Hofer and Pintrich (1997) ascertain that metacognitive practices are thought to influence academic achievement. A meta-analysis by Danişman (2017) that looked at the effects of SRL on achievement found that amongst the 192 research studies reviewed, there was a low-level effect of SRL on achievement. The aforementioned runs counter to findings by Dent (2013) who found a strong relationship between SRL and achievement. Empirically, Muis et al.'s (2015) study found that both shallow, and deep cognitive, along with metacognitive, processes predicted achievement on a complex mathematics problem. Findings from this study demonstrated that the use of collaborative metacognitive processes involved in monitoring and evaluating cognitive strategies positively related to achievement outcomes on the complex problem. Therefore, results from this research study, at the CoRL level of learning regulation, corroborate findings by Muis et al. (2015) and contribute to the conclusion of Dent's (2013) meta-analysis findings.

Specifically, analysis from this study found a positive correlation between instances of inhibition-slow functions of CoRL during the planning and goal setting, and monitoring and evaluation phase of learning regulation, and achievement on the mathematics problem. Additionally, there was a positive correlation between instances of facilitative-activation functions of CoRL during the monitoring and evaluation phase of learning regulation and achievement outcomes on the complex problem. The function of the inhibition-slow CoRL process is to decelerate the continuance of the previous direction's thought or action, whereas the function of facilitative-activation is to initiate action in accordance with the previous direction. It is possible that this slowing down of collective thought or action, and the

activation of, the metacognitive practice of monitoring and evaluation, could be considered a *high-level collaborative process* particularly if the reason for the deceleration or activation was due to questioning. The act of questioning is high-level in that it requires other members to display understanding rather than rehearse facts and information (Volet et al., 2009). Considering that high-level collaborative processes are analogous to metacognitive strategies in self-regulation, this is consistent with the typical finding that the more students engage in these processes, the higher their achievement (Volet et al., 2009). It is important to note that analyzing the CoRL functions for instances of questioning was beyond the scope of this study, but would nonetheless be a fruitful line of inquiry.

CoRL research has considered the function and focus of CoRL (Iiskala et al., 2011) and high vs low-level collaborative processes (King, 2002; Volet et al., 2009). Malberg et al. (2017) considers the four phases in learning regulation, but does not include the function of the processes. Theory and research has yet to contemplate the importance of identifying the function and phase during which the co-regulation occurs. Early theorists submitted that metacognition was an important factor in performance and achievement, and has the ability to either constrain or facilitate self-regulated learning processes (Paris & Winograd, 1990). This study has demonstrated that the collaborative metacognitive processes involved in monitoring and evaluating cognitive strategies directly related to achievement outcomes. Other research has shown that the occurrence of CoRL indeed has an impact on achievement outcomes (see Janssen, Erkens, & Kirschner, 2011; Saab, Joolingen, & Hout-Wolters, 2012), however, a uniform theoretical framework that takes into consideration the ‘why’ and ‘when’ would help to situate the empirical testing of CoRL and performance outcomes. Future theoretical considerations of CoRL could benefit from taking into consideration the functions of CoRL and various phases of learning regulation such as those proposed in Iiskala et al.’s (2011) and Muis’ (2007) models.

Lastly, it was hypothesized that global negative individual and global negative social emotions would positively correlate to the inhibition function (slow and change) of CoRL. Additionally, it was hypothesized that CoRL functions, inhibitory and facilitative (slow and change), at the monitoring and evaluation phase would correlate to performance outcomes on the complex problem. That is, the assumption was that metacognitive processes would predict achievement regardless of whether their antecedent was a negative emotion. The results from this study found that negative emotions correlated to inhibition-change functions, however it was the inhibition-slow function during the monitoring and evaluation phase that positively correlated to achievement. It is therefore important to reconsider the emotions that spawn the inhibition-slow function, and the consequences that emanate from that dynamic. Therefore, another worthwhile avenue, would be to contemplate theorizations regarding the emotions that surround, and in turn the function that, slowing down group processes has on collaborative achievement.

Emotions as Mediators Between Control, Value and BPN, and Episodes of CoRL

The final research question addressed whether social emotions mediate the relationship between task value, control, and BPN, and the functions of CoRL. Other studies have considered the role that social emotions may play in the regulation of learning (Muis et al., 2015; Volet et al., 2009), but this study is the first of its kind to empirically test these suppositions. Results partially supported the hypothesis that emotions serve as a mediator between perceptions of control, task value, and BPN, and episodes of CoRL.

Internalization, or the, "…process by which individuals attempt to transform socially sanctioned mores or requests into personally endorsed values and self-regulations" (p. 235-236, Deci & Ryan, 2000) is best facilitated through feelings of relatedness (Niemiec & Ryan, 2009). Additionally, an individual is more likely to internalize the practices and values of those with whom they feel, or want to feel connected to, or within contexts where they

experience a sense of belonging (Niemiec & Ryan, 2009). Niemiec and Ryan (2009) further explain that the promotion of feelings of relatedness within the classroom environment aid specifically in the internalization of motivation to learn, regulation for the tasks required for learning to take place, and increase self-governed behaviour in relation to what they are learning. Considering the aforementioned theorizations, and specific to the results of this research study, analyses in this study revealed that positive and negative individual, and positive and negative social emotions, mediated the relationship between feelings of relatedness and total instances of CoRL across the two functions and all four phases of learning regulation. That is, relatedness, the degree to which one feels that they belong and are connected to others (Ryan & Deci, 2000), above all other antecedents, predicted the use of facilitative and inhibitory co-regulatory processes across all four phases of learning regulation that the students engaged in, as mediated by both individual and social emotions.

As previously demonstrated through the results presented in this thesis (see RQ1), in the social learning context, specific emotions were the consequence of the appraisals relating to perceptions of competency, autonomy, and relatedness (in addition to appraisals of control and value). In turn, various emotions were correlated to specific CoRL functions and phases (see RQ2). Through the mediation analysis, relatedness predicting CoRL processes is mediated, or explained by, the emotions experienced within the social context. Kreijns et al., (2003) who warns that the occurrence of social interaction should not be taken for granted, puts forth that socially setting the stage is required for CoRL, but not enough to ensure that it happens. Findings from this study serve to partially support the aforementioned theorization, that is, relatedness on its own was not found to be a significant predictor of the use of CoRL processes. Therefore, feeling like a valued member within the group does not, on its own predict the use of CoRL.

Additionally, Pekrun (2006) posits that a reciprocity exists where antecedents can

become consequences over time; control and value are antecedents to emotion, and in turn through experiences with learning within the social environment, emotions can themselves become antecedents to control and value (Pekrun, 2006). Of importance, is that reciprocal interactions of the variables function in full relation with one another, and changes in perception on one variable impact the chain of antecedents, emotions, and effects. Future investigations would be wise to focus on the reciprocity between antecedents, consequences, and the elements of the social environment. Future empirical analysis into the antecedents and consequences of social emotions that includes consideration of the mediating effects of the various variables at play in the control-value theory would help to further depict these reciprocal linkages.

Lastly, perceptions of relatedness came up throughout the research study as being an influential consequence of, and having a rather influential effect on, the other variables analyzed. Contrary to the theorizations made by Deci & Ryan (2000) who describe relatedness as being a more distal contributor to motivation as when compared to competency and autonomy, the findings presented in this study show that relatedness as an antecedent was found to share the most relationships with emotions, and again, was the only antecedent to have an effect in the mediation analysis. Therefore, although SDT theorizes that relatedness may be a background player in the maintenance of motivation, considering the findings presented here, future studies that delve into collaborative learning and/or social emotions research would be wise to consider the potential role played by feelings of relatedness.

Educational implications

Findings from this study demonstrated that perceptions of control over mathematics understanding and performance, and the social appraisals of competency, autonomy, and relatedness, predicted the kinds of social emotions that students experienced. Pekrun, Muis, Goetz, and Frenzel (in press) explained that instruction and assignments should be

appropriately matched to student capabilities in order to increase perceptions of control and task value. In a collaborative learning context, educators need to be aware of two things when assigning an appropriately demanding task to a group. (1) Group member ability should be at the same level so that the task demands are appropriate for all members, or (2) should the group be of mixed ability, task demands are appropriate for a high- to medium-ability learner with the intention that they will be able to successfully scaffold the lower-ability learner(s), and the lower-ability learner(s) will be active and receptive to the scaffolding/assistance. Both contexts require that there has been enough performance information acquired to properly and appropriately formulate groups. That said, it is recommended that small group collaborative work should be avoided in the first few weeks of school until enough information about student ability and personality has been collected so groups can be formulated with appropriate consideration. In both instances, but perhaps more imperative for the second context, explicit instruction of sufficient modelling and practice of scaffolding techniques by the students themselves should be conducted in a variety of collaborative learning contexts.

Considering the aforementioned, it is important that for students to appropriately engage in learning regulation, they need to know what SRL and CoRL look like behaviourally, and concretely. Järvela et al., (2013) explains that collaborative success based on collaborative experiences shape the kinds of regulation students engage in. Zimmerman and Labuhn (2012) discuss that modeling learning regulation plays an important role in that it influences students' development of learning strategies and self-efficacy. Additionally, strategies used to overcome instances of confusion have been shown that they can be successfully modeled and taught (MacArthur, 2011). It is therefore suggested that teachers communicate to their students explicit SRL and CoRL protocol, and conduct SRL and CoRL protocol training. Clear training of this sort aimed at helping students remedy issues

concerning obstructions, uncertainty, and conflict in learning would assist students in eventually being able to independently mediate collaborative related roadblocks. Additionally, educators should not hesitate to be transparent and share with students the actual phases involved in learning regulation (i.e., task definition, planning and goal setting, enactment, and monitoring and evaluation) and explain how the model works

The second educational implication concerns pedagogical practices that address increasing perceptions of social appraisals (i.e., competency, autonomy, and relatedness). Primarily, explicit negative social comparisons made by the teacher and/or other students should be avoided completely. Levine (1983) warned that social comparisons are unavoidable and happen even in classrooms that downplay grade competition and allow students to work at their own pace and level. However, positive feedback in the form of praise when students perform well have been shown to result in feelings of pride and increased sense of competence (Webster, Duval, Gaines, & Smith, 2003). Establishing a positive and supportive classroom climate that encourages students to openly discuss their ideas, express their opinions, respectfully respond to their peers, and inspires imagination and collaborative exploration are suggested. Learning tasks should afford students the time and space to share ideas, opinions, suppositions, and reflections. Teachers can model respectful behaviour and appropriate ways to respond to peers when instances of disagreement occur. Additionally, allowing students movement within the classroom, granting them a sense of control and autonomy by allowing choice over their learning tasks, and providing students with multiple low-stakes instances for interacting with peers, and collaborating on tasks is suggested in order to boost feelings of competence and autonomy. With regards to promoting relatedness within the classroom, suggestions follow those previously made by Niemiec and Ryan (2009), in that feelings of relatedness are primarily associated with teacher responses. Teachers are encouraged establish positive relationships with their students characterized by

displaying a warm and approachable disposition where students feel liked and valued. It is also suggested that the teacher convey to students that pro-social behaviour is the mandatory way of interacting in all peer interactions.

Limitations and future directions

The most evident limitation to this research study is the small sample size (n = 29). In small sample sizes (e.g. n = 20), there may exist a larger amount of outliers, as compared to larger sample sizes (e.g. n = 60), and thus influences on parameter estimates and standard errors are susceptible to greater influence (Creedon & Hayes, n.d.). Additionally, small sample sizes suffer from low statistical power and thus run the risk of concluding a false positive (Faber & Fonesca, 2014). This study would also have benefitted from increased demographic diversity by expanding the study to various classrooms in several elementary schools in and around the Montreal area. It is recommended that results be replicated before they are generalizable to the greater population. As a result, future studies should focus on larger sample sizes and diversified sample population.

There exists some controversy around the use of think-aloud protocols in that having to verbalize internal cognitive processes has the possibility of slowing down these cognitive processes (see Iakobsen, 2003). However, considering that conversation and open dialogue is a natural requirement of CoRL, it is not believed that the think aloud protocol in this study impacted cognitive processes above and beyond the natural cognitive processes required to engage in conversation. With this said, this research could have benefited from a mixed methods approach. The addition of individual interviews with randomly selected students, or open-ended surveys, would serve to provide a deeper understanding of the responses obtained from the questionnaires and think aloud analyses. Via the inclusion of interviews, it would be worthwhile to explore questions such as; what were the specific instances that brought about feelings of jealousy/empathy/pride/guilt? What was done to mediate these feelings? What

were the specific strategies used to deal with instances of frustration and confusion?

Although beyond the scope of this research study, a suggestion for possible future research would be to explore whether instances of control and value mediate the relationship between autonomy, competency, and relatedness, and social emotions experienced during the learning task. Such an inquiry would help to shed further light on the inter-individual nature of basic psychological needs.

Lastly, a future research study of this kind could profit from a longitudinal extension. That is, the current study was merely a snapshot of the kinds of CoRL that took place within a single 75-minute, collaborative mathematics problem solving session, without any kind of formal training into prosocial collaborative practices or CoRL protocol training. Future studies of this kind could take into account how the processes of CoRL transform after repeated measurements at various time points throughout the academic year, or even throughout grade levels. A longitudinal study also has the benefit of providing information on possible changes in performance outcomes related to ongoing experiences in collaborative work. Extensions of this study could also include an intervention or training component prior to the administration of a collaborative mathematics problem solving task with the aim of improving the facilitation of CoRL during collaborative complex problem-solving sessions. Post-intervention studies could help shed light on the impact of CoRL training, modelling, scaffolding, and subsequent influences on the dynamics between antecedents and consequences.

Conclusion

This aim of this research was to expand the understanding of the social aspects of emotion in the classroom by exploring the antecedents (control, value, and basic psychological needs) and consequences (co-regulatory processes and learning outcomes) of social emotions of fifth grade students as they solved a complex mathematics problems in a

collaborative learning. Results from the study revealed that control, value, and feelings of competency, autonomy and relatedness serve as influential antecedents to the socially experienced individual emotions, and social emotions that occur in a learning context. In turn, specific emotions were found to relate to specific CoRL processes. Additionally, specific functions and phases of CoRL correlated to performance on the task. Lastly, feelings of relatedness within the group predicted CoRL processes as mediated by the emotions students experienced within the learning context.

Theoretically, results from this research extend the theoretical assumptions of Pekrun's (2006) control-value theory to another facet of activity emotions; social emotions. Additionally, this research study helps to situate the role of Deci & Ryan's (2000) dimensions of BPN within the social emotions line of research. Lastly, this research responded to a call for inquiry by Muis et al., (2015) concerning the need to study emotional experiences of students as they work collaboratively, along with an investigation into the CoRL processes that possibly accompany these experiences. Theoretical implications include working towards a uniform theoretical framework that could help to define and situate CoRL processes, considering the temporal dynamics of CoRL processes and social affect, contemplating the importance of feelings of relatedness and its role in the occurrence of CoRL processes, and the possibility of re-assessing the emotional link between inhibitory functions of CoRL Educational implications encompass collaborative group composition factors, the impact of classroom climate on the three dimensions of BPN, and interventions aimed at supporting effective CoRL practices.

This study is special in that it was conducted in an authentic learning environment, using a think aloud protocol to capture the real-time occurrences of CoRL. The main concern regarding think aloud protocols (i.e., it may be a cognitive burden to externalize internal cognitive processes) is in fact the natural process required for conversation, thus proving its

appropriateness as a measurement tool in the documentation of CoRL. It is suggested that future studies use a think aloud protocol in order to measure instances of CoRL, and include interviews in order to obtain a more in-depth understanding of social emotion, and CoRL processes.

The social environment of the classroom affords us a special opportunity to study the facets of the dynamics surrounding, and embedded in, collaborative interactions. The results provided in this research study offer an intriguing glimpse into the important influence that social emotions have on personal and social appraisals, and associated consequences. As well, the implications garnered from the results offer multiple suggestions for extending exploration in this field that have the possibility of leading to insightful future study. Kreijns et al. (2013) hazards against educators falling prey to the pedagogic falsehood, *if you build it, they will come*, which implies that because an individual is simply involved in a collaborative task, they will socially interact, and CoRL will occur. It is my hope that the conclusions drawn from this research thwart the haphazard implementation of collaborative educational practices, and instead, inspire thoughtful pedagogical design that is affectively supportive, socially positive, and has the student's well-being residing at its heart.

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Appendix A: Achievement Emotions Questionnaire (AEQ)

Math-Class

Please color in the circle
that best fits your answer.

1 I enjoy math class.				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much
2 Math class bores me.				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much
3 Math scares me.				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Math Class

Please color in the circle
that best fits your answer.

4	I look forward to math class.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

5	When I think about math class, I get nervous.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

6	Math bores me.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Math Class

Please color in the circle
that best fits your answer.

7 When I think about math class, my stomach feels upset.

1	2	3	4	5
not at all	a little	somewhat	a lot	very much

8 Math is fun for me.

1	2	3	4	5
not at all	a little	somewhat	a lot	very much

9 I find doing math boring.

1	2	3	4	5
not at all	a little	somewhat	a lot	very much

Math Class

Please color in the circle
that best fits your answer.

10	During math class, I worry that everything is too difficult for me.				
					
	1 not at all	2 a little	3 somewhat	4 a lot	5 very much

11	I find Math class so boring that I would rather do something else.				
					
	1 not at all	2 a little	3 somewhat	4 a lot	5 very much

12	I enjoy doing math.				
					
	1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Math Homework

Please color in the circle
that best fits your answer.

1	When I do math homework, I am in a good mood.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

2	Math homework bores me to death.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

3	I worry so much about not finishing my math homework that I start sweating.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

Math Homework

Please color in the circle
that best fits your answer.

4	**Math homework bores me so much that I don't want to keep doing it.**				
					
1 **not at all**	**2** **a little**	**3** **somewhat**	**4** **a lot**	**5** **very much**	

5	**When I do math homework, I worry if I will ever understand it.**				
					
1 **not at all**	**2** **a little**	**3** **somewhat**	**4** **a lot**	**5** **very much**	

6	**I enjoy math homework so much that I don't want to stop.**				
					
1 **not at all**	**2** **a little**	**3** **somewhat**	**4** **a lot**	**5** **very much**	

Math Homework

Please color in the circle
that best fits your answer.

7	Math homework scares me so much that I don't want to start doing it.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

8	When I do math homework, I get tired quickly because I am bored.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Math Tests

Please color in the circle
that best fits your answer.

1	**I enjoy math tests.**			
1 not at all	2 a little	3 somewhat	4 a lot	5 very much
2	**When I take a math test, I am afraid of getting a bad grade.**			
1 not at all	2 a little	3 somewhat	4 a lot	5 very much
3	**I am so nervous during a math test that I cannot remember properly what I have learned.**			
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Math Tests

Please color in the circle
that best fits your answer.

4	I look forward to math tests.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

5	Math tests scare me so much that I would rather not take them.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

6	I am so nervous during a math test that I cannot concentrate properly.				
					
1 not at all	2 a little	3 somewhat	4 a lot	5 very much	

Math Tests

Please color in the circle
that best fits your answer.

7	I get very nervous during math tests.				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

8	During a math test, I think, "This is going great!"				
				
1 not at all	2 a little	3 somewhat	4 a lot	5 very much

Appendix B: Academic control questionnaire

Academic Control Scale

The following statements are focused on your beliefs about math. There are no right or wrong answers. Please carefully read each statement and answer it based on your personal experience.

1	2	3	4	5
Strongly Disagree				**Strongly Agree**

1. I have a lot of control over my grades in math.

2. The more effort I put into learning math, the better I do.

3. No matter what I do, I can't seem to do well in math.

4. I am responsible for how well I do in math.

5. How well I do in math is often the "luck of the draw."

6. There is little I can do about my math grade.

7. When I do poorly in math, it's usually because I haven't given it my best effort.

8. My grades are decided by things out of my control, and there is little I can do to change that.

Appendix C: Academic task value questionnaire

Task Value Measure

The following statements are focused on your beliefs about math. There are no right or wrong answers. Please carefully read each statement and answer it based on your personal experience.

1	2	3	4	5
Not at all true of me				**Very true of me**

(a) _____ In general, I find learning about math very interesting.

(b) _____ The amount of effort it takes to understand math is worthwhile to me.

(c) _____ In general, learning about math is useful.

(d) _____ I like reading texts about math.

(e) _____ Compared to my other activities, learning about math is very useful for me.

(f) _____ I feel that, to me, learning more about math is very important.

(g) _____ Learning more about math is useful for my life.

Appendix D: Academic Emotions Scale

Activity Emotions Scale

We are interested in how you feel when working on the math problem. For each emotion, please indicate how strongly you felt that emotion by circling the number that best describes the level of the feeling you experienced when working on the math problem. Also indicate by check-mark whether that emotion was directed at yourself, your group or both

	Not at all	Very little	Moderate	Strong	Very strong	Myself	Group
Curious	1	2	3	4	5	☐	☐
Shame	1	2	3	4	5	☐	☐
Empathy	1	2	3	4	5	☐	☐
Confused	1	2	3	4	5	☐	☐
Hopeless	1	2	3	4	5	☐	☐
Surprised	1	2	3	4	5	☐	☐
Enjoyment	1	2	3	4	5	☐	☐
Anxious	1	2	3	4	5	☐	☐
Frustrated	1	2	3	4	5	☐	☐
Jealousy	1	2	3	4	5	☐	☐
Fearful	1	2	3	4	5	☐	☐
Worried	1	2	3	4	5	☐	☐
Happy	1	2	3	4	5	☐	☐
Embarrassment	1	2	3	4	5	☐	☐
Guilt	1	2	3	4	5	☐	☐
Interested	1	2	3	4	5	☐	☐
Angry	1	2	3	4	5	☐	☐
Envy	1	2	3	4	5	☐	☐
Bored	1	2	3	4	5	☐	☐
Pride	1	2	3	4	5	☐	☐

Appendix E: Basic Psychological Needs Scale (in Relationships)

Basic Need Satisfaction in Relationship Scale

Please answer each statement by indicating how true it is for you. There are no right or wrong answers.

Use the following scale:

1	2	3	4	5	6	7
Not at all true			**Somewhat true**			**Very true**

1. When I was solving the math problems with my group, I felt like I could be myself.
2. When I was solving the math problems with my group, I felt like I can do this problem.
3. When I was solving the math problems with my group, I felt they cared about me.
4. When I was solving the math problems with my group, I often felt like I didn't know how to do the work or can't do the work.
5. When I was solving the math problems with my group, I had a say in what happens, and I could voice my opinion.
6. When I was solving the math problems with my group, I often felt disconnected from the members of the group.
7. When I was solving the math problems with my group, I felt very capable and successful.
8. When I was solving the math problems with my group, I felt a lot of closeness and kindness.
9. When I was solving the math problems with my group, I felt controlled and pressured to do the problems in certain ways.

Appendix F: Complex problem

Hi, Grade Five!

You're working a shift at St. George's very popular ice cream shop, *The Dragon's Desserts*. Your job is to find the total of each family's bill **and** calculate the tax on the total bill amount (tax rate is 15%). You'll find the orders of four families on page 3.

At the end of your shift, in order to cash-out, you'll have to calculate the total amount that you sold during your shift (taxes included).

Use the price list to help you…

- calculate the amount for each item
- total for each bill

Use the **Cash Out** sheet provided to record your answers for…

- bill totals (subtotals)
- bill totals including taxes
- final cash out

Happy scooping!

The Dragon's Desserts Menu

Regular ice cream	**Cost** (without tax)
Kiddy scoop	$1.25
Regular scoop	$2.15
Soft ice cream	
Small	$1.15
Medium	$1.65
Large	$2.25
Formats	
Cup	$0.35
Regular cone	$0.45
Waffle cone	$1.10
Milkshakes	$3.75
Extras	
Sprinkles	$0.35
Chocolate dipped	$0.75
Whipped cream	$0.85
Doggy ice cream	$2.05

The Orders

The Branston Family 	- 1 kiddy scoop in a cup, with sprinkles - 1 kiddy scoop in a regular cone - 1 regular scoop in a waffle cone - 2 regular scoops in a cup, with sprinkles
The Senecal Family 	- 1 chocolate milkshake, with whipped cream - 1 kiddy scoop in a waffle cone - 1 regular scoop in a cup, with sprinkles
The Coles Family 	- 1 kiddy scoop in a regular cone, with sprinkles - 1 medium soft ice cream in a regular cone - 1 medium soft ice cream in a regular cone, chocolate dipped
The Clarke Family 	- 1 scoop of doggy ice cream - 2 regular scoops in a waffle cone, with sprinkles - 1 regular scoop in a regular cone

Cash out

Families	Items	Cost	Subtotal	Total (tax incl.)
The Branston Family 				
The Senecal Family 				
The Coles Family 				
The Clarke Family 				
	Cash out total:			

A worksheet to help you…

The Branston Family 		
The Senecal Family 		
The Coles Family 		
The Clarke Family 		

Appendix G: Scoring rubric

Dragon's Desserts Rubric

iPad Number: _____ Student IDs: _____

Category	1	2	3	4
Mathematical Concepts	Mathematical explanation shows very limited understanding of the underlying concepts needed to solve the problem(s) OR is not written.	Mathematical explanation shows some understanding of the mathematical concepts needed to solve the problem(s).	Mathematical explanation shows substantial understanding of the mathematical concepts used to solve the problem(s).	Mathematical explanation shows complete understanding of the mathematical concepts used to solve the problem(s).
Mathematical Reasoning	Little evidence of mathematical reasoning.	Some evidence of mathematical reasoning.	Uses effective mathematical reasoning.	Uses complex and refined mathematical reasoning.
Strategy/Procedures	Rarely uses an effective strategy to solve problems.	Sometimes uses an effective strategy to solve problems, but does not do it consistently.	Typically uses and effective strategy to solve the problem(s).	Typically uses an efficient and effective strategy to solve the problem(s).
Mathematical Errors	60% or less error-free solutions.	61%-75% error-free solutions.	76%-84% error-free solutions.	85%-100% error-free solutions.
Completion	25% of the problems are completed.	50% of the problems are completed.	75% of the problems are completed.	All of the problems are completed.

Appendix H: Correlations between all variables

Table 4

Correlations between all variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1. Problem Achievement		-.03	-.03	.01	.05	.13	.02	.28	-.05	.12	.05	-.07	.02	-.342*	-.394*	-.22	.04	-.08	-.15	-.10	.21	.10	-.26	.19	.02	.00	.19	-.25	.819**	-.18	-.86	.328*	.15	.28	.427*	.32	.498**	-.02	.20	.30	.11	.27
2. Control			.422*	.11	.20	.361*	.27	.354*	.03	-.452**	-.14	.17	-.02	.09	-.04	-.342*	-.07	.389*	-.326*	-.24	.25	.324*	-.340*	.375*	-.16	-.02	.05	.25	-.07	.01	-.17	.07	.02	.01	-.08	-.08	-.12	.02	-.03	-.06	-.02	.06
3. Value				.13	.00	.08	.09	.25	-.03	.08	.03	.13	.07	.02	-.10	-.392*	.01	.323*	.16	.21	.429*	.405*	-.10	.21	.14	-.329*	-.23	-.387*	-.21	-.20	.28	-.417*	-.25	-.13	-.16	-.04	-.16	.25	.439*	.408*	.17	-.31
4. Competency					.499**	.424*	-.07	.361*	-.22	-.18	-.18	-.10	.19	.06	-.370*	-.14	-.519**	.30	-.22	-.446**	.441**	.402*	-.528**	.19	-.09	-.26	-.03	.04	.11	-.03	.09	.15	.02	-.25	.16	-.17	-.12	.00	-.09	-.12	.327*	.02
5. Autonomy						.505**	.03	.437**	-.22	-.16	-.07	.15	.17	-.05	-.369*	-.15	-.510**	.508**	-.677**	-.650**	.524**	.545**	-.718**	.29	.04	-.18	.29	.356*	.22	-.13	-.342*	.16	.07	.22	.08	-.09	-.05	.10	.11	.07	-.07	.20
6. Relatedness							.07	.470**	-.30	-.338*	-.26	-.26	.13	-.13	-.26	-.537**	-.11	.574**	-.437**	-.501**	.529**	.578**	-.586**	.336*	-.316*	.17	.330*	.592**	.427*	.13	-.416*	.391*	.01	.12	.18	-.03	.23	.19	-.16	-.364*	.25	.395*
7. Empathy								.422*	.14	-.21	.08	.19	.354*	.329*	.20	-.17	.07	.473**	-.19	.02	.319*	.405*	-.05	.822**	.22	.13	.25	.25	-.28	.336*	-.08	.19	.413*	.24	-.03	.27	-.16	-.02	.09	.14	-.21	.32
8. Pride									-.337*	-.340*	-.325*	.01	.04	.12	-.356*	-.417*	-.10	.711**	-.539**	-.489*	.754**	.775**	-.571**	.863**	-.23	.02	.05	.08	.11	.03	-.86	.06	-.02	.03	.03	.04	.06	.11	.06	-.01	.12	.09
9. Shame										-.05	.617**	-.05	-.06	.17	.352*	.02	.08	-.18	.17	.18	-.20	-.20	.23	-.14	.15	-.13	.05	-.10	-.13	-.14	.13	-.09	.05	-.18	.12	-.26	.03	-.17	-.15	-.07	-.09	-.09
10. Jealous											.371*	-.07	.314*	-.17	-.15	.494**	-.04	-.366*	.452**	.408*	-.31	-.350*	.380*	-.333*	.660**	-.17	-.05	-.21	-.18	-.19	.04	-.22	.01	.12	-.15	.06	-.11	.01	.353*	.472**	-.21	-.13
11. Embarrassment												-.10	.314*	.16	.393*	.13	-.01	-.13	.27	.328*	-.15	-.15	.313*	-.16	.471**	-.06	.19	-.15	-.11	.11	.20	.10	.387*	.04	.25	.07	-.03	-.25	-.09	.07	-.21	.13
12. Guilt													-.08	.31	.06	.09	-.04	-.11	-.17	-.01	.04	-.03	-.02	.11	.435**	-.13	-.08	-.18	-.13	-.14	-.02	-.19	-.01	.22	-.23	.20	-.14	.10	.462**	.555**	-.19	-.09
13. Envy														.29	.01	.03	-.27	.26	.08	.07	.10	.18	-.06	.22	.677**	-.09	-.06	.26	-.12	.01	-.22	.25	.21	.04	-.16	.03	-.32	-.17	.01	.15	-.11	.09
14. Surprise															.26	.03	-.10	.29	-.02	.19	.17	.23	.07	.26	.28	.08	.02	.06	-.24	.24	.11	.16	.26	-.11	.04	.05	-.12	-.17	-.17	-.10	.00	.12
15. Hopeless																.08	.417*	-.09	.332*	.317*	-.344*	-.25	.651**	-.11	.04	.25	-.11	-.02	-.21	.22	.04	.06	.15	.06	-.11	.13	-.15	-.30	-.31	-.20	-.327*	-.04
16. Bored																	-.352*	-.514**	.07	.02	-.599**	-.593**	.338*	-.354*	.326*	-.13	-.03	-.20	-.12	.02	.12	.03	.27	.14	.01	.11	-.29	-.30	-.05	.16	-.384*	-.06
17. Confused																		-.13	.523**	.529**	-.12	-.13	.640**	-.02	-.18	.30	-.11	.01	-.17	-.01	-.89	-.384*	-.390*	.09	-.32	.00	.15	.23	.07	-.09	-.12	-.20
18. Curiosity																			-.481**	-.31	.796**	.930**	-.512**	.713**	-.15	.08	.20	.32	-.04	.23	-.14	.18	.16	.11	.02	.09	-.07	.10	-.02	-.10	.04	.25
19. Frustration																				.842**	-.438**	-.481**	.819**	-.443**	.23	-.12	-.27	-.27	-.421*	-.02	.26	-.424*	-.22	-.13	-.27	-.06	-.27	.10	.14	.11	-.05	-.353*
20. Anxiety																					-.28	-.31	.774**	-.25	.29	-.04	-.07	-.23	-.482**	.21	.339*	-.373*	-.03	-.01	-.17	.13	-.21	.22	.25	.18	-.01	-.14
21. Enjoyment																						.963**	-.597**	.654**	-.14	-.17	.13	-.02	.17	.02	.11	.04	.00	-.06	.21	-.02	.06	.20	.11	.00	.30	.09
22. Global positive inividual emotions																							-.591**	.715**	-.15	-.07	.17	.13	.09	.12	.00	.10	.07	.02	.13	.03	.00	.17	.06	-.04	.20	.17
23. Global negative individual emotions																								-.385*	.21	.09	-.19	-.22	-.486*	.10	.18	-.339*	-.09	.07	-.27	.08	-.23	-.03	.01	.04	-.31	-.26
24. Global positive social emotions																									-.02	.09	.18	.19	-.09	.21	-.88	.15	.23	.16	.00	.18	-.05	.06	.09	.08	-.04	.24
25. Global negative social emotions																										-.24	-.09	-.08	-.26	-.20	-.89	-.09	.13	.15	-.26	.08	-.30	-.09	.383*	.590**	-.29	-.08
26. F-AC-TD																											.27	.465**	.15	.490**	-.448*	.492**	.31	.399*	-.03	.537**	.607**	-.12	-.23	-.23	-.22	.589**
27. F-AC-PGS																												.405*	.21	.633**	-.01	.32	.584**	.528**	.618**	.407*	.408*	.407*	.12	-.15	.05	.839**
28. F-AC-EN																													-.04	.25	-.746**	.383*	.14	.30	-.18	.00	.10	.10	-.18	-.328*	-.16	.495**
29. F-AC-MEV																														-.08	-.18	.540**	.14	.21	.541**	.18	.521**	-.21	-.29	-.24	.09	.31
30. F-CO-TD																															.25	.438*	.719**	.350*	.442*	.679**	.16	.21	-.06	-.25	.13	.777**
31. F-CO-PGS																																-.29	.11	-.438*	.496**	-.01	-.10	.17	.07	-.04	.526**	-.16
32. F-CO-EN																																	.726**	.24	.447**	.424*	.28	-.537**	-.553**	-.342*	-.10	.699**
33. F-CO-MEV																																		.430*	.548**	.658**	.07	-.30	-.18	-.02	-.21	.780**
34. I-SL-TD																																			-.04	.741**	.08	.15	.372*	.395*	-.627**	.533**
35. I-SL-PGS																																				.18	.436*	.00	-.30	-.411*	.417*	.546**
36. I-SL-EN																																					.20	.07	.30	.351*	-.26	.654**
37. I-SL-MEV																																						.14	-.10	-.25	.29	.480**
38. I-CH-TD																																							.695**	.18	.457**	.12
39. I-CH-PGS																																								.832**	.01	-.05
40. I-CH-EN																																									-.335*	-.17
41. I-CH-MEV																																										.03
42. Total instances of CoRL																																										

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).